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DISSERTATION

“Ensuring the international competitiveness of innovatively oriented industrial enterprises”

051 Economics
05 “Social and behavioral sciences”

Submitted for the degree of Doctor of philosophy

The dissertation contains the results of the author’s own research. The use of ideas, results, and texts of other authors are referenced to the corresponding sources.

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ABSTRACT

He Jingwen. Ensuring the international competitiveness of innovatively oriented industrial enterprises. – Qualification scientific work on the rights of a manuscript.

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The introduction substantiates the relevance of the research topic, formulates the aim and objectives of the study, defines its object and subject, describes the research methods, presents the scientific novelty and practical significance of the obtained results, and provides information on their approbation. The research logic is determined by the need to combine theoretical provisions concerning enterprise competitiveness with methodological tools for its assessment and practical measures aimed at strengthening the competitive positions of innovatively oriented industrial enterprises in international markets.

The first chapter generalizes and systematizes scientific approaches to defining the essence of international competitiveness of enterprises, examines the specific features of its formation under globalization and technological transformation, and develops the theoretical and methodological foundations for ensuring the competitiveness of innovatively oriented industrial enterprises. International competitiveness of an enterprise is defined as its ability to sustain its position in global markets through R&D intensity, the technological complexity of exports, intellectual property accumulation, the conversion of innovation activity into financial performance, and the continuous renewal of competitive advantages in response to changes in market conditions and technological trajectories.

The distinctive characteristics of innovatively oriented industrial enterprises that determine the specific features of ensuring their international competitiveness are identified. These characteristics include strategic innovation orientation, intensive

research and development activities, the formation of an organizational environment supportive of innovation, the use of open innovation and external cooperation mechanisms, the ability to adapt rapidly to market and technological changes, the development of dynamic capabilities, intellectual property management, data-driven decision-making, and sustainability orientation. Their combination distinguishes innovatively oriented industrial enterprises from enterprises whose competitive advantages are primarily based on production scale, access to traditional resources, or cost leadership. Accordingly, ensuring the international competitiveness of such enterprises requires the coordination of innovation, resource, market, and integration decisions within a unified system.

Methodological approaches to assessing enterprise competitiveness are systematized and the areas of their application are determined. It is established that competitiveness assessment should provide an analytical basis for developing international market entry strategies, planning innovation activities and R&D investment, selecting partners for technological cooperation, and determining directions for strengthening competitive positions. The advantages and limitations of the main methods of competitiveness assessment are identified.

The theoretical foundations for ensuring the international competitiveness of innovatively oriented industrial enterprises are developed through the integration of the Resource-Based View, the Dynamic Capabilities Framework, and the Open Innovation Concept. It is established that sustainable competitive advantages of such enterprises are formed not only through the availability of material, financial, and technological resources but also through intellectual capital, technological knowledge, employee competencies, and the enterprise’s ability to transform its resource base in response to changes in the external environment.

The second chapter analyzes the current state and development prospects of the artificial intelligence market in China, identifies the principal determinants of the competitiveness of innovatively oriented industrial enterprises, and assesses their competitiveness using an integrated approach. It is established that the competitive

positions of such enterprises are formed under the combined influence of macroeconomic, financial, innovation, and technological factors. Particular importance is attributed to innovation factors, which contribute to enterprises' ability to create long-term competitive advantages and adapt to structural changes in international markets.

An original framework for the utilization of innovation resources by innovatively oriented industrial enterprises is developed, reflecting the resource structure, the actors involved, development trends, and functional purposes. The effectiveness of innovation resource utilization is assessed based on the formulation and achievement of enterprise innovation objectives. The concept of an "innovation objective" is specified with regard to the role of such enterprises in creating technological innovations and generating their commercial value. BOE, Midea, BYD, CATL, and TCL are comprehensively assessed in terms of profitability, solvency, operational efficiency, and growth potential.

The comparative assessment reveals differences in the structure and level of enterprise competitiveness and demonstrates that similar overall performance may result from different combinations of financial, operational, and innovation advantages. This requires a differentiated approach to identifying competitive reserves. Depending on the enterprise, priorities may include improving financial stability and capital efficiency, increasing innovation commercialization, strengthening technological independence, enhancing operational efficiency, or expanding participation in international production and innovation networks. The results provide an analytical basis for developing enterprise-specific recommendations.

The third chapter develops scientific and practical recommendations for ensuring the market adaptability of innovatively oriented industrial enterprises across functional, technological, financial, innovation, and intellectual dimensions. A two-way fixed effects model based on panel data from 7209 Chinese A-share listed manufacturing firms is used to assess the relationship between R&D intensity and international competitiveness measured through export technology complexity. The results indicate a statistically significant positive relationship, with ROA mediating it and firm size

exerting a negative moderating effect.

The findings clarify how innovation investment affects international competitiveness. R&D expenditure supports the development of technological capabilities and the production of technologically complex exports, while improved financial performance facilitates the transformation of research results into commercially valuable products. At the same time, the negative moderating effect of firm size indicates that organizational growth does not automatically increase the effectiveness of innovation investment. Large enterprises may face coordination costs, organizational inertia, and slower decision-making, which should be considered when developing innovation strategies and allocating resources.

The development of market adaptability in the technological dimension is substantiated with consideration of Industry 4.0 processes. The main directions of enterprise adaptation include the digital transformation of business processes, platform-based interaction models, digitalization of products and services, and new business models for creating and delivering customer value. Technological adaptability is identified as an important component of long-term international competitiveness.

Market adaptability is regarded not as a temporary response to individual external changes but as a permanent organizational capability to identify market and technological signals, reassess strategic priorities, redistribute resources, and implement appropriate managerial decisions. Its development requires coordination among functional divisions, access to relevant information, flexible resource allocation, and the integration of innovation objectives into the overall enterprise development strategy. This capability enables enterprises to maintain competitiveness under uncertainty and rapid technological change.

A resource provision framework for strengthening enterprise competitiveness is further developed across five interrelated dimensions: financial, technological, functional, human, and information provision. Directions for optimizing these dimensions are determined with regard to the need to strengthen innovation potential and market adaptability. In the financial dimension, the transition from predominantly

asset-intensive to knowledge-intensive value creation models is substantiated, with a greater role assigned to digital products, services, and other intangible components.

The interdependence of these dimensions is substantiated. Financial resources enable technological modernization and R&D investment; technological resources support innovation development and commercialization; human resources provide the necessary competencies; information resources support managerial decision-making; and functional provision coordinates the relevant areas of enterprise activity. Limitations in any dimension may reduce the effectiveness of the resource provision system and weaken the enterprise's ability to respond to changes in international markets.

A methodological approach to evaluating and selecting integration strategies is improved through the comparative assessment of five pathways: vertical integration, horizontal integration, strategic alliances and long-term contractual relationships, open innovation and digital ecosystem integration, and cross-border international integration. Enterprise-specific priorities are aligned with the competitive reserve profiles of BYD, CATL, BOE, Midea, and TCL.

A set of measures aimed at enhancing the market adaptability of innovatively oriented industrial enterprises is proposed, covering technological innovation, digitalization, improvement of information support for managerial decision-making, formation of strategic alliances, and application of integration strategies. The principles for evaluating the economic efficiency of commercial cooperation among innovatively oriented industrial enterprises are developed. Based on the assessment of the effects generated by innovation and integration strategies, reserves for the formation of financial resources that can be directed toward improving market adaptability and strengthening the competitive positions of enterprises are identified.

Keywords: *international competitiveness, innovatively oriented industrial enterprise, competitive advantages, technological innovation, market adaptability, competitiveness model, R&D investment, export technology complexity, dynamic capabilities, resource provision, vertical integration, Industry 4.0.*

АНОТАЦІЯ

Хе Цзінвен. Забезпечення міжнародної конкурентоспроможності інноваційно орієнтованих промислових підприємств. – Кваліфікаційна наукова праця на правах рукопису.

Дисертація на здобуття ступеня доктора філософії за спеціальністю 051 Економіка. – Національний технічний університет України «Київський політехнічний інститут імені Ігоря Сікорського»; Національний технічний університет України «Київський політехнічний інститут імені Ігоря Сікорського», Київ, 2026.

У вступі обґрунтовано актуальність теми дослідження, сформульовано його мету і завдання, визначено об’єкт і предмет, охарактеризовано методи дослідження, розкрито наукову новизну та практичне значення одержаних результатів, а також наведено відомості про їх апробацію. Структура дослідження забезпечує послідовний перехід від теоретичних положень щодо конкурентоспроможності підприємств до методичного інструментарію її оцінювання та практичних заходів із посилення конкурентних позицій інноваційно орієнтованих промислових підприємств на міжнародних ринках.

У першому розділі узагальнено й систематизовано наукові підходи до визначення сутності міжнародної конкурентоспроможності підприємств, досліджено особливості її формування в умовах глобалізації та технологічних трансформацій, розвинуто теоретико-методологічні засади забезпечення конкурентоспроможності інноваційно орієнтованих промислових підприємств. Міжнародну конкурентоспроможність підприємства визначено як його здатність утримувати позиції на світових ринках завдяки інтенсивності НДДКР, технологічній складності експорту, накопиченню інтелектуальної власності, перетворенню результатів інноваційної діяльності на фінансові результати та постійному оновленню конкурентних переваг відповідно до змін ринкових умов і траєкторій технологічного розвитку.

Визначено характерні ознаки інноваційно орієнтованих промислових

підприємств, що зумовлюють особливості забезпечення їх міжнародної конкурентоспроможності. До них належать стратегічна орієнтація на інновації, інтенсивна науково-дослідна діяльність, формування сприятливого для інновацій організаційного середовища, використання механізмів відкритих інновацій і зовнішнього співробітництва, здатність швидко адаптуватися до ринкових і технологічних змін, розвиток динамічних здатностей, управління інтелектуальною власністю, прийняття рішень на основі даних та орієнтація на сталий розвиток. Сукупність цих ознак відрізняє інноваційно орієнтовані промислові підприємства від підприємств, конкурентні переваги яких переважно ґрунтуються на масштабах виробництва, доступі до традиційних ресурсів або лідерстві за витратами. Отже, забезпечення міжнародної конкурентоспроможності таких підприємств потребує узгодження інноваційних, ресурсних, ринкових та інтеграційних рішень у межах єдиної системи.

Систематизовано методичні підходи до оцінювання конкурентоспроможності підприємств і визначено сфери їх застосування. Встановлено, що оцінювання конкурентоспроможності має створювати аналітичне підґрунтя для розроблення стратегій виходу на міжнародні ринки, планування інноваційної діяльності та інвестицій у НДДКР, вибору партнерів для технологічного співробітництва й визначення напрямів посилення конкурентних позицій. Виявлено переваги та обмеження основних методів оцінювання конкурентоспроможності. Теоретичні засади забезпечення міжнародної конкурентоспроможності інноваційно орієнтованих промислових підприємств розвинуто шляхом інтеграції ресурсного підходу, концепцій динамічних здатностей і відкритих інновацій. Встановлено, що стійкі конкурентні переваги таких підприємств формуються не лише завдяки матеріальним, фінансовим і технологічним ресурсам, а й завдяки інтелектуальному капіталу, технологічним знанням, компетентностям працівників та здатності трансформувати ресурсну базу відповідно до змін зовнішнього середовища.

У другому розділі проаналізовано сучасний стан і перспективи розвитку ринку штучного інтелекту в Китаї, визначено основні чинники

конкурентоспроможності інноваційно орієнтованих промислових підприємств та здійснено її оцінювання на основі інтегрованого підходу. Встановлено, що конкурентні позиції таких підприємств формуються під сукупним впливом макроекономічних, фінансових, інноваційних і технологічних чинників. Особливе значення мають інноваційні чинники, що сприяють формуванню довгострокових конкурентних переваг та адаптації підприємств до структурних змін на міжнародних ринках.

Розроблено авторську модель використання інноваційних ресурсів інноваційно орієнтованими промисловими підприємствами, яка відображає структуру ресурсів, суб'єктів їх використання, тенденції розвитку та функціональне призначення. Ефективність використання інноваційних ресурсів оцінено за ступенем досягнення інноваційних цілей підприємства. Уточнено поняття «інноваційна ціль» з урахуванням ролі таких підприємств у створенні технологічних інновацій і формуванні їх комерційної цінності. Проведено комплексне оцінювання підприємств BOE, Midea, BYD, CATL і TCL за показниками прибутковості, платоспроможності, операційної ефективності та потенціалу зростання. Порівняльне оцінювання виявило відмінності у структурі та рівні конкурентоспроможності підприємств і засвідчило, що подібні результати можуть забезпечуватися різними поєднаннями фінансових, операційних та інноваційних переваг. Це потребує диференційованого підходу до визначення конкурентних резервів. Залежно від підприємства пріоритетними можуть бути підвищення фінансової стійкості й ефективності використання капіталу, активізація комерціалізації інновацій, посилення технологічної незалежності, підвищення операційної ефективності або розширення участі в міжнародних виробничих та інноваційних мережах. Одержані результати є аналітичною основою для розроблення індивідуальних рекомендацій.

У третьому розділі розроблено науково-практичні рекомендації щодо забезпечення ринкової адаптивності інноваційно орієнтованих промислових підприємств у функціональному, технологічному, фінансовому, інноваційному та інтелектуальному вимірах. Взаємозв'язок між інтенсивністю НДДКР

та міжнародною конкурентоспроможністю, виміряною за технологічною складністю експорту, оцінено за допомогою моделі з двосторонніми фіксованими ефектами на основі панельних даних 7209 китайських виробничих підприємств, акції класу А яких котируються на фондовому ринку. Виявлено статистично значущий позитивний зв'язок, у якому рентабельність активів (ROA) виконує опосередковувальну роль, а розмір підприємства чинить негативний модераційний вплив.

Одержані результати уточнюють механізм впливу інвестицій в інновації на міжнародну конкурентоспроможність. Витрати на НДДКР сприяють розвитку технологічних можливостей і виробництву технологічно складної експортної продукції, а поліпшення фінансових результатів забезпечує перетворення результатів досліджень на комерційно цінну продукцію. Встановлено, що зі збільшенням розміру підприємства віддача від інвестицій в інновації може знижуватися. Великі підприємства можуть зазнавати додаткових координаційних витрат, організаційної інерції та уповільнення прийняття рішень, що необхідно враховувати під час розроблення інноваційних стратегій і розподілу ресурсів.

Обґрунтовано особливості розвитку ринкової адаптивності у технологічному вимірі в умовах Індустрії 4.0. Основними напрямами адаптації є цифрова трансформація бізнес-процесів, розвиток платформних моделей взаємодії, цифровізація продукції та послуг і застосування нових бізнес-моделей створення і надання цінності споживачам. Технологічну адаптивність визначено важливою складовою довгострокової міжнародної конкурентоспроможності. Ринкову адаптивність підприємства визначено як постійну організаційну здатність розпізнавати ринкові й технологічні сигнали, переглядати стратегічні пріоритети, перерозподіляти ресурси та реалізовувати управлінські рішення. Її розвиток потребує координації функціональних підрозділів, доступу до актуальної інформації, гнучкого розподілу ресурсів та інтеграції інноваційних цілей у стратегію розвитку підприємства.

Розвинуто систему ресурсного забезпечення конкурентоспроможності підприємств за п'ятьма складовими: фінансовою, технологічною,

функціональною, кадровою та інформаційною. Визначено напрями їх оптимізації для посилення інноваційного потенціалу та ринкової адаптивності підприємств. Обґрунтовано перехід від активомістких до знаннєвомістких моделей створення вартості з підвищенням ролі цифрових продуктів, послуг та інших нематеріальних складових. Встановлено взаємозалежність складових ресурсного забезпечення: фінансові ресурси створюють можливості для технологічної модернізації та інвестування у НДДКР; технологічні забезпечують розроблення і комерціалізацію інновацій; кадрові формують необхідні компетентності; інформаційні підтримують прийняття управлінських рішень; функціональне забезпечення координує відповідні напрями діяльності. Обмеженість будь-якої складової може знизити ефективність усієї системи та здатність підприємства реагувати на зміни на міжнародних ринках.

Удосконалено методичний підхід до оцінювання та вибору інтеграційних стратегій на основі порівняння вертикальної і горизонтальної інтеграції, стратегічних альянсів і довгострокових договірних відносин, інтеграції у відкриті інноваційні та цифрові екосистеми, а також транскордонної міжнародної інтеграції. Пріоритети підприємств узгоджено з профілями конкурентних резервів BYD, CATL, BOE, Midea і TCL. Запропоновано комплекс заходів із підвищення ринкової адаптивності підприємств, що охоплює технологічні інновації, цифровізацію, удосконалення інформаційного забезпечення управлінських рішень, формування стратегічних альянсів і застосування інтеграційних стратегій. За результатами оцінювання інноваційних та інтеграційних стратегій визначено резерви фінансових ресурсів для підвищення ринкової адаптивності та посилення конкурентних позицій підприємств.

Ключові слова: *міжнародна конкурентоспроможність, інноваційно орієнтоване промислове підприємство, конкурентні переваги, технологічні інновації, ринкова адаптивність, модель конкурентоспроможності, інвестиції у дослідження і розробки, технологічна складність експорту, динамічні здатності, ресурсне забезпечення, вертикальна інтеграція, Індустрія 4.0.*

LIST OF CANDIDATE'S PUBLICATIONS ON THE DISSERTATION TOPIC

Scientific publications presenting the main research results of the dissertation:

1. He J., Kukharuk A. Study on the essence of international competitiveness of innovation-oriented enterprise taking Huawei as an example. *Scientific innovations and advanced technologies.* 2025. No. 2 (42). P. 746–756. DOI: https://doi.org/10.52058/2786-5274-2025-2(42)-746-756 (0,76 p.s.). *Candidate's personal contribution: an analysis of Huawei's competitive advantages was conducted, considering its development history and innovation strategies; a quantitative analysis was performed on company's financial indicators and the dynamics of its intellectual property over recent years; strategic initiatives undertaken by Huawei at different stages of its growth to enhance corporate competitiveness was summarized (0,59 p.s.); Anna Kukharuk: the research concept developed; the company's revenue structure by business segment and its patent portfolio were examined (0,17 p.s.).*

2. Kukharuk A., He J. Analysis of the impact of technological innovation investment on the competitiveness of innovative enterprises. *Scientific Perspectives*. 2024. No. 8 (50). P. 321–330. DOI: https://doi.org/10.52058/2708-7530-2024-8(50)-321-330 (0,67 p.s.). *Candidate's personal contribution: the relationship between R&D investment and enterprise efficiency and competitiveness was analyzed, and its positive association with income and asset value growth was identified (0.41 p.s.); Anna Kukharuk: the role of technological innovation investment in enhancing enterprise competitiveness was substantiated (0.26 p.s.).*

3. Kukharuk A., He J. Problems of assessing the level of competitiveness of innovatively oriented industrial enterprises based on a statistical approach. *Efektyvna ekonomika*. 2025. No. 8. DOI: https://doi.org/10.32702/2307-2105.2025.8.85. (0.75 p.s.). *Candidate's personal contribution: statistical approaches to assessing enterprise competitiveness were analyzed and their advantages and limitations for innovation-oriented industrial enterprises were identified (0.46 p.s.); Anna Kukharuk: the*

expediency of a multidimensional statistical approach to assessing enterprise competitiveness was substantiated and the main assessment dimensions were specified (0.29 p.s.).

4. He J., Kukharuk A. Strategic aspects of resource provision of competitiveness of innovation-oriented enterprises. *National interests of Ukraine*. 2026. No. 2 (19). P. 1091–1104. DOI: https://doi.org/10.52058/3041-1793-2026-2(19)-1091-1104 (0.89 p.s.). *Candidate's personal contribution: the structure of resource provision of innovation-oriented enterprises was systematized and strategic measures for optimizing financial, technological, functional, human and information resources were developed (0.54 p.s.); Anna Kukharuk: the role of integrated resource provision in strengthening market adaptability and enterprise competitiveness was substantiated, and the principles of coordinated resource allocation were defined (0.35 p.s.).*

5. He J., Bai Q. The impact of technological innovation on the competitiveness of firms in emerging economies. *Economic Bulletin of NTUU "Kyiv Polytechnic Institute"*. 2026. No. 36. P. 149–155. DOI: 10.20535/2307-5651.36.2026.360559 (0.70 p.s.). *Candidate's personal contribution: the impact of R&D investment on the international competitiveness of enterprises was empirically assessed, and the mediating role of financial performance in this relationship was identified (0.35 p.s.); Qiang Bai: differences in the impact of R&D investment on international competitiveness across enterprises of different sizes were identified, and the moderating effect of firm size was established (0.35 p.s.).*

Scientific publication additionally presenting research results of the dissertation:

6. He J., Qiao D. Strategic resource configuration and organizational adaptability in innovation-driven enterprises. *International Journal of Business Management and Economics and Trade*. 2026. Vol. 7, No. 1. P. 83–91. DOI: https://doi.org/10.38007/IJBMET.2026.070110. (0.70 p.s.). *Candidate's personal contribution: a multidimensional framework of resource provision for innovation-driven enterprises was developed and strategic directions for optimizing financial, technological, functional, human and information resources to enhance market*

adaptability were substantiated (0.44 p.s.); Dong Qiao: the organizational aspects of resource configuration and their role in improving enterprise adaptability were analyzed (0.26 p.s.).

Publications that certify the approbation of dissertation materials:

7. Bai Q., He J., Kukharuk A. Modern challenges for the international competitiveness of industrial enterprises in the era of globalization. *Scientific Achievements of Contemporary Society: Proceedings of the 7th International Scientific and Practical Conference (*London, UK, 6–8 February 2025). London: Cognum Publishing House, 2025. P. 413–415. URL:https://sci-conf.com.ua/wp-content/uploads/2025/02/SCIENTIFIC-ACHIEVEMENTS-OF-CONTEMPORARY-SOCIETY-6-8.02.25.pdf.

8. He J., Kukharuk A. Challenges of applying a statistical approach in competitive analysis. *Research in Science, Technology and Economics*: *Proceedings of the 4th International Scientific and Practical Conference* (Luxembourg, 6–8 August 2025). Luxembourg: International Scientific Unity, 2025. P. 46–49. DOI: 10.70286/ISU-06.08.2025.1. URL: https://isu-conference.com/wp-content/uploads/2025/08/Luxembourg_Luxembourg_06.08.25.pdf.

9. He J., Kukharuk A. The reserves of competitive potential of innovatively oriented industrial enterprises in the context of global transformations. *Science and Technology: New Horizons of Development*: *Proceedings of the 2nd International Scientific and Practical Conference* (Prague, Czech Republic, 13–15 August 2025). Prague: International Scientific Unity, 2025. DOI: 10.70286/ISU-13.08.2025.

10. He J., Bai Q., Kukharuk A. Challenges to ensuring the competitiveness of innovative enterprises in China. *Current Issues, Problems and Prospects for the Development of Science, Education, Technology and Society*: *Proceedings of the International Scientific and Practical Conference*(Boston, USA, 10 February 2026). Boston: Golden Quill Publishing, 2026. P. 64–66. DOI: 10.64076/GQP-10.02.2026.002. URL: https://www.economics.in.ua/2026/02/10.html?m=1.

11. Bai Q., He J., Kukharuk A. Disruptions in manufacturing and electronics sectors amid global crises: implications for competitiveness. *Research in Science, Technology and Economics*: *Proceedings of the 6th International Scientific and Practical Conference* (Luxembourg, 18–20 February 2026). Luxembourg: International Scientific Unity, 2026. P. 107–108. DOI: 10.70286/ISU-18.02.2026.008. URL: https://isu-conference.com/wp-content/uploads/2026/02/Luxembourg_Luxembourg_18.02.26.pdf.

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LIST OF ABBREVIATIONS, SYMBOLS, AND TERMS

AI – Artificial Intelligence

AHP – Analytic Hierarchy Process

API – Application Programming Interface

CSMAR – China Stock Market & Accounting Research Database

DEA – Data Envelopment Analysis

FDI – Foreign Direct Investment

GDP – Gross Domestic Product

H-O Theory – Heckscher-Ohlin Theory

I-IMD – International Institute for Management Development

IP – Intellectual Property

IT – Information Technology

M&A – Mergers and Acquisitions

MNC – Multinational Corporation

OECD – Organization for Economic

Cooperation and Development

R&D – Research and Development

RBV – Resource-Based View

ROA – Return on Assets

ROE – Return on Equity

SWOT – Strengths, Weaknesses, Opportunities, Threats

VIF – Variance Inflation Factor

WEF – World Economic Forum

WIPO – World Intellectual Property Organization

INTRODUCTION

Relevance of the research topic. The international competitiveness of enterprises represents a critical determinant in achieving and maintaining sustainable competitive positions in global and international markets. innovatively oriented industrial enterprises constitute a particularly strategic sector for national economic development, as they embody the transformation from knowledge and research into high-value products and services, thereby generating substantial added value and driving technological progress. This study proposes to investigate the theoretical foundations of international competitiveness of innovatively oriented industrial enterprises, including their distinctive characteristics, challenges, market opportunities, competitive landscape analysis, and strategic directions for ensuring and enhancing their international competitiveness in an increasingly dynamic global environment.

The issue of competitiveness has been extensively addressed in the works of such economists as I. Ansoff, L. L. Antonyuk, I. I. Beletska, V. V. Derhachova, J. Dunbar, A. L. Flehantova, O. A. Gavrysh, T. V. Hrynko, V. A. Ilyina, O. O. Khiznichenko, M. McDonald, L. S. Melnychuk, O. M. Momot, O. M. Palamarchuk, A. I. Piddubna, I. O. Piddubnyi, M. M. Poliarush, M. Porter, S. O. Radzievska, N. V. Reznikova, O. A. Shvydanenko, A. J. Strickland, A. A. Thompson, V. V. Zhvan, and S. M. Zinchyk, among others.

Scholars have comprehensively defined the concepts of “competitiveness”, “country competitiveness”, “enterprise competitiveness”, “product competitiveness”, and have identified numerous factors influencing competitiveness. However, contemporary academic literature lacks comprehensive recommendations for enhancing and ensuring the competitiveness level of innovatively oriented industrial enterprises operating in international markets. This gap is particularly significant given that innovation-driven enterprises are at the forefront of the Fourth Industrial Revolution and possess the potential to secure prominent positions among other high-technology sectors in the global economy. The distinctive nature of innovatively oriented industrial

enterprises – characterized by their reliance on research and development, rapid technological change, knowledge-intensive processes, and the need for continuous innovation – requires specialized approaches to competitiveness management that differ substantially from traditional industrial enterprises.

Furthermore, the accelerating pace of globalization, the emergence of disruptive technologies, increasing market volatility, and intensifying international competition create both unprecedented opportunities and formidable challenges for innovatively oriented industrial enterprises seeking to establish and maintain their competitive advantages internationally. The digital transformation of business processes, the growing importance of intellectual capital, changing consumer expectations, and evolving regulatory frameworks across different markets necessitate a comprehensive re-examination of competitiveness strategies specifically tailored to innovation-driven business models.

The aforementioned considerations constitute significant scientific interest within the framework of the chosen topic and determine the goals, objectives, and structure of this research, which aims to develop a holistic framework for ensuring the international competitiveness of innovatively oriented industrial enterprises in the contemporary global economic landscape.

Connection of the research with scientific programs, plans, and themes. This dissertation was completed in accordance with the research agenda of the Department of International Economics at the National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”, within the framework of the research project “Transformation of International Activities Based on Industry 4.0 / 5,0 and Circular Economy” (state registration number 0123U101154). Within this research project, the author developed and proposed theoretical, methodological, and practical recommendations for ensuring the international competitiveness of innovatively oriented industrial enterprises under conditions of digital transformation, Industry 4.0 / 5.0, and global market changes.

Research Aim and Objectives. The aim of the research is to develop theoretical foundations, substantiate scientific and methodological provisions, and formulate practical recommendations for ensuring and enhancing the international competitiveness of innovatively oriented industrial enterprises in the context of globalization, technological transformation, and dynamic market conditions.

Achievement of this aim is ensured through the resolution of the following theoretical and practical objectives:

– to clarify and refine the essence and conceptual framework of international competitiveness of enterprises, with particular emphasis on innovatively oriented industrial enterprises;

– to systematize and critically evaluate scientific and methodological approaches to assessing the level of enterprise competitiveness in conditions of global market dynamics and uncertainty;

– to develop theoretical and methodological provisions for ensuring the appropriate level of competitiveness of innovatively oriented industrial enterprises;

– to analyze the current state, trends, and development prospects of the IT market in China as representative contexts for innovation-oriented enterprise operations;

– to assess the level of competitiveness of innovatively oriented industrial enterprises based on an integrated approach that incorporates multiple dimensions of competitive performance;

– to identify and determine the reserves of competitive potential of innovatively oriented industrial enterprises in the context of global transformations and digital economy development;

– to develop a multivariate regression model for analyzing the international competitiveness of innovatively oriented industrial enterprises based on technological innovation factors;

– to substantiate the resource provision mechanisms for enhancing market adaptability of innovatively oriented industrial enterprises within the system of increasing their competitiveness;

– to propose strategic approaches for the integration of economic efforts of innovatively oriented industrial enterprises for the purpose of synergistic development of the competitive environment and achieving collaborative competitive advantages.

The object of the research is the processes of ensuring the international competitiveness of innovatively oriented industrial enterprises.

The subject of the research is the complex of theoretical aspects, methodological provisions, and practical recommendations for ensuring the international competitiveness of innovatively oriented industrial enterprises in the context of global market dynamics and uncertainty.

Research methods. General scientific methods employed in this research include abstraction, analysis, synthesis, systematization, generalization, and comparison. These methods are utilized throughout the entire research process regardless of the specific field of knowledge or particular characteristics of the study.

Among the specialized scientific methods selected for this research are Porter's Diamond of National Advantage model for analyzing competitive environment factors, expert evaluation methods for assessing competitiveness levels, SWOT analysis for identifying strengths, weaknesses, opportunities and threats of innovatively oriented industrial enterprises, cluster analysis for grouping countries and enterprises based on competitive characteristics, factor analysis for determining key drivers of competitiveness, correlation and regression analysis for establishing relationships between variables, multivariate regression modeling for analyzing the impact of technological innovation on international competitiveness, comparative analysis for benchmarking enterprise performance across different markets, and integrated assessment approaches for evaluating the overall competitive position of innovatively oriented industrial enterprises.

The information base of the research comprises scholarly works of domestic and foreign scientists on enterprise competitiveness, innovation management, and international business; materials from international scientific conferences and symposiums on competitiveness and innovation; legislative and regulatory acts

of Ukraine and China concerning innovation development and enterprise internationalization; official statistical materials and analytical reports from the State Statistics Service of Ukraine, the National Bureau of Statistics of China, the World Bank, the International Monetary Fund, the World Economic Forum, the World Intellectual Property Organization (WIPO), and the Organization for Economic Cooperation and Development (OECD); financial statements, accounting data, and corporate reports of innovatively oriented industrial enterprises operating in the IT sector and other high-technology industries in China and Ukraine; industry analytical reports and market research studies on IT markets and innovation-driven sectors; databases on international trade, foreign direct investment, research and development expenditures, patent activities, and technological innovation indicators; as well as case studies and empirical data on successful innovatively oriented industrial enterprises competing in global markets.

Artificial intelligence-assisted tools, including ChatGPT, Elicit, and Scite, were used to refine search queries, identify, classify, and structure relevant academic sources, examine citation relationships, and verify bibliographic data. All AI-assisted outputs were independently reviewed and verified by the author. The research design, empirical analysis, interpretation of results, conclusions, and scientific novelty were developed independently by the author.

Scientific novelty of the research results. The scientific novelty of the obtained results lies in the development of theoretical foundations, elaboration of methodological provisions, and scientific substantiation of practical aspects for ensuring the international competitiveness of innovatively oriented industrial enterprises in the context of rapid technological transformation, globalization, and the Fourth Industrial Revolution. The most significant results of the research of theoretical and applied nature that are submitted for defense are as follows:

Improved:

– a resource provision framework for innovatively oriented industrial enterprises across five interrelated dimensions: financial, technological, functional,

human, and information provision. Compared with general resource classifications, the framework links the identified resource gaps to market adaptability, innovation continuity, and international competitive positioning and differentiates recommendations according to enterprise size, innovation-cycle stage, and geopolitical exposure;

– an innovation linkage mechanism connecting the mobilization of measurable financial and operational reserves with sustained innovation investment and long-term international competitive positioning. Unlike general improvement recommendations, each measure is linked to a specific performance gap identified through the comparative assessment of the five sample enterprises;

– an econometric approach for quantifying the relationship between R&D intensity and the international competitiveness of innovatively oriented industrial enterprises, measured through export technology complexity. Compared with existing single-channel approaches, it employs a two-way fixed effects model using panel data from 7209 Chinese A-share listed manufacturing firms and combines mediation and moderation analysis. The results indicate that R&D intensity is positively associated with export technology complexity both directly and indirectly through ROA, while firm size negatively moderates this relationship;

– a comprehensive integrated method for determining the level of competitiveness of innovatively oriented industrial enterprises based on composite index methodology. Unlike existing approaches that focus on single dimensions, this method integrates multiple assessment criteria across four key dimensions: profitability, solvency, operational efficiency, and growth potential, and employs entropy weighting to derive objective dimension weights from data information content, enables systematic ranking and benchmarking of enterprises, and facilitates identification of competitive strengths and weaknesses across multiple dimensions;

– a methodological approach for evaluating and selecting integration strategies for innovatively oriented industrial enterprises. Compared with conventional integration analysis, the approach examines five pathways: vertical integration, horizontal

integration, strategic alliances and long-term contractual relationships, open innovation and digital ecosystem integration, and cross-border international integration.

Further developed:

– the theoretical understanding of international competitiveness through a refined definition of the international competitiveness of innovatively oriented industrial enterprises. Compared with existing definitions focused mainly on economic efficiency and production factors, it explicitly incorporates sustained R&D intensity, the technological complexity of exports, intellectual property accumulation, and the ability to convert innovation activity into financial performance as determinants of competitive advantage under technological transformation and market dynamism;

– the conceptual framework through refined interpretations of an innovatively oriented industrial enterprise, market adaptability, and resource provision. Such an enterprise is characterized by strategic innovation orientation, intensive R&D, an innovation-supportive culture, open innovation practices, adaptability, dynamic capabilities, intellectual property management, data-driven decision-making, and sustainability orientation. Market adaptability is interpreted as the dynamic capability to respond to volatility and technological change through continuous innovation and strategic resource reconfiguration, while resource provision is structured across financial, technological, functional, human, and information dimensions;

– the theoretical provisions for ensuring the international competitiveness of innovatively oriented industrial enterprises through the integration of the Resource-Based View, the Dynamic Capabilities Framework, and the Open Innovation Concept. The integrated framework explains how the strategic orchestration of resources, adaptive capabilities, and external knowledge within collaborative ecosystems contributes to sustainable international competitiveness.

Personal contribution of the author. The dissertation is an independently conducted scientific study. The theoretical and methodological foundations, scientific and practical recommendations, and conclusions formulated within the dissertation are the results of the candidate’s own research. The candidate’s personal contribution to the

co-authored scientific publications presenting the main research results is specified in the list of publications.

Practical significance of the research results. The practical significance of the obtained results is confirmed by their implementation in scientific, educational, and practical activities. The research results were incorporated into the scientific activities of the Department of International Economics of the Faculty of Management and Marketing at the National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”, particularly within the research project No. 0123U101154 “Transformation of International Activities Based on Industry 4.0/5.0 and Circular Economy” (Certificate No. 28.02/44/2026 dated May 12, 2026). Certain research results were also introduced into the educational process under the educational programme “International Economics” within the educational component “Competitiveness of International Business” (Certificate No. 28.02/45/2026 dated May 12, 2026). The proposed resource provision system, integration framework, and composite competitiveness assessment methodology were implemented in the activities of Hangzhou Ruifan Education Technology Co., Ltd. (Certificate dated December 31, 2025; implementation period: July 1–December 31, 2025). The recommendations for identifying and mobilizing competitive reserves by improving financial indicators, operational efficiency, capital structure, and innovation activity were taken into account in the strategic planning activities of LLC “ELFAPACK” (Certificate No. 07/01-04/26 dated April 7, 2026). Copies of the supporting documents are provided in Appendix A.

Approbation of the dissertation materials. The results of the dissertation were presented and discussed through participation in and publication of conference proceedings at the following international scientific and practical conferences: “Scientific Achievements of Contemporary Society” (London, UK, February 6–8, 2025), “Research in Science, Technology and Economics” (Luxembourg, August 6–8, 2025), “Science and Technology: New Horizons of Development” (Prague, Czech Republic, August 13–15, 2025), “Current Issues, Problems and Prospects for the Development of Science, Education, Technology and Society” (Boston, USA, February 10, 2026), and

“Research in Science, Technology and Economics” (Luxembourg, February 18–20, 2026).

Publications. The main scientific results of the dissertation have been published in 5 scientific professional publications of Ukraine, Category B, and 1 article in an international scientific journal. The approbation of the dissertation results is confirmed by 5 published conference papers in the proceedings of international scientific and practical conferences.

Structure and scope of the dissertation. The dissertation consists of an introduction, three chapters with their respective conclusions, and general conclusions. It includes 21 figures and 33 tables, a reference list containing 134 sources, and 3 appendices. The total volume of the dissertation is 214 pages, the main text of the dissertation comprises 159 pages.

CHAPTER 1
THEORETICAL FOUNDATIONS OF COMPETITIVENESS OF INNOVATIVELY ORIENTED ENTERPRISES

1.1 The essence and improvement of international competitiveness of enterprises

Innovation has been defined in a variety of ways across disciplines and contexts. The Oslo Manual, which is widely used as a reference for innovation research, defines innovation as "a new or improved product or process (or combination thereof) that is significantly different from the unit's previous products or processes and that is made available to potential users (product) or put into use by the unit (process)" [83]. Based on this definition, innovation-oriented firms can be broadly understood as organizations that prioritize innovation in their strategic orientation and operational practices. However, defining the specific characteristics and behaviors of such firms has been a subject of ongoing debate and refinement in academia.

Recent literature has attempted to provide a more nuanced definition of innovation orientation. For example, Nambisan et al. [79] define innovation orientation as "a strategic and behavioral guiding principle that commits an organization to innovation as a source of competitive advantage." They argue that innovation orientation includes not only the propensity to innovate but also the organizational systems, processes, and culture that support innovative activities. Innovation orientation includes three key dimensions: strategic intent for innovation, organizational support for innovation, and innovative behavior. This approach emphasizes the importance of aligning strategic goals, organizational resources, and employee actions to foster a genuine innovation orientation. innovatively oriented industrial enterprises are those that are able to continuously launch new products and services and continuously gain competitive advantages in market competition. innovatively oriented industrial enterprises usually have strong R&D capabilities, flexible management mechanisms and

open organizational cultures, and can respond quickly to market changes and adjust business strategies in a timely manner, thereby gaining advantages in fierce market competition.

Regarding the concept of international competitiveness, domestic and foreign research institutions and scholars have defined the concept of international competitiveness from different perspectives [48; 122]. For example, the US Presidential Commission Report on Industrial Competitiveness points out that "international competitiveness is the ability to provide good products and services in the international market while improving the living standards of the country's people under free and good market conditions" [91]. Balassa defines international competitiveness from the perspective of international trade as the share of a country's exports in the world's exports and its growth [12]. Dunning believes that international competitiveness is a systematic process in which economic entities exert their potential and form their advantages [31]. Professor Jin Bei of China pointed out that international competitiveness is the productivity of the same industry and enterprises in the same sector in various countries compared with each other [15]. The interpretation of the central concept of international competitiveness focuses on three levels: enterprises, industries and countries. For example, the World Economic Forum (WEF, 1985) defined international competitiveness from the perspective of micro-enterprises in its "Report on Competitiveness" as the ability of business owners to produce, sell goods and provide services at more attractive prices and quality than domestic and foreign competitors in their respective environments at present and in the future [126]. The China International Competitiveness Joint Research Group believes that the essence of international competitiveness is the ability of enterprises or entrepreneurs to engage in business activities in various environments successfully [25]. The International Institute for Management Development defines international competitiveness from the perspective of a macro-country as a country's ability to create added value by relying on its natural resource endowments in its unique economic and social structure or to focus on improving domestic economic environment conditions to attract foreign investment or

to rely on domestic internal economy and develop international economy to create and increase added value and increase a country’s wealth [52]. WEF (1996) supplemented the concept at the national level and defined it as a country's ability to achieve sustained and rapid growth in per capita GDP.

It is necessary at this point to clarify what is meant by innovatively oriented industrial enterprises and how their competitive position differs from that of ordinary firms. According to the Oslo Manual [83], innovation can be classified into four main types: product innovation, process innovation, organizational innovation, and marketing innovation. Beyond these categories, scholars further distinguish innovations by their degree of novelty. Incremental innovation refers to gradual refinement and continuous improvements to existing products or processes, while radical innovation involves fundamental changes that create new markets or substantially displace established ones [2]. Sufyan et al. [111] note that both types strengthen competitive position in dynamic markets, though radical innovation tends to generate more durable and harder-to-replicate advantages because it opens entirely new competitive space rather than improving within existing boundaries. Research based on 201 Chinese firms confirms that radical innovation has a greater impact on competitive advantage compared to incremental innovation, and that innovation speed mediates this relationship [68].

For ordinary enterprises, competitiveness rests primarily on cost efficiency, factor endowments, and the ability to execute within established market structures, with incremental process and product improvements being the dominant mode of innovation. Innovatively oriented industrial enterprises differ in that their competitive advantages are built around sustained R&D investment, the accumulation of intellectual property, and the capacity to generate both incremental and radical innovations as a strategic priority rather than an occasional response to competitive pressure. Acemoglu et al. [2] show that firms which are more open to disruption are significantly more likely to engage in radical innovation and sustain this engagement through organizational cultures and management structures designed to support it, whereas firms not of this type tend to remain confined to incremental improvements. This distinction matters for

how international competitiveness is understood and measured: for ordinary enterprises, market share and financial performance largely capture competitive strength, while for innovatively oriented industrial enterprises, the technological sophistication of products and the intensity of innovation activity are equally, if not more, important indicators of their standing in global markets.

In today's economic globalization and market internationalization era, international competition among enterprises is becoming increasingly fierce. The study of international competitiveness issues originated in the West and has received widespread attention from theoretical and academic circles. For innovative enterprises, international competitiveness is the core that determines their success or failure. In 1985, the World Economic Forum proposed in its "Report on Competitiveness" that the international competitiveness of enterprises is the ability and opportunity of enterprises to design, produce and sell goods and provide services at a more attractive price and quality than their domestic and foreign competitors in their respective environments at present and in the future [126]. This definition emphasizes that the international competitiveness of an enterprise is the ability of the enterprise to produce goods and services in domestic and foreign markets [99].

The international competitiveness of an enterprise is reflected by the price and quality of the goods and services produced by the enterprise. It emphasizes that the key factors affecting the international competitiveness of an enterprise are quality and price. In his famous book "The Competitive Advantage of Nations", Porter, a professor at Harvard University and an authority on strategic management and international competition theory, proposed that the international competitiveness of an enterprise refers to the ability of an enterprise to compete in the international market with a global strategic posture [86]. This definition emphasizes that enterprises should participate in international competition with a worldwide strategy and believes the strategy is the key to winning. Braja and Gemzik-Salwach [19] believes that the international competitiveness of an enterprise is a comparative concept used to measure the strength of each specific enterprise in international competition. The conditions and sources

of enterprise competitiveness involve factors in the internal and external environment.

External environment. The market structure school believes that market structure is essential in forming enterprise competitiveness. Porter's diamond model points out that the crucial factors include enterprise strategy, enterprise structure, demand conditions, factor conditions and related industries, and auxiliary factors include opportunities and government support.

Internal factors. An enterprise's knowledge, resources and capabilities play a key role in maintaining competitive advantage. The resources and capabilities of an enterprise are the foundation for implementing strategies and the basis for formulating and selecting strategies [53]. Resources and capabilities determine the strengths and weaknesses of an enterprise in competitive activities and impact the enterprise's competitiveness. Unique and valuable resources and capabilities are the basis for an enterprise's sustainable competitive advantage. The resources of an enterprise include tangible resources, intangible resources (technology, goodwill, culture), and human resources (professional skills and knowledge, the ability to communicate and influence each other, and motivation) [74]. Enterprise capability analysis includes R&D, production, marketing, financial, and organizational management capabilities [124].

As the founder of the absolute advantage school, the representative of British classical economics, Adam Smith established an economic system centered on laissez-faire in his book "An Inquiry into the Nature and Causes of the Wealth of Nations" (abbreviated as "The Wealth of Nations") published in 1776. On this basis, he proposed the international division of labour and free trade and established the "absolute cost theory" to promote international market competition, the absolute advantage theory. Based on the principle of minimizing production costs, he pointed out that if a company's production cost of a specific type of product is lower than that of its competitors and can obtain more excellent benefits through trade exchanges, then the company should focus on the production of such products to achieve optimal resource allocation, increase output, improve production efficiency and enhance market competitiveness. The theory includes the following points: First, specialized production

helps to improve the labour productivity of enterprises; second, the competition principle of enterprises is based on the absolute advantage or absolute benefit; third, the international competitiveness of enterprises can rely on favourable conditions in technology, resources or management [40].

David Ricardo, another representative of classical economics, proposed the "relative cost theory", or the principle of comparative advantage, in 1817. Based on the theory of absolute advantage, he made up for its limitation of being limited to absolute cost advantage and further pointed out that in international market competition, even if an enterprise is at a disadvantage in all areas, as long as it can focus on areas where its relative disadvantage is more minor, it can still gain competitive advantage in the international market. He believes that as long as there are relative differences in production costs between different enterprises (i.e., comparative cost differences), enterprises can play their advantages in international competition through reasonable resource allocation and market positioning. For example, a company can focus on producing products with minor relative competitive disadvantages and gain market benefits through exports. In contrast, importing products with more considerable relative competitive disadvantages improves overall market competitiveness. In addition, the relative competitiveness of an enterprise can also be measured through indicators such as labour productivity, product pricing, supply chain management, and brand influence [129]. The proposal of this theory not only laid the foundation for the theory of international market competition but also revealed the basic operating principles of enterprises in global market competition; that is, regardless of the size of the enterprise or the strength of its economy, it can find its competitive positioning in the international market and gain competitive benefits by exerting its relative advantages.

Swedish economists Albert Heckscher and Bertil Ohlin proposed the factor endowment theory, also known as the Heckscher-Ohlin (H-O) theory, in 1933. They pointed out that because countries have different degrees of factor resource endowments, their factor prices will be differentiated, leading to differences in production costs, product prices, and production efficiency. Therefore, a country should focus on

producing and exporting products with relatively abundant factor resources and specialize in importing products with relatively scarce factor resources to gain comparative advantages in international trade and division of labour [56].

The above theory expands the idea of comparative advantage. It explains from the perspective of the relative endowment of production factors why some countries still have comparative advantages in producing certain products under the same technological level, that is, they have more abundant resources for making such products than other countries, such as land, labour, capital, knowledge, and technology. For example, countries with abundant labour resources can gain comparative advantages by exporting labour-intensive products compared with other countries, countries with abundant capital can gain comparative advantages by exporting capital-intensive products, and countries with advanced technology can gain comparative advantages by exporting technology-intensive products.

Since the beginning of the study of international competitiveness in the field of the international division of labour and trade, Western scholars have gradually explored the research proposition of international competitiveness on this basis and truly put forward the concept of international competitiveness in the 1980s, and studied it from the perspective of the source of competitive advantage for the first time. The most representative is the theory of national competitive advantage proposed by Professor Michael Porter in the early 1990s. He created a unique international competitiveness analysis method from the enterprise level, which provides an analytical framework for comprehensive and correct analysis of the international competitiveness of enterprises.

However, because the theory of comparative advantage studies the international competitiveness of enterprises from the perspective of international trade, and the theory of core competitiveness focuses on finding the source of international competitiveness from within the enterprise, the theory of national competitive advantage proposed by Professor Michael Porter of Harvard Business School in the United States truly explores the source of competitiveness. It applies to the study of international competitiveness at the enterprise level. At the same time, the two-factor model proposed by World Bank

expert Garelli and the causal relationship model constructed by Chinese scholar Jin Bei and others comprehensively analyzed the components and sources of competitiveness and explained the formation mechanism and action mode of competitiveness [15; 40]. They are of great significance to the research on the sources and influencing factors of the international competitiveness of enterprises. At the same time, they also provide essential theoretical reference and practical guidance for enterprises to enhance their international competitiveness.

Porter's competitive advantage theory provides a systematic analytical framework and practical guidance for enterprises to enhance their international competitiveness. He believes that a single factor does not determine the competitive advantage of an enterprise but is jointly shaped by multiple interacting factors. Porter believes that the factors affecting the competitiveness of a particular enterprise in a country include production factors, demand conditions, related industries and corporate strategies, structures and peer competition [43].

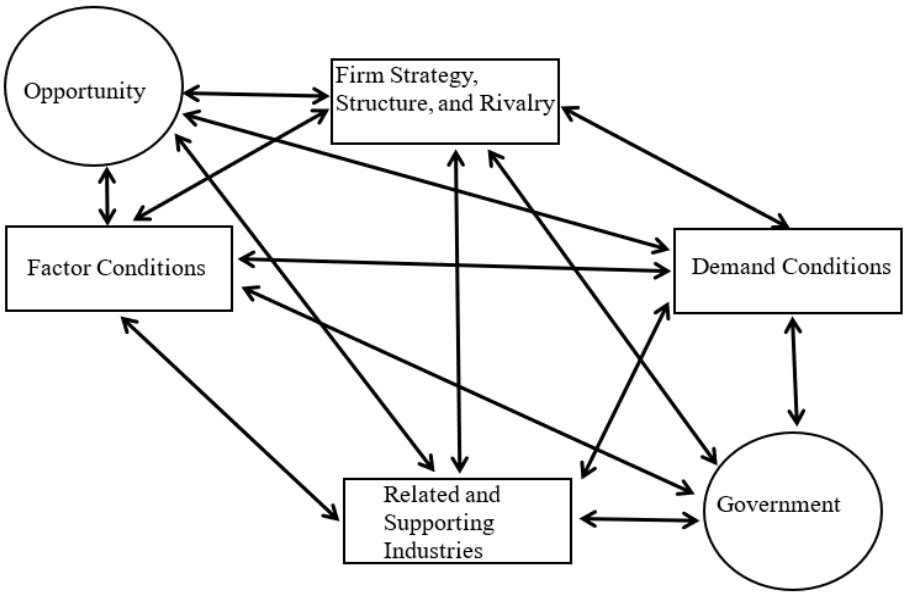

Figure 1.1 – The Diamond Model [42]

Regarding the relationship between the national environment and corporate competitiveness, there are two variables: "opportunity" and "government". They constitute the famous "Diamond model" (Figure 1.1). This theory emphasizes that enterprises must continuously optimize resource allocation, promote innovation,

strengthen industrial synergy, and adjust development strategies according to market demand in a dynamic competitive environment to maintain long-term competitive advantages in the international market [59].

Production factors. Refer to the various factors used to produce a product, including natural, capital, infrastructure, human, and technological resources. Compared with primary production factors, the competition for advanced production factors such as talent and knowledge will intensify. In addition, unfavorable production factors, i.e. disadvantages, can often effectively stimulate some companies to continue to innovate.

Demand conditions. This refers to the demand status and degree of a country's market for products or services a specific industry produces. It is the driving force for the company to sprint. From the perspective of competitive advantage theory, the characteristics of a country's market consumption demand will directly affect the country's competitive advantage in the international market, and picky consumers will help companies maintain or even create advantages.

Related industries and supporting industries. This refers to the general term for related sectors closely linked to a particular industry and can promote the company's industrial upgrading and development through interactive exchanges between horizontal and vertical directions. Whether they are internationally competitive will also be related to the company's competitiveness level because there is a network of resource factors and an inseparable industrial chain between them.

Enterprise strategy, structure, and peer competition. The business strategy, organizational structure characteristics of the enterprise, the overall strength of competitors, and the domestic market competition structure and nature belong to the category of enterprise elements. Whether there is fierce competition between the subjects participating in the competition for elements will primarily affect the maintenance and improvement of the overall competitive advantage of the enterprise.

Opportunity. Refers to sudden or uncontrollable events beyond the enterprise's expectations. They can achieve the destruction and reorganization of the original

competitive order and competitive environment, create new competitive space for countries with weak competitiveness, or make the advantages of the original countries disappear. All enterprises that occupy space for new demand growth generally could create competitive advantages.

Government. It cannot create competitive advantages for enterprises by itself. Still, it acts on other elements in the model through administrative, economic, legal, and policy means, thereby affecting the competitiveness of enterprises and seeking a balance between laissez-faire and intervention.

World Bank expert Garelli proposed a two-factor model when studying national competitiveness [40]. Garelli argues that a country's international competitiveness is shaped by two interrelated sets of factors: external macro-environmental conditions and internal firm-level factors. Rather than operating independently, these two sets of factors form a complementary whole, jointly driving the formation and sustained improvement of competitive capacity. Regarding external macro-environmental factors, Garelli identifies five key dimensions that collectively support a country's international competitiveness from outside the firm.

Overall system vitality. This refers to a country's capacity for economic growth and its aggregate economic strength, reflected in the short-, medium-, and long-term growth trajectories of the national economy, as well as trends in total social investment.

Financial system vitality. This refers to a country's ability to mobilize and allocate capital effectively, encompassing fiscal growth capacity, public debt management, foreign exchange reserves, and the operational functioning of the banking system with respect to interest rates and credit provision.

Market system vitality. This refers to the dynamism of key market actors, including government bodies, industries, and enterprises. It specifically encompasses the degree and nature of government intervention in the market, economic openness, average technological capability, industrial output capacity, and enterprise-level performance indicators such as overall scale, strategic focus, profitability, and social contribution.

Infrastructure status. Refers to the configuration of auxiliary facilities closely related to economic activities in a country. Specifically, it includes the country's transportation systems such as railways, roads, bridges, pipelines, information and communication, energy networks and other physical infrastructure, risk-taking institutions, technology innovation and diffusion institutions, human resources development and education institutions, import and export encouragement institutions and other economic organizations infrastructure, as well as natural resource conditions and the stability of social and political systems and other essential elements that promote economic development.

Human resources status. Referring to the overall development of a country's national quality. It includes explicitly national health status, intellectual quality, education level and adaptability. On the other hand, forming a country's international competitiveness is also inseparable from the influence of micro factors, that is, internally related factors at the enterprise level. They can be divided into two categories: enterprise production efficiency and enterprise internal production service factors. They are internal factors and direct causes that determine the strength of a country's international competitiveness.

The overall efficiency of the enterprise's production system. This includes the enterprise's production organization mode, internal structure, labor productivity, and management system level.

Enterprise internal production service factors. This includes product design and R&D capabilities, product quality control level, employee vocational training, market development capabilities, and information processing efficiency.

The causal relationship model proposed by Jin Bei and other scholars from the Institute of Industrial Economics of the Chinese Academy of Social Sciences provides theoretical support and practical guidance for enterprises to enhance their international competitiveness [15]. The model emphasizes that the global competitiveness of enterprises depends not only on their resources and capabilities but also on various

internal and external factors, including market environment, technological progress, enterprise policies, supply and demand relations, etc. (Figure 1.2).

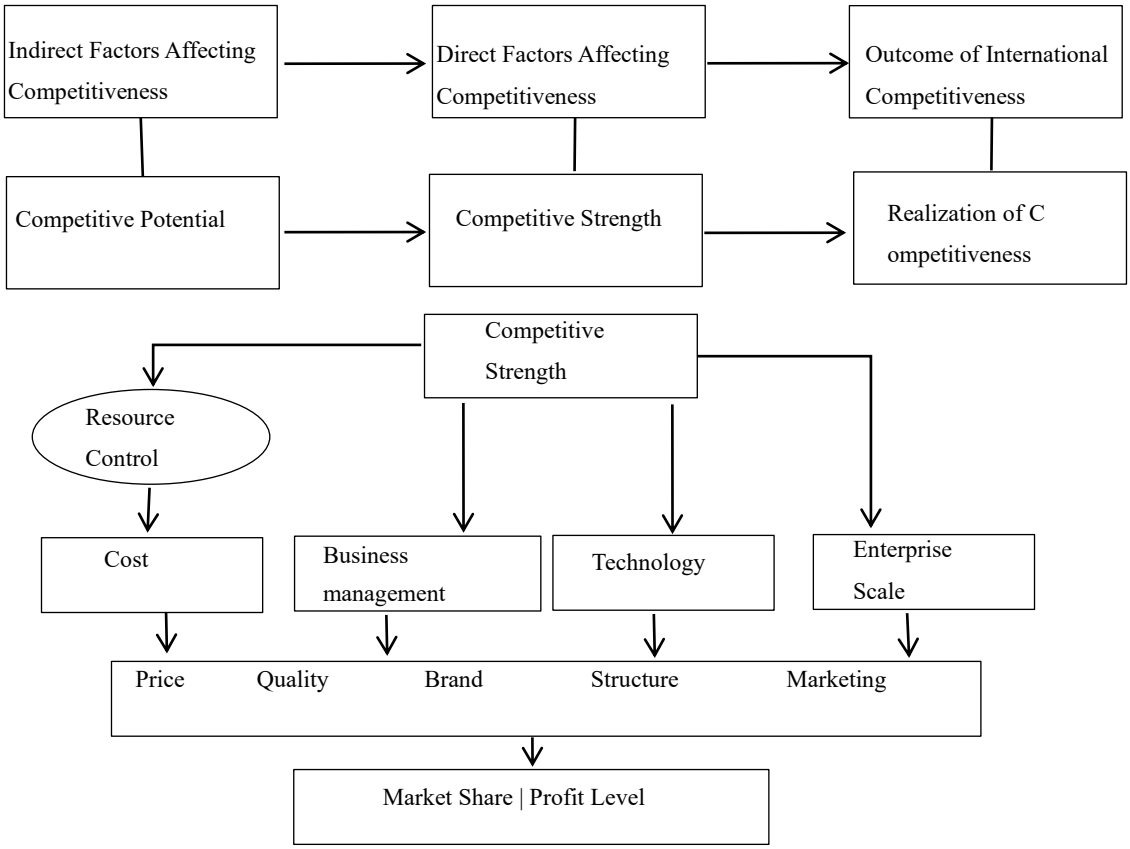

Figure 1.2 – Jin Bei's Causal Relationship Model

Source: *represented based on [15]*

Through the causal analysis framework, enterprises can systematically identify the key factors that affect their competitiveness, find the source of competitive advantage, and optimize resource allocation and strategic layout. This theory provides an effective idea and reference for enterprises to improve their competitiveness, enhance their market adaptability and build long-term competitive advantage in a complex international market environment.

From the results, the market share of a product in a country is a realistic manifestation of the international competitiveness of the country's enterprises. The larger the market share and the more profit, the stronger its competitiveness. Specifically, the two visible indicators of market share and profit level can be used to reflect the degree of realization of competitiveness; that is, the higher the market share of the product, the stronger the long-term profitability of the enterprise, and the stronger

the international competitiveness of the enterprise.

From the cause, Jin Bei believes that all factors that can make enterprises profitable and occupy as much market share as possible are the objects of competitiveness research. They can be further divided into two categories: direct factors and indirect factors. Among them, direct factors include product quality, cost, price, variety, structure, brand and marketing, etc., and indirect factors include enterprise scale, operation management, technical level, etc.

Table 1.1 – Comparative overview of theoretical approaches to international Competitiveness

Scholar / Theory	Level of Analysis	Core Argument	Key Competitive Factor
Smith (1776) Absolute Advantage	Enterprise Country	Firms should specialise where they hold an absolute cost advantage	Production cost efficiency
Ricardo (1817) Comparative Advantage	Country / Enterprise	Even disadvantaged firms can compete with relatives specialization	Relative cost differences
Heckscher-Ohlin (1933) Factor Endowment	Country	Competitive advantage derives from relative factor abundance	Natural, capital, and labour endowments
Vernon (1966) Product Life Cycle	Enterprise Country	Competitive advantage shifts dynamically as products mature across stages	Technology intensity and labour cost at each cycle stage
Porter (1990) Diamond Model	Country / Enterprise	Competitiveness is shaped by six interacting national and firm-level determinants	National environment, firm strategy, demand conditions, related industries
Garelli Two-Factor Model	Country / Enterprise	Competitiveness is jointly shaped by external macro-environmental and internal firm-level factors	Financial system, market vitality, infrastructure, firm production efficiency
Jin Bei Causal Relationship Model	Enterprise	Competitiveness results from the interaction of competitive potential and competitive strength	Product quality, cost, brand, scale, and management capability

Source: Completed by the author based on [15; 40; 84; 86; 96; 107; 120]

They indicate why a certain product of a country is or is not competitive and also affect the competitive strength and competitive potential of enterprises, respectively. Through mutual interaction, they ultimately promote the realization of competitiveness, which is reflected in intuitive competitive results such as market share.

The causal relationship model briefly summarizes the formation mechanism of competitiveness; that is, the formation of competitiveness is achieved through the joint action of competitive potential and competitive strength. At the same time, the results of competition will, in turn, affect competitive potential such as capital, enterprise scale, and management, as well as competitive strength such as product quality, price, and structure, thereby promoting a new round of corporate international competitiveness.

The theoretical frameworks reviewed above approach international competitiveness from distinct but partially overlapping perspectives. Table 1.1 summarizes the key similarities and differences across these scholarly approaches in terms of their level of analysis, core argument, and primary competitive factors.

The analysis of existing definitions and theoretical frameworks reviewed above reveals that scholars approach international competitiveness from several overlapping but distinct angles: factor endowment and trade advantage (Smith, Ricardo, Heckscher-Ohlin), dynamic product cycles (Vernon), multi-determinant national systems (Porter), macro-micro factor interaction (Garelli), and causal chains between competitive potential and market outcomes (Jin Bei). While each of these frameworks contributes meaningfully to understanding how enterprises compete internationally, a careful reading of the literature points to a shared limitation: the majority of these theories were developed with reference to relatively stable industrial structures and resource-driven competitive conditions, and do not fully account for the specific dynamics of enterprises whose competitive position is built primarily on sustained innovation activity. As Sangari et al. [99] note in a systematic review of 40 studies on innovation strategy and firm competitiveness, existing frameworks largely treat innovation as one among several competitiveness factors rather than as the central organizing principle of competitive advantage. In a similar vein, Porter's Diamond Model, while analytically

comprehensive, has been noted for its limited applicability to sectors where competitive advantage depends less on inherited national factor conditions and more on the firm's internal capacity to generate new knowledge, develop intellectual property, and commercialize technological advances ahead of rivals.

Agreeing with the view that all the frameworks above capture important dimensions of competitiveness, it should be noted, however, that their explanatory power varies considerably depending on the type of enterprise under analysis. For innovatively oriented industrial enterprises, the mechanism linking competitive inputs to market outcomes operates differently than it does for conventional firms. Traditional competitiveness models typically measure outcomes through market share and profitability, which are lagging indicators that do not capture the upstream innovation activity responsible for generating future competitive strength. Recent research confirms that for technology-intensive firms, the technological sophistication of exported products – reflecting the knowledge content and novelty of what firms bring to international markets – is a more informative measure of competitive position than price or volume alone [43].

In view of the above analysis of existing theoretical approaches and the specific characteristics of innovatively oriented industrial enterprises operating in technology-intensive markets, it is appropriate to clarify how the concept of international competitiveness is understood in the context of this study. In our view, the international competitiveness of innovatively oriented industrial enterprises should be defined as the ability of an enterprise to maintain and strengthen its position in global markets through sustained investment in research and development, the continuous upgrading of the technological sophistication of its products and processes, and the effective conversion of innovation activity into financial performance – under conditions of both favourable and adverse external influence, including technological disruption, shifting demand, and intensifying global rivalry. The definition offered here differs from existing ones in that it is more specific to the nature of innovation-driven competition: it treats R&D intensity and technological output quality as primary sources of competitive advantage

rather than as secondary supporting factors, and it reflects the dynamic, path-dependent character of how such enterprises build and renew their competitive positions over time.

1.2 Scientific and methodological approaches to assessing the level of competitiveness of enterprises

To date, there are dozens of competitiveness evaluation methods and techniques. When discussing the classification of existing methods, it should be noted that economists have proposed many methods for evaluating the level of corporate competitiveness. The corresponding methods are further classified according to theoretical content, the presentation form of evaluation results, and the mathematical correlation form of indicators.

A scientific evaluation index system must be established to evaluate corporate competitiveness consistently [119]. Therefore, it is necessary to decompose corporate competitiveness into different components according to the system idea, evaluate the components of competitiveness separately, and then evaluate the entire competitiveness system. He proposed an enterprise competitiveness index system by integrating domestic and foreign competitiveness evaluation academic theories, combining many research results on enterprise competitiveness evaluation by experts from relevant institutions and departments, and drawing on the division of enterprise competitiveness evaluation elements.

The main task of researchers studying the issue of enterprise competitiveness evaluation is to determine the standards, sources and factors of competitiveness. By analyzing the economic literature on this topic, we can find several ways to solve this problem. Next, we analyze the main known enterprise competitiveness evaluation methods and summarize the advantages and disadvantages of various methods.

Analytic Hierarchy Process. The analytic hierarchy process was developed by Thomas L. Saaty in the 1970s and is a structured technique for organizing and analyzing

complex decisions [98]. AHP has been widely used in various fields that require multi-criteria decision-making, including enterprise competitiveness evaluation. Enterprise competition in a market economy involves many factors. The competitiveness of an enterprise depends not only on the competitiveness of its products, but also on its organizational structure, financial strength, market position, technical capabilities and many other factors [121]. When people conduct systematic analysis of core issues in the social, economic and scientific management fields, they often face a complex system composed of many interrelated and mutually constrained factors that often lack quantitative data. The AHP is a simple method for making decisions on relatively complex and relatively ambiguous problems. It is particularly suitable for those problems that are difficult to fully quantify and analyze. It provides a new, concise and practical modeling method for decision-making and sorting of such problems. The competitiveness of an enterprise depends not only on the competitiveness of its products, but also on its organizational structure, financial strength, market position, technological capabilities and many other factors.

The AHP is based on the judgment that enterprise competitiveness assessment can be carried out by evaluating multiple criteria and sub-criteria organized in a hierarchical structure. By using paired comparison criteria, the AHP can determine the relative importance of each factor to the overall competitiveness. To determine the competitiveness of an enterprise using the AHP, various indicators are needed to reflect the company's performance in multiple dimensions. Implementing the AHP to assess enterprise competitiveness usually requires structuring the problem into a hierarchy. For enterprise competitiveness, the hierarchy usually consists of the overall goal (enterprise competitiveness) at the top level, followed by the main criteria (such as financial performance, market position, operational efficiency), sub-criteria (specific indicators under each main criterion) and the alternatives (compared enterprises) at the bottom level.

Once the hierarchy is established, the elements of each level are compared in pairs with the elements of the previous level according to their importance. The comparison

uses a basic scale of absolute numbers (usually 1-9), where 1 represents equal importance and 9 represents extremely important. For each set of comparisons, a matrix A is formed:

$$A=[a_{ij}]_{n\times n}, \tag{1.1}$$

where a_{ij} represents the importance of the i-th element compared to the j-th element, and $a_{ji}=\frac{1}{a_{ij}}$

The priority vector (weights) is calculated by finding the eigenvector w corresponding to the maximum eigenvalue λmax of of matrix A:

$$Aw=\lambda_{max}w. \tag{1.2}$$

To ensure the reliability of the judgments, a consistency check is performed by calculating the Consistency Index (CI) and Consistency Ratio (CR):

$$CI=\frac{\lambda_{max}\text{-}n}{n\text{-}1}; \tag{1.3}$$

$$CR=\frac{CI}{RI}\ , \tag{1.4}$$

where RI is the Random Index (the average CI of randomly generated pairwise comparison matrices).

If CR $\leqslant$ 0,10, the inconsistency is acceptable, otherwise, the judgments should be revised.

The final step involves synthesizing the priorities to obtain the overall competitiveness score for each enterprise:

$$C_i = \sum_j w_j \times p_{ij}\ , \tag{1.5}$$

where C_i represents the competitiveness score of the i-th enterprise; w_j denotes the weight of the j-th criterion; and p_{ij} represents the performance of the i-th enterprise on the j-th criterion.

The practical application of AHP in assessing enterprise competitiveness requires the identification of appropriate criteria and sub-criteria. Based on extensive research, a comprehensive system of criteria usually includes financial performance (profitability, liquidity, leverage and activity ratio), market position (market share, brand recognition, customer loyalty), operational efficiency (productivity, cost structure, quality management), innovation capability (R&D investment, new product development) and organizational strength (leadership quality, employee skills, organizational culture). The selection of specific indicators in each criterion should be tailored to the industry context and the strategic focus of the enterprise being assessed. For example, operational efficiency may have a higher weight when assessing the competitiveness of manufacturing enterprises, while for service companies, organizational strength and market position may be more critical.

Once the criteria and sub-criteria are determined, expert opinions are collected through structured questionnaires or interviews for pairwise comparisons. These comparisons are then processed using the mathematical procedures described earlier to derive the final competitiveness score.

AHP has been very successful in gaining recognition from practitioners, probably due to its advantages in the presentation of hierarchical questions and the appeal of pairwise comparisons in preference elicitation. Its wide range of practical applications covers areas such as resource allocation, strategic planning and project risk management, which are also crucial in the assessment of enterprise international competitiveness. For example, Ramanathan [93] proposed AHP to address the multi-criteria and multi-stakeholder needs in environmental impact assessment (EIA). In corporate competitiveness analysis, AHP can be used to measure the relative importance of multiple dimensions such as market share, technological innovation, supply chain management, brand influence, and financial performance. In addition,

Chatzinikolaou et al. [21] used AHP technology to reveal citizens' preferences for different goals of the European Common Agricultural Policy (CAP). This method can also be applied to corporate strategic choices to help decision makers weigh the impact of different strategic directions (such as cost leadership, differentiation, market expansion, etc.) on corporate competitiveness. As a multi-criteria decision analysis (MCA) method, AHP can systematically decompose and present key competitiveness factors in corporate competitiveness assessment and be used in the evaluation stage of policy or strategic choices. Enterprises can also use AHP to compare the competitiveness impact of different market strategies, technology investments, or supply chain optimization solutions, and then develop the optimal development path to maintain their advantages in international market competition.

Compared with other multi-criteria methods, the advantages of AHP lie in its flexibility, intuitive appeal to decision makers, and ability to check inconsistencies [93]. This characteristic is particularly important in the evaluation of corporate competitiveness, because companies need to weigh multiple factors in a complex market environment, such as technological innovation capabilities, market share, supply chain management, brand influence, and financial performance. AHP enables companies to clearly identify the importance of each competitiveness factor and optimize resource allocation to improve market competitiveness through paired comparison.

AHP has a unique advantage that can help enterprises simulate uncertainty and risk situations because it can derive scales that usually do not exist. This ability is particularly critical in the assessment of the international competitiveness of enterprises. Enterprises can use AHP to predict market changes, evaluate potential threats from competitors, and develop flexible response strategies to maintain long-term competitive advantages in the competitive global market.

However, the main disadvantage of AHP is that it has a very limited understanding of the strengths and weaknesses of enterprise operations, because the competitiveness of enterprises is presented as a complex comprehensive indicator and

does not involve many specific aspects of enterprise activities. After all, enterprise competitiveness reflects the efficiency level of economic activities, not just comparative rankings. It is not accidental that economic practice is full of examples of economic entities failing despite having high AHP scores. The reason lies in the fundamental contradiction between the theoretical model and the complex reality of enterprise competitiveness.

Alongside multicriteria evaluation, forecasting tools based on trend functions can be used to assess prospective changes in enterprises' competitive positions under conditions of economic globalization [35].

Factor analysis method. Among the enterprise competitiveness evaluation methods, factor analysis is a commonly used quantitative evaluation method with high objectivity and operability, which can evaluate the competitiveness of enterprises more comprehensively. Different scholars have conducted in-depth discussions on the application value of factor analysis and verified its effectiveness in research in different fields. Jurczak Jolanta and Jurczak Grzegorz [58] pointed out that factor analysis technology has great potential and can be used as an effective tool to reduce the complexity of observed phenomena or verify the accuracy of theoretical models. The study showed that factor analysis has great potential in solving various problems in corporate management. Tyukhtenko et al. [119] pointed out that factor analysis is suitable for situations with complex correlations, large sample sizes, many influencing factors, and many selected indicators; it can study a variety of topics; and it can better apply multivariate statistical methods to corporate competitiveness evaluation.

Factor analysis can objectively and comprehensively reflect an enterprise's financial status, operating results, cash flow and development capabilities [58; 119]. Its results support the identification of strengths and weaknesses and the formulation of development strategies [58; 119].

Factor analysis mainly includes five steps: data collection, factor extraction, factor rotation, factor score calculation and result interpretation. Data collection is the basis of factor analysis. Researchers need to collect relevant indicator data of enterprises,

including but not limited to enterprise scale, financial status, technological innovation capabilities, market share, etc. Result interpretation is the last step of factor analysis. In the result interpretation, researchers need to interpret the results of factor analysis and combine them with the actual situation to obtain a comprehensive evaluation of enterprise competitiveness. By interpreting the results of factor analysis, researchers can understand the advantages and disadvantages of enterprises in different ways and provide a reference for improving competitiveness.

As a multivariate statistical analysis technique, factor analysis plays an important role in the evaluation of enterprise competitiveness. First, this method can effectively reduce the data dimension and integrate multiple related variables into a few common factors, thereby reducing redundant information and improving the efficiency of data analysis. Secondly, factor analysis can objectively identify the core influencing factors of enterprise competitiveness, avoid the one-sidedness brought by single indicator evaluation, and make the evaluation results more scientific and comprehensive. In addition, this method can process a large amount of sample data and is suitable for competitive evaluation problems with many variables and complex influencing factors, thereby providing more guiding decision-making basis for enterprise managers.

However, factor analysis also has certain limitations when applied to the evaluation of corporate competitiveness. First, this method relies on the quality and rationality of sample data. If the variables are not properly selected or there are multicollinearity problems in the data, the accuracy of the analysis results may be affected. Secondly, factor analysis relies on subjective judgment, such as the determination of the number of factors and the selection of factor rotation methods, which may lead different researchers to draw different conclusions on the same data set. In addition, this method is mainly used for variable dimension reduction and data structure exploration, and it is difficult to directly establish causal relationships. Therefore, in the process of competitiveness evaluation, if other analysis methods (such as regression analysis, structural equation model, etc.) are not combined, it may affect the explanatory power and application value of the conclusions.

Overall, factor analysis has strong applicability and data processing capabilities in the evaluation of corporate competitiveness, but its limitations also require researchers to fully consider data quality, reasonably select variables, and combine other analysis methods when applying it to improve the scientific and reliability of the evaluation results.

SWOT analysis method. As a scientific management analysis method, SWOT analysis has been favored by many management companies since its inception. SWOT analysis provides companies with a comprehensive framework to evaluate their competitive position by examining internal and external factors of the company. The SWOT analysis method has a relatively fixed method of use, and the results are mainly expressed by arranging the analysis contents one by one in the matrix. In the matrix, multiple factors are intertwined, and with the help of the researcher's careful analysis, the development status under the joint action of multiple factors can be obtained. This conclusion helps enterprises to take corresponding countermeasures against development bottlenecks in the process of operation and development, thereby having a certain impact on future decisions. The SWOT analysis method is based on the environment in which the research object is located, comprehensively evaluates the research objectives, and then formulates specific and feasible strategies for the evaluation results. The SWOT analysis method specifically includes four factors: strengths, weaknesses, opportunities and threats. This method was developed by K. Andrews at the same time as the BCG matrix appeared and is the product of the development of the strategic planning school.

The indicators for measuring the competitiveness of an enterprise using the SWOT analysis method are usually determined by analyzing the balance between positive and negative factors in the internal and external environment of the enterprise:

The SWOT matrix can be expressed in the following form:

$$\begin{pmatrix} S_1, S_2, \dots, S_n & W_1, W_2, \dots, W_m \\ O_1, O_2, \dots, O_k & T_1, T_2, \dots, T_l \end{pmatrix}, \tag{1.6}$$

where:

$S_1, S_2, \ldots, S_n$ are the identified strengths.

$W_1, W_2, \ldots, W_m$ are the identified weaknesses.

$O_1, O_2, \ldots, O_k$ are the identified opportunities.

$T_1, T_2, \ldots, T_l$ are the identified threats.

In some advanced applications of SWOT analysis, each factor is assigned a weight and rating to reflect its relative importance and severity. This allows for a more quantitative assessment of the enterprise's competitive position:

$$K = \sum_{i=1}^{n} w_i \cdot r_i - \sum_{j=1}^{m} w_j \cdot r_j + \sum_{k=1}^{p} w_k \cdot r_k - \sum_{l=1}^{q} w_l \cdot r_l \quad , \tag{1.7}$$

where w_i, w_j, w_k, w_l are the weights of each factor; r_i, r_j, r_k, r_l are the ratings of each factor.

The scope of application of SWOT analysis is very wide, and it is mainly used in the following scenarios and fields. Overall, the SWOT analysis method has a high applicability in the evaluation of corporate competitiveness, but it needs to be combined with quantitative analysis and other strategic tools to improve its scientificity and decision-making guidance value.

Comprehensive Index Method. The Composite Index method is a multi-dimensional evaluation method that combines multiple indicators into a single index value, reflecting the overall performance of an evaluated object. The core idea of this method is to select a set of relevant indicators representing different aspects of the evaluated object, standardize the data to eliminate dimensional differences, assign appropriate weights to the indicators, and then compute the composite index by weighted summation. This method is widely used in enterprise competitiveness, regional development, and socio-economic level evaluations, among other fields.

The selection of indicators should follow scientific principles, avoiding redundancy and ensuring the independence and complementarity of indicators. Techniques such as correlation coefficient matrix analysis are often used to eliminate highly correlated

indicators, while principal component analysis (PCA) and factor analysis (FA) are employed for dimensionality reduction. These techniques help simplify the structure of the indicator system and improve the stability and interpretability of the composite index. Furthermore, expert consultation methods, such as the Delphi method, play an essential role in indicator selection and weight distribution, helping to reach consensus and enhancing the authority and practicality of the evaluation system.

Standardizing the data is an indispensable step in the composite index method. Due to the diverse magnitude and units of the evaluation indicators, direct summation would distort the results. The common standardization methods include range normalization and Z-score standardization. For example, range normalization is used to map the indicator values to the range [0,1], with the calculation formula:

$$x_{ij}=\frac{x_{ij}-x_j^{min}}{x_j^{max}-x_j^{min}}\ , \tag{1.8}$$

where x_{ij} represents the raw value of the j-th indicator for the i-th evaluated object, and x_j^{min} and x_j^{max} represent the minimum and maximum values of the j-th indicator. This method is simple and intuitive, suitable for indicators of similar nature with no extreme values. Z-score standardization, on the other hand, is based on the mean and standard deviation, with the calculation formula:

$$Z_{ij}=\frac{x_{ij}-\overline{x_j}}{s_j}\ , \tag{1.9}$$

where $\overline{x_j}$ and s_j are the mean and standard deviation of the j-th indicator. Z-score standardization is suitable for indicators that follow a normal distribution and when the focus is on highlighting extreme values. By standardizing the data, the indicators are unified into a common dimension, laying the foundation for subsequent weighting and aggregation.

Weight assignment is a critical step in the composite index method, determining

the contribution of each indicator to the overall evaluation result. Weight distribution methods are generally divided into subjective weighting, objective weighting, and hybrid weighting. Subjective weighting relies on expert judgment, with the Analytic Hierarchy Process (AHP) commonly used for weight determination. AHP constructs a judgment matrix and hierarchical structure, performing pairwise comparisons of indicators to calculate the weight vector. This method allows for reflecting strategic priorities and industry characteristics but may introduce subjective bias. Objective weighting methods, such as entropy weighting, calculate weights based on the data's information entropy, reflecting the degree of differentiation of the indicators, with high objectivity, though ignoring strategic intent. Hybrid weighting combines both methods, considering both data characteristics and expert judgment, improving the rationality and scientific nature of the weight distribution.

The basic steps for entropy weighting are as follows: first, normalize the indicator data and calculate the ratio of each value for the j-th indicator:

$$p_{ij}=\frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad . \tag{1.10}$$

Then, calculate the information entropy for the j-th indicator:

$$e_j=-k\sum_{i=1}^{m} p_{ij}\ln(p_{ij}),\ k=\frac{1}{\ln m} \quad . \tag{1.11}$$

The information utility value is then calculated as:

$$d_j=1-e_j \quad . \tag{1.12}$$

Finally, the weight is calculated as:

$$w_j=\frac{d_j}{\sum_{j=1}^{n} d_j} \quad , \tag{1.13}$$

where *d* is the number of evaluation objects and *n* is the number of indicators.

Entropy weighting assigns higher weights to indicators with greater variability, improving the discriminative power of the composite index. The final composite index is computed by weighted summation, with the formula:

$$S_i = \sum_{j=1}^{n} w_j x_{ij} \quad , \tag{1.14}$$

where S_i represents the composite index value for the i-th evaluation object, x_{ij} is the standardized value of the j-th indicator, and w_j is the weight of the j-th indicator. The higher the composite index, the better the overall performance of the evaluated object. Based on the composite index, the evaluation objects can be ranked, classified, or grouped, supporting management decision-making and policy formulation.

The composite index method offers several advantages: it integrates multiple dimensions into a single index, making the results more interpretable and actionable; it is flexible and can be tailored to different contexts and objectives; and it is computationally efficient, making it suitable for large-scale evaluations. However, the method also has limitations. The weighted summation assumes independence between indicators, ignoring potential correlations or interactions, which can lead to redundancy and evaluation errors.

Additionally, the subjective factors in weight assignment are unavoidable, and if expert opinions are inconsistent, it may affect the stability of the evaluation result. To address these issues, researchers have introduced principal component analysis, factor analysis, and multi-indicator ranking methods (such as TOPSIS and grey relational analysis) to improve the accuracy and robustness of the composite index. At the same time, dynamic composite index construction techniques are gradually emerging, focusing on the time evolution of the evaluated object's competitiveness, enhancing the practical value of the evaluation. With the rapid development of big data and artificial intelligence technologies, the composite index method will be combined with machine learning, data mining, and other advanced techniques to achieve more precise, intelligent, and dynamic composite evaluation system construction, promoting

the automation and real-time development of enterprise competitiveness evaluation.

In conclusion, the composite index method is a powerful and systematic tool for multi-indicator comprehensive evaluation. With its flexibility and clarity, it plays an irreplaceable role in evaluating enterprise competitiveness. Reasonably designing the indicator system, scientifically determining the weights, and combining modern statistical analysis and dynamic evaluation methods are key to improving the effectiveness of composite index evaluation. This method provides significant theoretical support and practical pathways for enterprise management and policy formulation, with broad application prospects and development potential.

In summary, the evaluation of enterprise competitiveness is a systematic and complex project involving multiple interrelated dimensions and indicators. As pointed out in many papers, a single evaluation method can often only reflect one aspect of competitiveness and it is difficult to fully reflect the overall competitive situation of the enterprise.

Enterprise competitiveness not only covers production efficiency, financial status, market performance and innovation capabilities, but also includes human resource management, resource utilization efficiency and management level and other factors. A single indicator or a single dimension cannot fully cover these contents. Therefore, the comprehensive index method based on multi-indicator comprehensive evaluation, combined with qualitative and quantitative analysis, to construct a scientific and reasonable indicator system and weight system has become the mainstream choice in current research and practice.

Mohammadi K. et al. [78] noted that firms with strong innovation orientations consistently outperform rivals not only in financial returns but in market share growth driven by technological differentiation, suggesting that traditional financial metrics alone cannot explain the full picture of their competitiveness. Slater et al. [106] similarly argued that innovation orientation should be measured across strategic, technological, human resource, and organizational culture dimensions, rather than through financial ratios alone.

Table 1.2 – Comparative analysis of enterprise competitiveness assessment Methods

Criterion	AHP	Factor Analysis	SWOT Analysis	Composite Index Method
Objectivity of weighting	Low – relies on expert judgment; subjective bias	Moderate – data-driven but rotation choice is subjective	Low – fully qualitative and analyst-dependent	High – entropy weighting derives weights objectively from data distributions
Quantitative rigor	Moderate – pairwise comparisons with consistency check	High – statistical factor extraction	Low – qualitative framework only	High – standardized indicators, weighted summation, comparable composite scores
Multi-dimensional coverage	High – hierarchical structure covers multiple criteria	High – reduces dimensions but may lose specificity	Moderate – covers internal/external but not systematically	High – integrates profitability, solvency, efficiency, and growth in one index
Applicability to innovatively oriented industrial enterprises	Moderate – can include innovation criteria but weights are subjective	Moderate – requires large samples; limited for small-firm panels	Low – descriptive; does not yield comparative rankings	High – flexible indicator selection accommodates innovation-specific dimensions
Cross-enterprise comparability	Moderate – rankings possible but dependent on expert input	Moderate – factor scores comparable within sample only	Low – results are enterprise-specific, not directly comparable	High – composite scores enable direct ranking and benchmarking across firms
Transparency of methodology	Moderate – process documented but subjective elements remain	Moderate – statistical steps replicable but interpretation varies	Low – highly analyst-dependent	High – full calculation process is replicable and auditable
Key limitations	Subjective weighting; inconsistency risk	Sample size requirements; factor interpretation ambiguity	No quantitative output; static snapshot only	Assumes indicator independence; requires sufficient data variability

Source: Compiled by the author

The international competitiveness of innovatively oriented industrial enterprises also differs fundamentally from that of conventional firms. Conventional enterprises typically compete internationally on the basis of price, factor cost advantages, or resource endowments, as classical trade theory suggests. innovatively oriented industrial enterprises, by contrast, build their international competitive advantage primarily through technological sophistication, product differentiation, and the ability to continuously upgrade their offerings in response to changing market demands.

The following table provides a comparative overview of the four methods reviewed above across key evaluation criteria, substantiating the selection of the Composite Index Method combined with Entropy Weighting as the most appropriate approach for this study [46; 63].

The selected assessment method generates a set of indicators and composite scores, which reflect the relative competitiveness of enterprises. These results serve as the analytical foundation for subsequent management decisions. Therefore, it is necessary to incorporate these evaluation outcomes into a structured competitiveness management system, which is discussed in the following section.

1.3 Theoretical and methodological provisions on ensuring the proper level of competitiveness of innovatively oriented enterprise

The modern stage of economic development is characterized by rapid technological change, shortened product life cycles, and intensified global competition. In this context, maintaining an appropriate level of competitiveness is not only beneficial for survival but also essential for innovation-oriented firms. These firms are essentially at the forefront of technological and market changes, so how they maintain their competitiveness is crucial.

The need to ensure an appropriate level of competitiveness for innovation-oriented firms depends on several economic factors. First, innovation-oriented firms typically invest a lot of resources in research and development, which can bring huge

financial pressure and increase operational risks. Second, the results of innovation activities are inherently uncertain, and there is no guarantee that the investment will produce commercially viable products or services. Third, innovation-oriented firms face fierce competition not only from existing market players, but also from new entrants with disruptive technologies or business models. In addition, the competitiveness of innovation-oriented firms has broader economic significance. As Schumpeter [29] pointed out, innovation-oriented firms become important drivers of economic development through a process of "creative destruction". By launching new products, new processes, or new business models, these firms promote economic growth, job creation, and productivity. Therefore, ensuring their competitiveness is not only about the survival of the firm, but also about economic prosperity.

Competitiveness as a concept has been explored from various theoretical perspectives. Grant [42] defines competitiveness as the ability of a firm to create and maintain competitive advantage in its industry. The resource-based view (RBV) pioneered by Barney [13; 14] argues that competitiveness stems from the valuable, scarce, inimitable and non-substitutable resources that a firm possesses. The dynamic capabilities approach developed by Teece [115] emphasizes the ability of a firm to integrate, build and reconfigure internal and external capabilities to respond to a rapidly changing environment.

Therefore, the concept of an "appropriate level" of competitiveness needs clarification as it varies according to different contexts and criteria. Three main criteria can be identified:

Industry benchmarking. This approach assesses competitiveness relative to industry leaders or average performance within an industry. An appropriate level is achieved when a firm's performance indicators (market share, profitability, innovation output) match or exceed those of comparable firms in the same industry.

Market sustainability. This criterion focuses on the firm's ability to maintain profitability over the long term despite market fluctuations and competitive pressures. An appropriate level of competitiveness is achieved when a firm can maintain stable

financial performance and operational viability even under adverse market conditions.

Technological leadership. For innovation-oriented firms, competitiveness can be measured by their technological advantage relative to their competitors. When a firm continuously innovates to create value and differentiation in the market, it reaches the appropriate level.

Due to the dynamic nature of markets and technologies, determining the "appropriate level" becomes more complex. What is considered appropriate today may not be adequate tomorrow due to emerging technologies, changing consumer preferences, or new competitive threats. Therefore, competitiveness should be viewed as a moving target rather than a static one. The basis for studying the characteristics that ensure the competitiveness of innovation-oriented firms is to understand the specifics of the relevant market environment.

The competitiveness of innovation-oriented firms is derived from the following theoretical foundations:

Resource-based view (RBV). The resource-based view (RBV) theory was proposed by Barney [14] and has been developed through the research results of many scholars. According to this theory, the competitiveness of an enterprise is derived from its unique combination of resources, including tangible assets (equipment, facilities), intangible assets (patents, brands, knowledge), and human capital (skilled employees, management capabilities). For innovation-oriented firms, key resources include intellectual property, professional and technical knowledge, and creative human capital. These resources form the basis for developing unique capabilities that can bring sustainable competitive advantages.

This view tends to be static analysis, with an implicit assumption that the speed of technological change is constant, and fails to clearly define the relationship between the various factors that guide enterprise innovation. If enterprises want to achieve long-term competitive advantages, it is not enough to simply use isolation mechanisms to prevent competitors from imitating. They also need to cultivate the ability to continuously innovate and focus on the dynamic changes of capabilities. Therefore, the analytical

framework of competitive advantage has gradually changed from a static analysis framework based on RBV theory to a dynamic analysis framework based on dynamic capability theory. Since then, more scholars have further studied the basic principles of RBV theory, the connotation and classification of resources, and the organizational background of enterprises as the source of sustainable competitive advantages of enterprises, thus forming a relatively mature resource-based view theory [71; 132].

From the perspective of the resource-based view (RBV), resources are the fundamental source of competitive advantage of innovatively oriented industrial enterprises, and technological progress and innovation-driven transformation are important mechanisms for optimizing resource allocation. In the process of innovation, innovatively oriented industrial enterprises integrate and internalize various advanced technologies such as big data, cloud computing, and artificial intelligence, greatly improving the efficiency of traditional factor combinations and amplifying the value effect of resources.

Dynamic capability theory. The development of dynamic capability theory can be traced back to the 1990s, when Teece and others [32; 115] first proposed the term dynamic capability. They believed that the ability of enterprises to maintain competitive advantage in a changing environment depends not only on their existing resources and capabilities, but more importantly on their ability to update and integrate resources, namely dynamic capabilities. This view is based on the resource-based view and emphasizes the ability of enterprises to adapt to a changing environment. Teece [115] defines dynamic capabilities as “the ability of enterprises to integrate, build and reconfigure internal and external capabilities to cope with a rapidly changing environment”. For innovatively oriented industrial enterprises, dynamic capabilities include the ability to perceive market opportunities, seize these opportunities through strategic decisions, and reconfigure resources to effectively implement these decisions. These capabilities are particularly important in industries with short product life cycles and rapid technological advancement, as they enable companies to quickly adapt to changes and maintain competitive advantages.

As an extension of the RBV theory, the dynamic capability theory can help companies improve their adaptability in highly uncertain, ambiguous and volatile competitive markets [115]. Dynamic capabilities have the meaning of change and dynamics, and refer to the ability of companies to adapt to and lead changes. This ability enables companies to adapt to and lead environmental changes by constantly adjusting and improving their conventional capabilities. Although resources are the focus of the RBV theory, in the dynamic capability theory, changing and innovating resources to adapt to turbulent markets becomes the key point of the theory.

Annarelli et al. [5] proposed that innovation-driven capabilities are an important prerequisite for companies to maintain sustained competitive advantages in an era of rapid technological advancement. Companies must actively cultivate specific innovation-oriented capabilities at different organizational and operational levels of the strategic and operational framework.

Therefore, the theoretical research on innovation-oriented dynamic capabilities has received extensive attention in recent years, mainly focusing on its conceptual definition and characteristics. Existing research generally regards innovation-driven capabilities as high-level capabilities above traditional dynamic capabilities, enabling enterprises to develop and improve their adaptive and transformative capabilities in the process of restructuring and optimizing operational and strategic frameworks.

Open innovation theory. This theory, originally proposed by Chesbrough [24], suggests that enterprises should use external ideas and approaches as well as internal ideas and approaches for marketing. Building on this foundation, scientists [5] further explored the contextual drivers of open innovation adoption across different industrial environments. By consciously integrating the internal capabilities and resources of the enterprise with external technologies and innovative ideas and developing market opportunities through multiple channels, open innovation shows how the most valuable ideas, internal or external ideas, are realized through internal and external channels of the enterprise. According to this view, competitiveness comes not only from internal innovation capabilities, but also from the ability of enterprises to utilize external sources

of knowledge, collaborate with other organizations (universities, research institutions, suppliers, customers), and integrate these external inputs into their innovation processes. This approach is particularly important in complex technological fields, as no single enterprise possesses all the necessary knowledge or resources.

Since its inception, the concept of open innovation has attracted widespread attention from scholars. Dahlander and Gann [28] proposed that economic globalization, the improvement of the market system, the enhanced mobility of high-tech talents, and the advancement of modern communication technology are the main driving forces for the development of open innovation within enterprises.

Fu et al. [38] pointed out that an open strategic approach can stimulate corporate innovation activities while improving innovation efficiency. Studies have shown that open innovation has significant external effects and is often positively correlated with corporate competitiveness. Therefore, in the context of ensuring the competitiveness of innovatively oriented industrial enterprises, open innovation is an important strategic approach that enables enterprises to exploit external knowledge, improve their innovation capabilities, and strengthen their market positioning.

The ability to integrate external expertise and cross-industry collaboration plays a fundamental role in fostering the long-term competitive advantage of innovatively oriented industrial enterprises. Table 1.3 illustrates the interrelationships between these theoretical foundations and how they contribute to the competitiveness of innovatively oriented enterprises.

As Table 1.3 shows, RBV emphasizes that unique and inimitable resources are the basis of competitive advantage, while dynamic capability theory builds on RBV and emphasizes the importance of resource reconfiguration and adaptation in a dynamic environment. Open innovation theory further expands these views and emphasizes the role of external collaboration and knowledge exchange in promoting innovation. These theories are interrelated, with RBV as the foundation, dynamic capability theory promoting adaptability, open innovation RBV as the foundation, and open innovation theory as broadening the scope of innovation.

Table 1.3 – Comparative analysis of theoretical foundations for ensuring the competitiveness of innovatively active enterprises

Theory	Core Concept	How It Enhances Competitiveness	Interrelationship
Resource-Based View (RBV)	The competitive advantage of enterprises originates from scarce, inimitable, and non-substitutable resources and capabilities.	Emphasizes internal resource accumulation and optimization to strengthen the enterprise's unique competitive advantage.	RBV serves as the foundation for Dynamic Capabilities Theory and Open Innovation Theory, emphasizing that competitive advantage stems from acquiring and managing unique resources.
Dynamic Capabilities Theory	Enterprises must possess the ability to sense opportunities, seize them through strategic decisions, and reconfigure resources to adapt to a rapidly changing environment.	Helps enterprises dynamically adjust resource allocation to maintain long-term competitiveness.	Dynamic Capabilities Theory builds upon RBV but focuses more on the ability to reconfigure and adapt resources, providing essential support for open innovation.
Open Innovation Theory	Enterprises can enhance their innovation capabilities and competitiveness through internal and external knowledge exchange and collaborative innovation.	Enhances market adaptability through external cooperation, technology sharing, and open collaborative innovation.	Open Innovation Theory relies on the internal resources and adaptive capabilities provided by RBV and Dynamic Capabilities Theory to enable cross-organizational collaboration and innovation.

Source: developed by the author

Under the theoretical and methodological framework that ensures the appropriate level of innovatively oriented industrial enterprises, the key factors affecting competitiveness are clarified. The formation and maintenance of competitiveness not only depends on the enterprise's own resource endowment and dynamic adjustment capabilities but also is affected by factors such as the external market environment, policy support, and cross-organizational cooperation. Therefore, in-depth analysis of the

components of enterprise competitiveness is helpful to build a scientific competition guarantee mechanism from a theoretical perspective and provide methodological guidance for enterprises in actual operations. On this basis, it is possible to discuss the two aspects of internal factors (product strength, technological innovation capability, human resources) and external factors (market performance, economic environment, government behavior) to systematically reveal the core structure and competitive mechanism of innovation-oriented active corporate competition. As illustrated in Figure 1.3, the international competitiveness of innovatively oriented industrial enterprises is shaped by three core internal factors: product strength, technological innovation capability, and human resources.

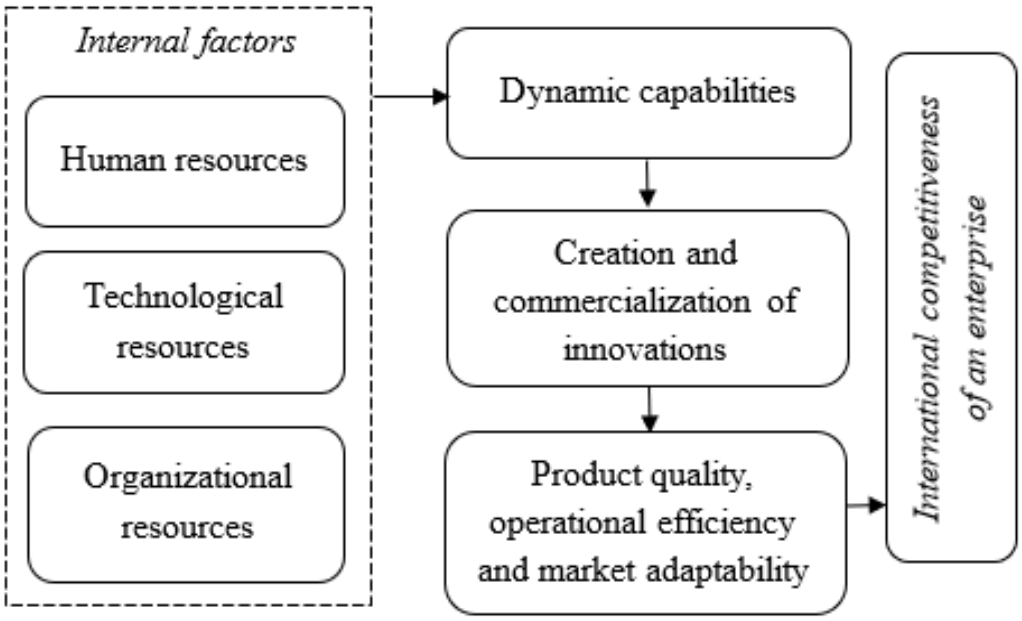

Figure 1.3 – Internal Factors Affecting the Competitiveness of Innovatively Active Enterprises

Source: developed by the author

These factors operate in an interconnected manner – strong human capital drives technological innovation, which in turn enhances product quality and market positioning – collectively forming the internal foundation upon which sustainable competitive advantage is built.

As illustrated in Figure 1.4, three external factors – market performance, economic environment, and government behaviour – converge to shape the formation of

international competitiveness. Unlike internal factors that are directly controllable by the enterprise, these external dimensions define the operating conditions and competitive boundaries within which innovatively oriented industrial enterprises must position themselves strategically.

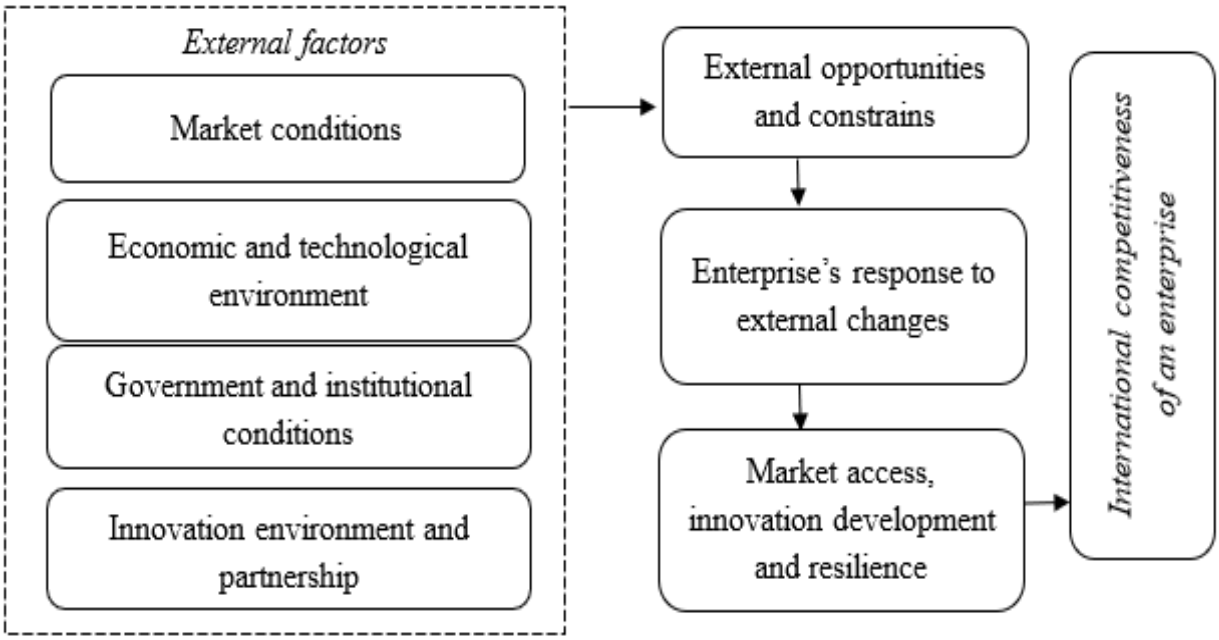

Figure 1.4 – External Factors Affecting the Competitiveness of Innovatively Active Enterprises

Source: developed by the author

The framework presented in Figures 1.3 and 1.4 synthesises the competitiveness determinants identified across the literature reviewed in Section 1.1, drawing in particular on Jin Bei's distinction between competitive potential (reflected in internal factors such as technological capability and human resources) and competitive strength (reflected in external outcomes such as market performance). From the author's perspective, while all six factors are relevant to competitiveness in general, their relative importance differs for innovatively oriented industrial enterprises compared to conventional firms.

Specifically, technological innovation capability occupies a structurally superior position among the internal factors: it is the primary mechanism through which product strength is generated and renewed, and it determines the rate at which human capital investments translate into marketable output. Among the external factors, government

behavior has taken on particular strategic significance for Chinese innovatively oriented industrial enterprises under current geopolitical conditions, as state-directed industrial policy, R&D subsidies, and technology standard-setting increasingly shape the competitive environment in ways that neither market performance nor macroeconomic conditions alone can capture. This author's view informs the weighting and analytical priority assigned to these factors in the competitiveness assessment framework developed in Chapter 2.

Product strength. Product strength directly determines the strength of an enterprise's international competitiveness and is one of the core components of international competitiveness. It can be comprehensively considered from the aspects of product variety, price, quality, structure, brand, and technical level. Among them, product quality, especially its content quality, can be said to be the foundation and key of product strength and the lifeblood of an enterprise.

In recent years, many scholars have conducted in-depth research on the impact of product strength on the international competitiveness of enterprises. Porter (1990) pointed out in the theory of competitive advantage that product quality and technological innovation are the key factors for enterprises to gain an advantage in global competition. Qiu et al. [92] emphasized that green product innovation and green dynamic capabilities strengthen competitive advantage and support the continuous renewal of product competitiveness.

Prahalad and Hamel [88] proposed the core capability theory, believing that the technical level and innovation ability of products are the basis of enterprises' long-term competitive advantage. Eisenhardt and Martin [32] pointed out in the theory of dynamic competition that enterprises should continuously improve their product strength through product upgrades, supply chain optimization, and digital transformation to adapt to the rapidly changing international market. Taken together, these studies show that product strength not only determines the current market performance of enterprises but also plays a vital role in shaping the global competitiveness of enterprises.

Technological innovation capability. Technological innovation capability is

a theory that studies how enterprises or organizations can improve their competitiveness and market position by systematically developing and applying new technologies. This theory covers many aspects such as the process, influencing factors, evaluation methods and improvement strategies of technological innovation. The core of this capability is that enterprises can not only conduct technological research and development, but also transform the research and development results into competitive products or services in the market.

Schumpeter [100] first proposed the innovation theory, emphasizing that technological progress is the core driving force for enterprise growth and economic development. Eisenhardt and Martin [32] pointed out in the dynamic capability theory that enterprises must constantly adjust and integrate technological resources to adapt to the changing market environment. Nelson and Winter [81] analyzed the path support of enterprise technological innovation under the economic framework and believed that the technological accumulation and innovation capabilities of enterprises are affected by their past experience and organizational inertia.

Recently, Du et al. [30] studied the impact of inter-enterprise technological cooperation and alliances on innovation capabilities and found that external cooperation can effectively improve the technological innovation efficiency of enterprises. Through reasonable technological innovation strategies, enterprises can maintain their leading position in the fierce market competition and continuously create new market value.

Human resources. Human resources are the foundation of innovation, productivity and organizational adaptability, and play a key role in ensuring the competitiveness of enterprises. Many researchers have identified three key levels that affect enterprise competitiveness: resource level; capability level; market structure level. From the resource level, Ramirez-Aleson and Espitia-Escuer [94] believes that the factors affecting enterprise competitiveness can be divided into physical capital resources, human resources and organizational capital resources, and stated that resources are an important factor for sustainable development.

Ali [4] discussed the role of human resources in competitiveness and designed a relevant scale, concluding that resource elements and service quality are important factors affecting the competitiveness of human resource service enterprises. From the perspective of capabilities, Tidd [116] believes that enterprise competitiveness is the organizational marketing capability, organizational learning capability, and organizational innovation capability that enterprises gain by making full use of economies of scale in the process of development.

From the perspective of market structure, Wongsansukcharoen and Thaweepaiboonwong examined the external and internal factors that affect the competitiveness of small and medium-sized enterprises in Thailand in the context of ASEAN [124]. The results showed that both enterprise performance and organizational strategy have a positive effect on competitiveness, and the path coefficient of performance on competitiveness is greater than that of organizational strategy [124].

Market performance. Market performance includes indicators such as market share, sales growth, customer acquisition and retention rate, and price premium relative to competitors [119]. These indicators can provide insights into the competitive position of enterprises in the market and their ability to create and acquire value.

Bain [11] pointed out in the market structure-performance (SCP) paradigm that market structure determines the competitive behavior of enterprises, which in turn affects their market performance and profitability. Barney [14] further proposed that the sustainable competitive advantage of enterprises comes from the scarcity, inimitableness and non-substitutability of resources, and these factors will eventually be reflected in market performance. These studies together show that market performance is not only an important indicator of corporate competition but also reflects the ability of enterprises to create and obtain value in the market.

Economic environment. The economic environment is a key external factor in corporate competitiveness. It shapes the competitive advantage of enterprises by affecting their cost control, market expansion, financing capabilities and production efficiency [78]. First, the macroeconomic cycle directly determines the market demand

and profitability of enterprises. The economic cycle often prolongs with the increase of consumption power and investment expansion, providing enterprises with a larger market space, while economic trade may lead to demand contraction and cost increase, thus affecting the competitiveness of enterprises.

Secondly, the financing environment (financing conditions) affects the ability of enterprises to obtain funds, including interest rate levels, credit policies and capital market activity. Lower interest rates and a large amount of credit can reduce the financing costs of enterprises, promote R&D investment, production upgrades and market expansion, while high interest rates may limit the investment capacity of enterprises, which has the characteristics of its competitive advantage.

Government behavior. Especially for innovatively oriented industrial enterprises with special characteristics, market behavior and market competition are often more likely to fail than general enterprises, so scientific intervention and strong guarantee of government behavior are urgently needed. Here, government behavior refers to the sum of a series of policies, regulations, laws and regulations taken by the government to promote the development of innovatively oriented industrial enterprises. Its role in enhancing the international competitiveness of innovatively oriented industrial enterprises is mainly reflected in the planning and support of enterprise development through the introduction of policies, systems, laws and regulations, optimizing the allocation and benefits of existing factors of enterprises, and then promoting further innovation and upgrading of enterprise factors.

As verified by Castellachi's research using evolutionary economics methods, government behaviors such as institutional arrangements and policy interventions play a fundamental role in the factor innovation model and its impact on enterprise competitiveness. At the same time, the role of government behavior in promoting is also reflected in regulating competitive behavior and market order with the help of administrative and legal means and improving the environment for enterprise development. Specifically, reasonable enterprise policies, sound laws and regulations, and good government credibility are important guarantees for enterprise development,

which are conducive to comprehensively promoting the formation and improvement of innovation-oriented international competitiveness.

The analysis of internal and external factors shaping the competitiveness of innovative firms in this section raises a broader question: in which industry contexts do these factors exert the greatest influence, and where can the relationship between innovation and competitive advantage be most directly observed? The theoretical framework constructed in this chapter – drawing on the resource-based view, dynamic capabilities theory, and open innovation theory – presupposes that innovation is not a peripheral consideration but a constitutive element of a firm's competitive position. This calls for examination of industries in which knowledge assets are the primary source of value, competitive advantages turn over rapidly, and R&D investment has a demonstrable impact on market outcomes. The information technology sector satisfies these conditions more fully than most. IT firms depend on continuous technological renewal for their survival in international markets; their product lifecycles are measured in months rather than years; and their competitive advantages derive principally from intangible assets – software, patents, talent, and data.

Within information technology, artificial intelligence warrants particular attention. AI represents what economists have termed a general-purpose technology: its effects extend across virtually every sector of the economy and fundamentally alter the competitive landscape [113; 118].

For innovative firms, the significance of AI lies not so much in the products it enables as in how it reshapes the competitive environment – compressing decision cycles, generating new forms of product differentiation, and raising the returns to R&D investment in ways that place slower-moving incumbents at a structural disadvantage. It is for this reason that Chapter Two takes China's artificial intelligence technology market as its empirical setting, examining the competitive dynamics among innovative firms operating in this domain.

Conclusions to Chapter 1

As a result of the research conducted in the first chapter of the dissertation, the following conclusions were formulated.

1. During summarization and interpretation of the existing specific scientific literature, the conceptual definition of international competitiveness of innovatively oriented industrial enterprises has been further developed (scientific novelty): the definition specifies competitiveness as the ability to maintain global market position through sustained R&D investment, continuous technological upgrading, and the effective conversion of innovation into financial performance – distinguishing innovatively oriented industrial enterprises from conventional firms by treating R&D intensity and technological output as primary rather than secondary sources of competitive advantage.

2. Based on the systematization and critical evaluation of scientific and methodological approaches to assessing enterprise competitiveness, including a comparative analysis of AHP, DEA, SWOT, factor analysis, and the Composite Index Method, the scientific and methodological approaches to assessing enterprise competitiveness have been systematised and critically evaluated (further developed): a comparative analysis of AHP, DEA, SWOT, factor analysis, and the Composite Index Method has been conducted (Table 1.2), substantiating that the combination of Composite Index Method with Entropy Weight Method provides the highest objectivity of weighting, quantitative rigor, multi-dimensional coverage, and cross-enterprise comparability, providing the methodological basis for Chapter 2.

3. Based on the generalization and integration of the theoretical foundations of enterprise competitiveness, the theoretical and methodological provisions for ensuring the appropriate level of competitiveness of innovatively oriented industrial enterprises have been further developed. The Resource-Based View, the Dynamic Capabilities framework, and the Open Innovation concept are integrated into a unified analytical framework, with each perspective assigned a specific explanatory role in linking resources, adaptive capabilities and sustainable international competitiveness.

CHAPTER 2
EVALUATION OF THE COMPETITIVENESS OF INNOVATIVELY ORIENTED ENTERPRISES OPERATING IN THE MARKET OF TECHNOLOGY

2.1 The state and development prospects of the artificial intelligence technology market in China

To ensure analytical rigor in the assessments that follow, it is first necessary to establish the scope and structure of the information technology market as the operational environment of the firms under study. The IT market encompasses a broad range of technological domains, including infrastructure hardware, software products, communications technology, digital services, and emerging technology sub-sectors. Within this landscape, artificial intelligence occupies a distinctive position: rather than constituting a discrete market segment, it functions as a horizontal technology whose applications extend across virtually every other sub-sector, from cloud computing and big data processing to industrial automation and financial services [16].

This study analyses China's information technology market along the following dimensions:

- the overall size and growth dynamics of the IT market over the past decade;
- the structural composition of IT market sub-sectors, with particular attention to the share and growth trajectory of AI-related technologies;
- the scale and composition of R&D investment in the IT industry, taken as an indicator of innovation intensity;
- import and export dynamics for IT products and services, as a reflection of international market integration;
- government policy frameworks and public investment directed at AI development, treated as key external factors shaping firm competitiveness;
- the competitive landscape of China's AI technology sub-sector, including the number and typology of active firms.

This framework permits systematic comparison of conditions across the countries examined, thereby establishing the market context against which firm-level competitiveness is assessed in the chapters that follow.

Figure 2.1 presents projected growth dynamics for the global AI market from 2023 to 2034. The chart illustrates year-on-year changes in market size, which constitute the primary empirical backdrop for this study.

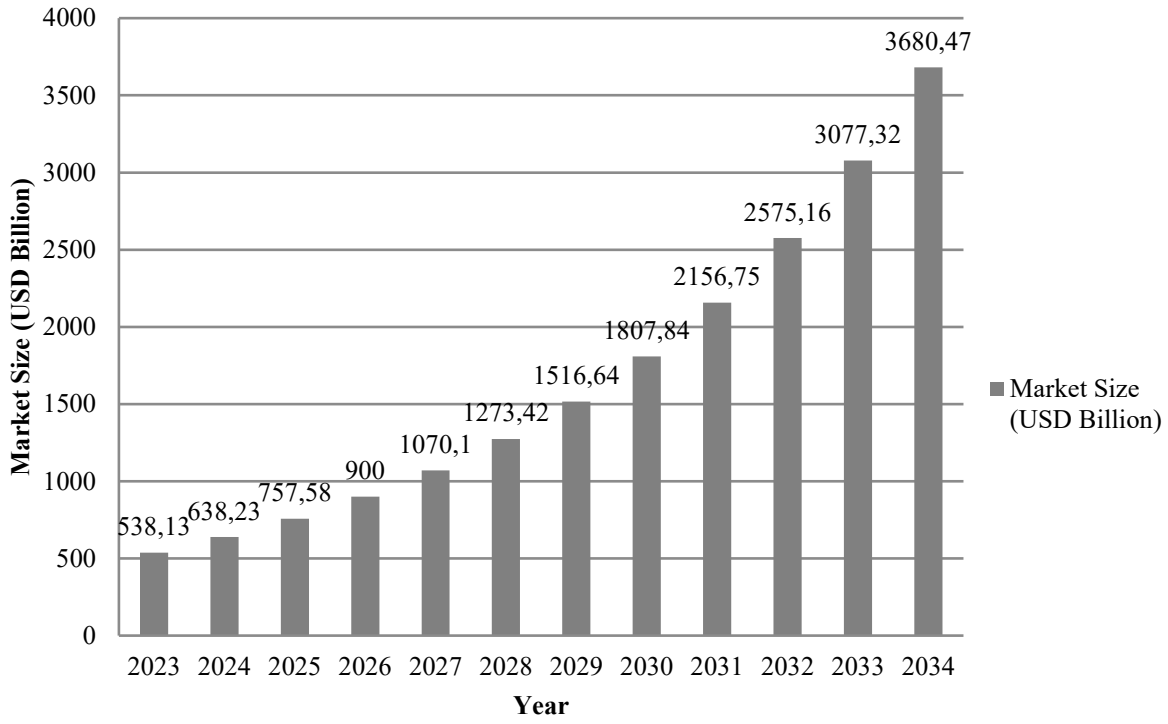

Figure 2.1 – Estimated growth dynamics of the global AI market from 2023 to 2034

Source: developed by the author based on [89]

Figure 2.1 presents the estimated growth dynamics of the global artificial intelligence market from 2023 to 2034, based on data compiled by Precedence Research, a specialized market intelligence firm focused exclusively on technology and emerging industry forecasting. The projections draw on Precedence Research's annual tracking of global AI investment flows, enterprise adoption rates, and regional deployment patterns, providing a systematic empirical foundation for the growth trajectory presented here.

As shown in Figure 2.1, the global AI market stood at USD 538,13 billion in 2023

and expanded to USD 638,23 billion in 2024, reflecting steady year-on-year growth driven by accelerating enterprise adoption across sectors including finance, healthcare, and manufacturing. Growth momentum continued into 2025 and 2026, with market size reaching USD 757,58 billion and USD 900 billion respectively, underpinned by the rapid commercialisation of large language models and the expansion of AI-powered cloud infrastructure.

From 2027 onwards, the market entered a steeper growth phase. According to Precedence Research's forecast, market size is projected to surpass USD 1 trillion by 2027 at USD 1070,1 billion, climb to USD 1516,64 billion by 2029, and reach USD 2156,75 billion by 2031.

The trajectory accelerates further in the early 2030s, with market volume expected to reach USD 3077,32 billion in 2033 and USD 3680,47 billion by 2034, representing a compound annual growth rate of 18,73% over the 2026–2035 forecast period. These projections are consistent with Precedence Research's broader assessment that global AI market revenue will approach USD 4216,29 billion by 2035 as the technology transitions from experimental adoption to large-scale industrial integration across virtually every sector of the global economy.

This growth trajectory forms the principal empirical backdrop of the present study, establishing the macro-level market context within which the competitiveness of innovatively oriented industrial enterprises operating in China's AI technology sector is assessed.

From these data, the global artificial intelligence market has great growth potential in the future, especially in the context of continuous technological innovation and increasing demand in multiple industries. It is expected that artificial intelligence will be widely used in multiple fields. This trend shows that artificial intelligence is increasingly positioned as a core driver of technological development across multiple sectors. Based on 2025 data, the AI software market is segmented by region into North America, Europe, Asia Pacific, Latin America, and the Middle East & Africa (Fig. 2.2).

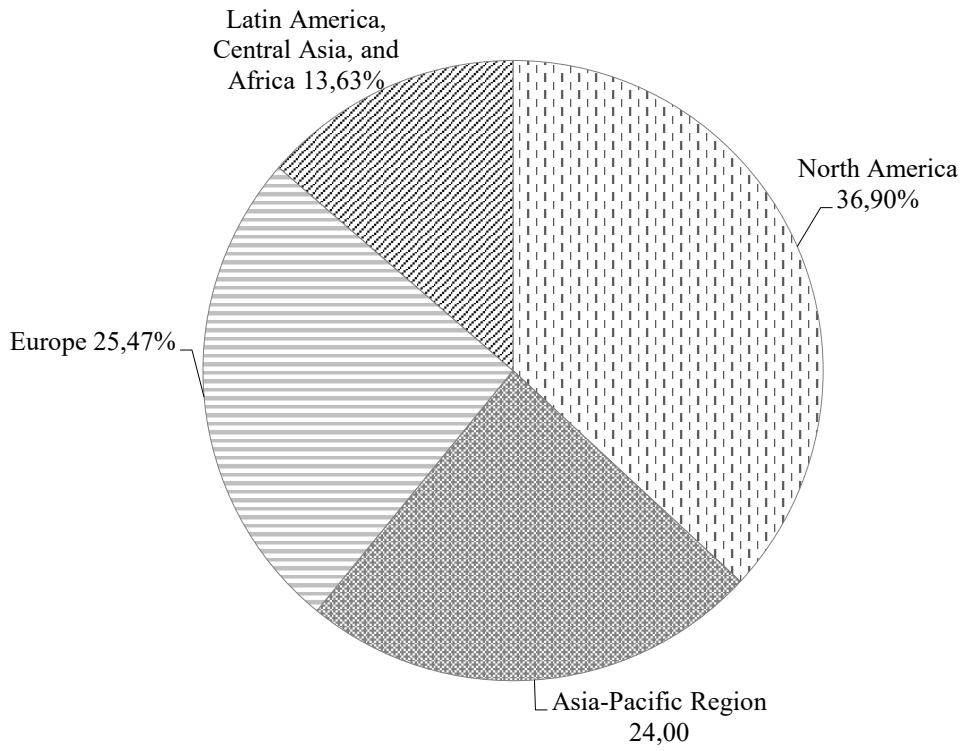

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Figure 2.2 – Artificial Intelligence (Al) Market Share, By Region, 2025 (%)

Source: *developed by authors based on [90]*.

As shown in Figure 2.2, more than one-third of the global AI software market is located in North America, accounting for about 36,90% of the market share. The demand for hardware and software products for automation and advanced technology in the region and favorable government policies that encourage the implementation of AI in North American industries have greatly contributed to the growth of the market. In 2019, the United States launched an initiative to promote the country to become a leader in AI technology. North America has technology giants such as Facebook, Amazon, Google, IBM, Microsoft, and Apple, which have made significant contributions to the development of the AI market in the region. We can also expect that Asia Pacific will be the fastest growing region in the AI market in the coming years. The increasing investment in AI adoption in the region is driving the demand for AI technology. For example, Chinese technology giant Baidu has reached an agreement with investors to split the company into an independent financial services group, which will include consumer finance, asset management, and other business services. In addition, the expanding application of AI in various fields such

as automobiles, healthcare, retail, food and beverages, etc., is driving the development of the AI market in Asia Pacific.

Against the backdrop of rapid advances in artificial intelligence worldwide, countries across the globe are intensifying their investment in and adoption of AI. China, in particular, has emerged as a nation actively committed to driving innovation in this domain, achieving considerable progress across technological research and development, market application, and industrial development. The sections that follow examine in depth the specific trajectory of China's AI technology market, analysing the range of applications the country has pursued in this field and the effects they have generated, while exploring how China has sought to shape the broader direction of development in AI technology.

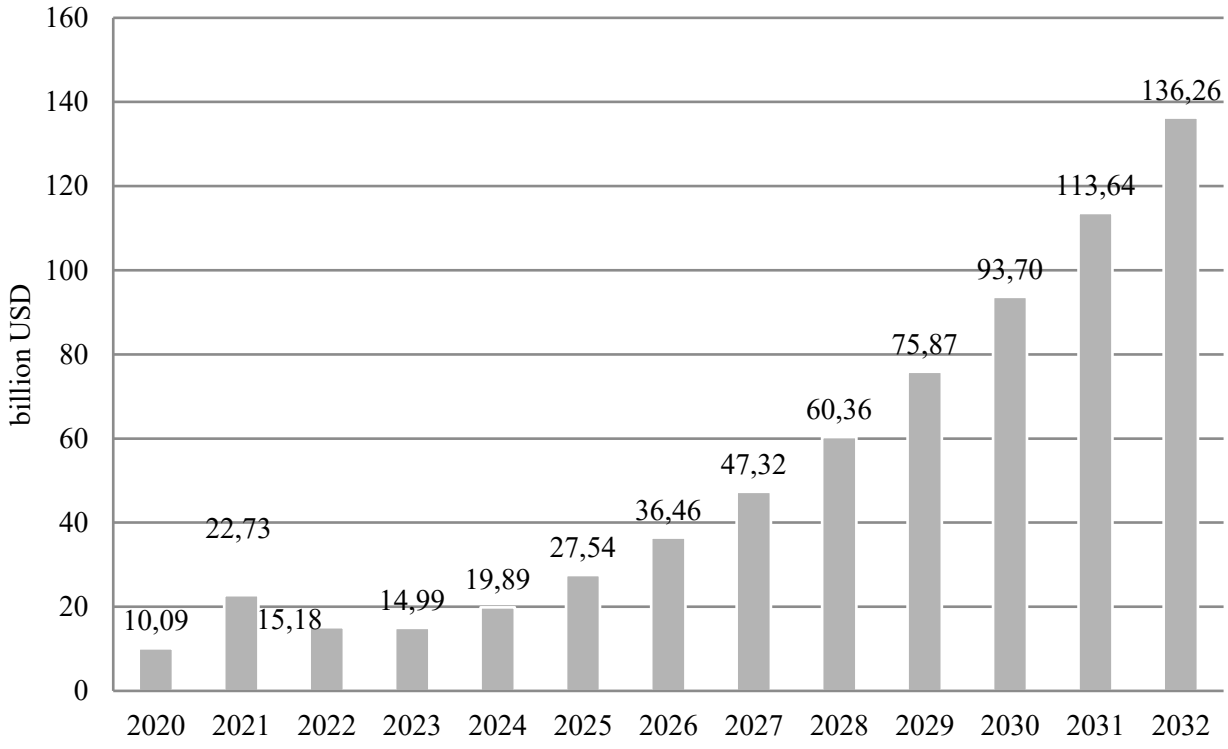


Figure 2.3 – China’s AI Market Size and Forecast (2020–2032)

Source: developed by authors based on [110].

China has made significant achievements in the field of AI and is showing a rapid development trend. In the future, with the continuous advancement of technology and the continuous expansion of application fields, China's AI is expected to achieve more significant achievements, and the scale of the AI market will gradually expand, making

greater contributions to the development of global AI. Since China's AI strategy is explicitly oriented toward establishing global technological leadership rather than regional dominance, benchmarking China against the global market represents the most appropriate and meaningful point of comparison. Figure 2.3 presents the scale of China's artificial intelligence market from 2020 to 2025 and the projected growth trajectory through to 2032.

As shown in Figure 2.3, China's AI market experienced notable volatility in its early development phase. Starting at USD 10,09 billion in 2020, the market surged to USD 22,73 billion in 2021, driven by accelerated enterprise digitalisation and the rapid deployment of machine learning and computer vision technologies across key sectors. This momentum, however, did not hold: market size contracted to USD 15,18 billion in 2022 and further to USD 14,99 billion in 2023, a correction reflecting tightened regulatory oversight of the technology sector, macroeconomic pressures, and a period of consolidation in AI investment. Recovery became visible in 2024, with market size rebounding to USD 19,89 billion, continuing into 2025 at USD 27,54 billion – a level consistent with the broader trend of generative AI adoption and the accelerating integration of large language models into commercial applications.

Looking ahead, China's AI market is projected to sustain strong upward momentum through to 2032. Market size is expected to reach USD 36,46 billion in 2026, USD 60,36 billion in 2028, and USD 93,70 billion by 2030, before approaching USD 136,26 billion in 2032. This trajectory reflects the cumulative impact of China's strategic policy commitments – including the "AI+" national initiative – alongside continued expansion of intelligent computing infrastructure, growing enterprise demand for AI-driven automation, and the progressive maturation of domestic foundation model ecosystems. The projected compound growth underscores the increasing centrality of artificial intelligence to China's long-term industrial competitiveness and positions the country's innovatively oriented industrial enterprises at the forefront of a rapidly evolving global technology landscape. It should be noted that the global and China-specific forecasts use different time horizons – 2034 and 2032 respectively – reflecting the distinct

reporting periods of their respective data sources (Precedence Research and Statista). Both datasets nonetheless consistently indicate accelerating growth trajectories over their respective forecast periods.

This growth expectation is based on the following key factors:

1) Continuous breakthroughs in technological innovation. With the improvement of computing power and the optimization of algorithms, artificial intelligence technology will achieve important breakthroughs in more fields, especially in the fields of artificial intelligence and brain-like computing [125].

2) Changes in application scenarios. The digital transformation of traditional industries will bring greater market space for artificial intelligence, especially in the fields of industrial Internet, intelligent manufacturing, smart medical care, etc., and the depth and breadth of applications will be greatly improved [133].

3) Accelerated industrial integration. The integration and innovation of AI with new technologies such as 5G, blockchain, and quantum computing will give rise to new application models and business forms [51].

4) Talent reserves continue to strengthen. With the increase in education investment and the improvement of the talent training system, the supply of high-quality AI talents will be further guaranteed. A variety of factors have contributed to the rapid expansion of China's AI industry [67].

This chart not only shows the current situation of China's AI market, but also shows the development prospects of China's AI industry in the next few years through forecasts. This is closely related to the overall development trend of China's information technology markets, indicating that China's rapid development in the field of AI technology will bring greater competitiveness to its information technology market and related industries.

In terms of key technologies such as deep learning, natural language processing, and computer vision, some of China's AI market technologies have reached the international leading level. At the same time, AI chips and algorithms have also achieved important results, providing strong support for the widespread application of

AI. Secondly, the Chinese government attaches great importance to the development of the AI market and has introduced a series of policies and measures to provide strong support for the innovative application of the AI market. These policies cover various aspects such as technology research and development, industrial application, and talent training, creating a good environment for the rapid development of China's AI.

Finally, China has become an important force in the field of global artificial intelligence. China ranks among the top in the world in terms of the number of AI-related papers published and the number of patent applications. At the same time, China has also actively participated in international AI cooperation and exchanges, contributing Chinese wisdom and solutions to the development of global artificial intelligence. In summary, China's artificial intelligence technology market has entered a stage of rapid development, with continuous technological breakthroughs, increasingly extensive applications, and a continuously optimized policy environment.

Table 2.1 – AI Investment Distribution by Sector in China (2025)

AI Investment Distribution by Sector in China			
(JPY to USD conversion rate: 1 USD = ¥159,22 | Source: US Federal Reserve, Apr 10, 2026)			
AI Sector	Investment Share	2026 Projected Value (USD bn)	Key Players
Autonomous Vehicles	22%	$123,10B	Baidu, Pony.ai, WeRide
Computer Vision	18%	$100,49B	SenseTime, Megvii, Cloudwalk
Natural Language Processing	11%	$84,16B	iFLYTEK, Baidu, ByteDance
FinTech AI	12%	$67,20B	Ant Group, Tencent, JD Finance
Healthcare AI	11%	$61,55B	Ping An Good Doctor, iCarbonX
Industrial AI	10%	$55,90B	Foxconn, Midea, SIASUN
E-Commerce AI	8%	$44,59B	Alibaba, JD.com, PDD Holdings
Others	4%	$22,61B	Various startups

Source: developed by authors on the basis of [101].

Table 2.1 provides a more detailed picture of how AI investment in China is allocated across major sectors and which segments are expected to play a leading role in the next stage of development.

As shown in Table 2.1, autonomous vehicles account for the largest share of AI investment in China, representing 22% of total investment, with a projected value of USD 123,10 billion in 2026.

This suggests that intelligent mobility remains one of the most strategically significant directions for AI development, driven by advances in autonomous driving systems, smart transportation infrastructure, and strong participation from leading firms such as Baidu, Pony.ai, and WeRide. Computer vision follows closely with an investment share of 18% and a projected value of USD 100,49 billion, highlighting the continued importance of image recognition, surveillance systems, facial recognition, and machine perception technologies in the Chinese market.

In addition, natural language processing, FinTech AI, and healthcare AI each occupy an important position within the investment landscape. Natural language processing accounts for 11% of total investment, with a projected value of USD 84,16 billion, reflecting the rapid expansion of large language models, intelligent assistants, and AI-powered content generation tools. FinTech AI, with a 12% share and a projected value of USD 67,20 billion, demonstrates the increasing integration of artificial intelligence into digital finance, risk control, smart payments, and credit evaluation. Healthcare AI also represents 11% of investment, amounting to USD 61,55 billion, which indicates growing demand for AI applications in medical imaging, diagnosis support, health management, and digital healthcare services.

By comparison, industrial AI and e-commerce AI account for 10% and 8% of total investment respectively, while the “others” category represents only 4%. Although these shares are relatively smaller, they still reveal the broadening scope of AI adoption in China’s real economy. Industrial AI reflects the country’s ongoing push towards intelligent manufacturing and automation upgrading, whereas e-commerce AI highlights the use of recommendation algorithms, customer analytics, and supply chain

optimisation in the digital retail sector.

Overall, Table 2.1 shows that the current development of China’s artificial intelligence market is characterised not only by rapid expansion in scale, but also by a gradually clearer sectoral structure. Investment is increasingly concentrated in high-value, technology-intensive, and application-oriented fields, especially those with strong market demand and long-term strategic importance. This pattern suggests that the future development of China’s AI industry will depend not only on continued market growth, but also on the deepening integration of AI technologies with transportation, finance, healthcare, manufacturing, and digital commerce. In this sense, the sectoral distribution of investment further confirms the strong development prospects of China’s artificial intelligence technology market.

Many studies have shown that China's artificial intelligence technology has been widely used in industrial manufacturing, retail, finance and other industries, and has achieved remarkable results [127].

In combination with the research focus of this article, we will further analyze the application status and future development trends of artificial intelligence technology in these three fields, so as to have a clearer understanding of China's development in artificial intelligence technology and its profound impact on the domestic information technology market. Specifically, we will analyze the development process of China's artificial intelligence technology in the fields of industrial manufacturing, retail and finance, and explore how these technologies are applied in different scenarios and the actual changes they bring. Through this in-depth study, we can not only have a more comprehensive understanding of the progress of China's artificial intelligence technology, but also provide important theoretical basis and practical guidance for subsequent research.

Manufacturing industry. The manufacturing industry is an important support for China to accelerate the construction of a modern industrial system. Industrial manufacturing companies can use artificial intelligence technology to improve R&D,

production and operational efficiency, and enhance the digitalisation capabilities of the entire value chain.

In the following manufacturing companies, the enabling role of artificial intelligence technology in key links, as well as the intelligence of management and services, have injected new impetus into the future business development of enterprises.

As an important promoter of 5G technology, standards and industries, China Mobile has developed a cloud platform that combines resource advantages to expand in the aspects of edge, AI, ecology, etc., helping factories to manage the entire process of informationization from orders to scheduling, production processes, process flow, process management, material management, quality inspection, order delivery and data statistical analysis, providing the manufacturing industry with a wide range of intelligent cloud service capabilities.

SmartMore is a technology company that focuses on applying artificial intelligence to multiple industries. SmartMore uses intelligent machines and robots for quality control, production monitoring and predictive maintenance. It provides one-stop digital services for industrial intelligent production, operation, management and visual decision-making, helping manufacturing companies build a new generation of digital factories. In response to the problems of low accuracy, difficulty in development, and difficulty in operation and maintenance in traditional industrial quality inspection scenarios, Huawei Industrial AI Quality Inspection, based on big data, cloud computing and other capabilities, combined with its own quality inspection practice experience, has built an industrial AI visual quality inspection platform for customers in the automotive, tobacco, electronics and other manufacturing industries, realizing the automation and intelligence of production quality control, and helping to continuously improve quality, reduce costs and increase efficiency.

As the coverage breadth and depth of industrial application scenarios continue to increase, the future development trend of artificial intelligence technology in this industry will gradually be fully explored. For example: driving computer vision technology capabilities to continue to develop in the direction of high precision and

standardization, helping enterprises to achieve intelligent upgrades in automated testing, quality control, safety monitoring and refined production. The emergence of large models has also injected more powerful cognitive capabilities into industrial intelligence, which will be able to deeply understand and adapt to different production environments and factory characteristics, and achieve a high degree of fit between AI and traditional industrial equipment.

Retail industry. In the retail industry, AI technology has achieved a product-centric linear value chain through intelligent supply chain management. It has gained deep insights into consumer needs through real-time, context-driven user journey interactions, and has connected multiple online and offline touchpoints based on data to create an omni-channel intelligent ecosystem. It has also conducted business ROI analysis based on customer demand patterns, achieved intelligent decision-making, and increased long-term customer value [37].

Many companies have successfully upgraded and transformed their businesses by adopting AI technology. JD.com has continuously improved its algorithm effects and brand CTR by leveraging its own big data resources and understanding of the retail industry. JD.com Intelligent Supply Chain, a subsidiary of the group, has helped retail companies reduce turnover days through intelligent decision-making technologies such as intelligent operations, warehouse network optimization, and omni-channel fulfillment. Tencent Enterprise Point provides enterprises with full-scenario enterprise digital upgrades from marketing touchpoints, sales conversion, transaction collaboration to customer service based on technologies such as instant messaging, audio and video, AI, and big data. Jirui Technology is committed to building China's leading full-link e-commerce content generation engine. With leading AIGC technology capabilities, internationally leading computer vision algorithms and engineering capabilities, the company has achieved highly automated and intelligent content generation, improved work efficiency, optimized the creative process, and further enhanced the company’s competitiveness and market adaptability.

The trend of AI application in the retail industry in the future will be fully rolled out from point to surface. First, AI applications will be added to all formats to form data touchpoints and connections. Secondly, it will penetrate all links of the retail industry chain. Accordingly, it will become increasingly important to continuously interconnect data and form a good AI application foundation.

Financial industry. The financial industry started early in digital transformation and currently has a high level of overall digital maturity, providing a good foundation for the in-depth application of artificial intelligence. The financial industry has become a key area for the implementation of generative AI and large model technologies. With the continuous expansion of artificial intelligence technology in the financial industry, it has covered key links in digital operations such as marketing, service, investment research, investment consulting, risk control, and R&D [65]. For the entire industry, the core value of artificial intelligence will be further released on the basis of existing AI capabilities. Combined with the trend of business cloudification, artificial intelligence finance is entering a stage of deepening application innovation [61; 72; 97].

Artificial intelligence technology has been widely used in many financial companies. The digital brand "Digital Bank" of Industrial and Commercial Bank of China took the lead in proposing a five-dimensional layout of "digital ecology, digital assets, digital technology, digital infrastructure, and digital genes", among which artificial intelligence technology plays a vital role in this layout. China Everbright Bank has increased its investment in technology year by year for digital transformation and has achieved business breakthroughs in many areas of wealth management business. Among them, the online sales platform for wealth customers based on artificial intelligence has centralized the intelligent AI functions of online wealth management products, reduced human resource investment, and improved the intelligence level of wealth management business. China Pacific Insurance Company focuses on the three strategic directions of "big health, big region, and big data" to further promote the application and implementation of artificial intelligence technology, especially in the “insurance digital labor ecosystem”, with digital employees as the core. China

Pacific Insurance actively explores new application paradigms in big model technology, and tries to widely apply digital employees with big model capabilities in the insurance industry, thereby promoting the development of insurance technology.

The future development trend of the financial industry will also move towards more segmented and professional scenarios. First, based on the basic capabilities of financial big models, it will have a deeper understanding and exploration of user needs and behaviors, and provide customers with more refined and personalized services in marketing recommendations, investment advice, etc. Secondly, AI will be the core of the entire industry to build more efficient, intelligent, and secure financial services and system support. Finally, future policy orientations will further increase support for digital intelligent technology, encourage innovation, and improve governance norms, which will help ensure the stability of the financial industry and promote its sustainable development.

In summary, China has made continuous breakthroughs in the development and application of artificial intelligence technology. With continuous technological innovation and policy support, it is expected to continue to lead the development of the global artificial intelligence industry in the future, and strengthen China's competitive position in the global artificial intelligence landscape.

In China, AI has become a core component of the national development strategy, with the country investing heavily in R&D, technological innovation, and industry applications. The Chinese government has created a favorable ecosystem for the development of AI, promoting its application in multiple industries such as manufacturing, retail, and finance. China's rapid development in AI technologies such as deep learning, natural language processing, and computer vision has enabled it to take a leading position in the global AI field, and it is expected that China's AI market will continue to expand significantly in the coming years. In addition, China's AI development mainly relies on state-supported policies and projects, which provide a good environment for innovation and large-scale application.

2.2 Assessing the level of competitiveness of innovatively oriented industrial enterprises based on an integrated approach

To ensure the comprehensiveness of the study and conduct a systematic evaluation of the competitiveness of innovatively oriented industrial enterprises, selecting appropriate assessment objects (corporate entities) is crucial. These assessment objects should encompass a diversified range of industry characteristics rather than being limited to a single specialized field. Additionally, they must be able to provide rich and relevant data that can be used for evaluation. Therefore, this study selects five representative innovatively oriented industrial enterprises in China–BOE, Midea, BYD, CATL, and TCL–as the research subjects for horizontal comparison and analysis [18; 20; 27; 77; 114]. These five enterprises exert significant industry influence and lead innovation in fields such as new energy vehicles, battery technology, and high-tech manufacturing, thus representing China's current innovatively oriented industrial enterprises from various industrial dimensions.

The primary evaluation method employed in this section is the Composite Index Method, which assesses the competitiveness of innovatively oriented industrial enterprises. It analyzes the financial indicators of these companies, delving into their competitive potential and reserves, laying the foundation for further exploration in subsequent chapters, and promoting their sustainable development in the international competitive environment.

The Composite Index Method is an analytical approach that evaluates the competitiveness of enterprises through multiple indicators. It integrates various assessment criteria from different dimensions into a single composite score, helping researchers gain a comprehensive understanding of a company's competitive position. The core of the Composite Index Method lies in the assignment of different weights to the evaluation results from various dimensions, thereby creating a comprehensive score. Unlike traditional single-indicator methods, the Composite Index Method considers a broader range of factors, offering a more holistic and systematic approach to evaluation.

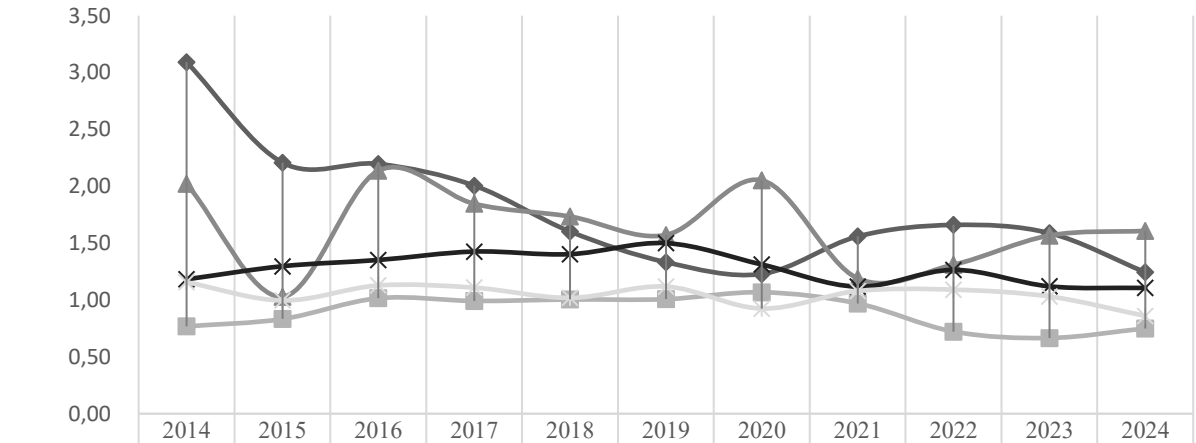
The assessment of corporate competitiveness is typically conducted from multiple dimensions. Many scholars have used financial indicators to evaluate competitiveness, with common dimensions including profitability, solvency, operational efficiency, and sustainability. Liu et al. [66] found that profitability and operational efficiency are key determinants of corporate competitiveness through an analysis of financial data from China's manufacturing enterprises. However, this study did not fully account for the impact of external market conditions, potentially leading to an overemphasis on financial metrics. In addition to financial perspectives, strategic choices are also crucial factors influencing corporate competitiveness. Song and Wang [108] examined the IT industry and argued that technological innovation, market segmentation, and brand development are essential to enhancing competitiveness. However, this research is limited to the IT sector, and its findings may not be applicable to other industries, particularly those that do not prioritize technological innovation. Furthermore, market positioning and brand influence have always been central to many studies. Zhang et al. [134] explored China's consumer goods industry, highlighting the importance of brand value and market share in driving corporate competitiveness.

Although this study provides valuable insights for the consumer goods industry, its applicability to other industries may be limited. Numerous studies indicate that the assessment of corporate competitiveness involves various dimensions such as financial performance, strategic positioning, brand building, sustainability, and digital transformation [69; 80; 104]. Each study has its own focus and limitations, reflecting the complexity of the field. Therefore, our research will focus on evaluating corporate competitiveness from four dimensions: profitability, solvency, operational efficiency, and sustainability. We aim to use this framework to conduct a comprehensive evaluation of the financial stability, market operational efficiency, debt management, and long-term sustainability of enterprises. Through a comparative analysis of relevant financial data from 2014 to 2024, this paper systematically observes the competitive potential of the sample enterprises over the past decade, achieving a comprehensive evaluation of their overall strength. This multidimensional approach not only reveals the

current competitive advantages of the enterprises but also helps to identify potential risks and areas for improvement, providing clear direction for future development. Ultimately, the findings will provide valuable data support and practical insights for strategic decision-making within the enterprises.

Debt Solvency. The assessment of solvency refers to a company's ability to repay its debts on time during its operations, reflecting its financial strength and overall financial condition. Solvency is typically analyzed in terms of short-term solvency and long-term solvency. Short-term solvency is primarily analyzed through the current ratio, which measures a company's ability to repay its current liabilities using its current assets. Long-term solvency is assessed through the balance sheet, focusing on the company's capacity to repay long-term debt principal and interest expenses. The solvency analysis of these enterprises provides profound insights into their capital management efficiency and financial stability, helping to understand their ability to bear risks and growth potential under different financial environments.

For short-term solvency, the higher the ratio within a reasonable range, the stronger the ability to repay debts in the short term (Fig. 2.4).



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
BOE	3,092474	2,208312	2,196969	2,006192	1,602046	1,332622	1,228909	1,559165	1,660217	1,588068	1,244
BYD	0,768228	0,832854	1,015776	0,991876	1,004326	1,007173	1,068073	0,969681	0,722386	0,665955	0,75
CATL	2,021	1,029	2,137	1,846	1,734	1,572	2,053	1,19	1,311	1,567	1,608
Midea	1,182	1,297	1,352	1,426	1,403	1,5	1,312	1,117	1,265	1,12	1,106
TCL	1,156411	0,995864	1,128233	1,108628	1,018677	1,118393	0,924974	1,079282	1,090841	1,030971	0,86

Figure 2.4 – Trends in Current Ratio of Five innovatively oriented industrial enterprises, 2014–2024

Source: Compiled by the author through corporate financial reports.

From the chart data, it can be seen that BOE’s current ratio has shown a clear downward trend, gradually declining from 3,09 in 2014, especially in 2015 and 2020. This trend reflects the increasing pressure on the company's short-term debt repayment, which may be closely related to its continued capital expenditure, industry cycle fluctuations and rising operating costs. If the turnover efficiency of current assets cannot be effectively improved, it may face challenges in dealing with liquidity risks and maintaining continuous innovation investment in the future.

BYD showed a continuously improving current ratio level, which fell slightly in 2023 but remained in a relatively reasonable range overall. The chart clearly shows its effectiveness in improving liquidity and optimizing short-term debt repayment structure. This improvement provides financial support for its high-intensity investment in new energy vehicles and batteries, and also enhances the company's financial flexibility during market expansion, which is an important manifestation of its steady increase in comprehensive competitiveness.

CATL’s current ratio remained at a relatively high level throughout the analysis period, fluctuating between 1,19 and 2,14, reflecting its strong short-term liquidity position. The ratio peaked at 2,14 in 2014 and experienced some volatility over the decade, declining to 1,19 in 2021 before recovering to 1,608 in 2024. This solid liquidity foundation provides CATL with the financial flexibility to sustain its heavy investment in battery research and development and global capacity expansion without compromising its short-term debt repayment capability.

Midea’s current ratio showed a slight but steady upward trend in the early stage, from 1,18 in 2014 to 1,50 in 2019, but it showed a slight downward trend in 2020. Although the increase is limited, the long-term stable upward trend reflects the company's good control over short-term debt repayment and financial stability. In the context of global supply chain adjustments and technological transformation, this financial stability will become an important support for its continued promotion of smart manufacturing and globalization strategies.

TCL's current ratio during this period changed relatively smoothly, always maintaining between 1,00 and 1,16, indicating that its short-term debt repayment ability remained stable without significant fluctuations. Although this result is not outstanding, it also shows that the company tends to be conservative in working capital management. If it hopes to improve financial flexibility in the future, it may need to make breakthroughs in improving liquidity utilization efficiency.

From the overall trend of the chart, CATL maintains consistently strong liquidity, with its current ratio well above the industry average throughout the period, providing a solid financial base for its ongoing battery and energy storage investment. Midea Group has demonstrated a solid operating foundation in stability, further strengthening its risk resistance. The continued decline in BOE's liquidity indicators needs to be taken seriously, as it may affect its efficiency in mobilising funds in the new round of technological competition. Although TCL has maintained a certain degree of stability, it may find it difficult to support future expansion or technological investment without structural improvements.

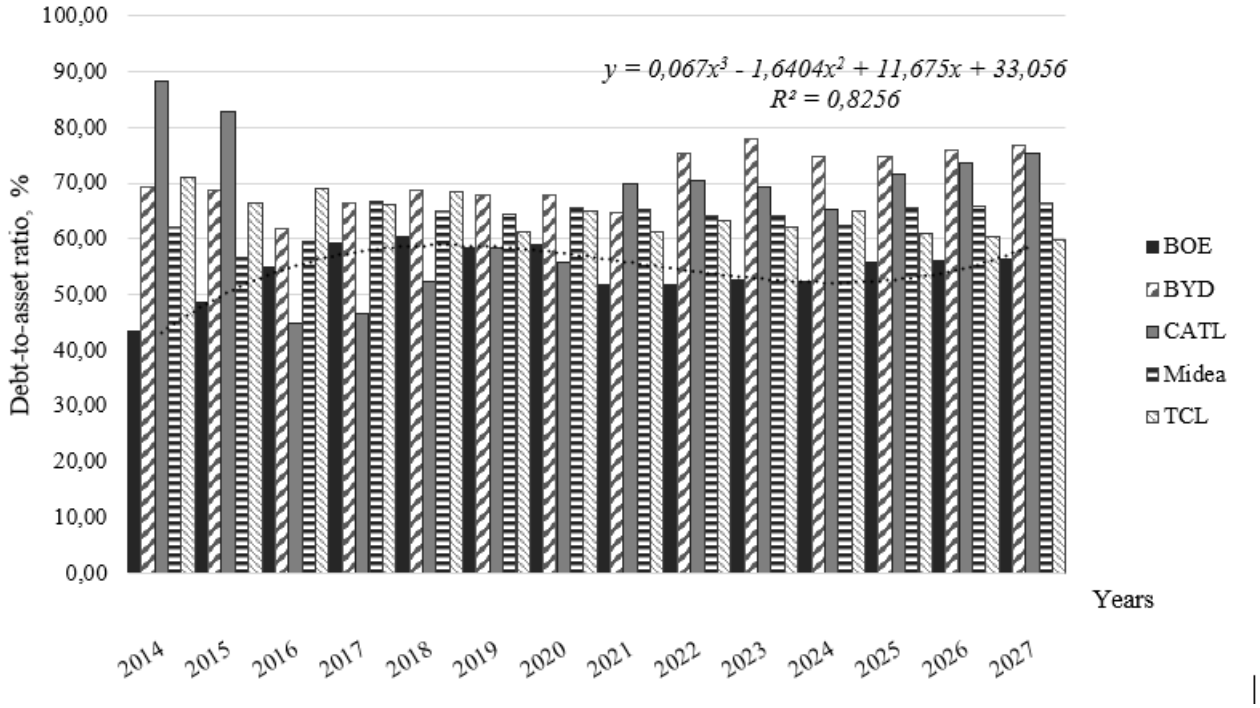


Figure 2.5 – Dynamics and forecast of the debt-to-asset ratio of five innovatively oriented industrial enterprises (2014–2027)

Source: adapted from [63].

The debt-to-asset ratio indicator can not only reflect the use of borrowed capital by an enterprise but also reflect the debt repayment ability of an enterprise. A high debt-to-asset ratio indicates that the enterprise has a large debt scale, a weak ability to repay loans, and a high risk. A low debt-to-asset ratio indicates that the enterprise has a good debt repayment ability but low efficiency in using capital. Based on the debt-to-asset ratio data of sample enterprises from 2014 to 2024, we can conduct an in-depth analysis of the financial leverage and debt repayment risks of these enterprises (see Fig. 2.5).

As can be seen from the chart, the debt-to-asset ratio shows a clear differentiation among different companies. BYD's debt-to-asset ratio is on the rise as a whole, from 69,26% in 2014 to 74,64% in 2024, showing its high reliance on external financing. Combined with its active layout in the fields of new energy vehicles and battery technology, it can be foreseen that it will continue to maintain a high capital investment model in the future to strengthen industrial chain integration and technological leadership. If this high leverage strategy can match revenue growth, it will bring significant competitive advantages to BYD.

Although BOE's debt-to-asset ratio increased from 43,51% in 2014 to 52,43% in 2024, it remained relatively stable overall, indicating that its capital structure is relatively sound. The conservative debt strategy enables it to have a strong risk resistance, providing it with sufficient financial flexibility in the fluctuation cycle of the panel industry, which is conducive to long-term stable development.

CATL's debt-to-asset ratio exhibited a notable shift over the decade, declining sharply from 88,33% in 2014 to 44,76% in 2016 as the company reduced its early-stage reliance on external financing, before gradually rising again to 65,24% in 2024 in tandem with its massive capacity expansion. This trajectory reflects CATL's strategic use of leverage to fund battery gigafactories and global supply chain investments. While the rising leverage warrants monitoring, it aligns with the company's aggressive growth ambitions and strong revenue growth, suggesting the debt burden remains manageable relative to its earnings capacity.

Midea's debt-to-asset ratio is relatively stable, fluctuating between 61,98% and 66,58%, reflecting its good balance between capital utilization and financial risk control. As a representative of the manufacturing and smart home appliance industries, its capital strategy reflects a balance between stability and flexibility. It is expected that it will continue to maintain a stable growth trend in the future and enhance its competitiveness in the global market.

TCL's debt-to-asset ratio has shown a certain downward trend, from 71,08% in 2014 to 64,92% in 2024. Although it is still at a high level overall, the downward trend shows that it is actively optimizing its financial structure. This shift may mean that TCL is shifting from an expansion-oriented to an efficiency-oriented approach. If this strategy is appropriate, it is expected to improve its profitability and return on capital, bringing new support to the company's competitiveness.

In summary, BYD and TCL have adopted a high-leverage development strategy, which reflects their strong ambition in technology research and development and market expansion, but they also need to pay attention to potential financial risks. BOE and Midea pay more attention to financial stability, building long-term development capabilities while maintaining capital security. CATL has adopted a dynamic leverage strategy, actively adjusting its capital structure in line with its expansion phases. In the future, companies need to achieve a precise balance between financing capabilities, innovation investment and risk control in order to maintain a competitive advantage in a rapidly changing market.

Operational Efficiency. Operational efficiency refers to the extent to which a company effectively utilizes its assets to generate operating income. Analyzing operational efficiency is essential for assessing whether the company is operating healthily and for identifying issues that need to be addressed. Operational efficiency reflects the actual operational condition of the enterprise and can be measured through indicators such as accounts receivable turnover, inventory turnover, and total asset turnover.

Accounts Receivable Turnover is the ratio of a company's sales revenue to the average accounts receivable balance, reflecting the speed at which accounts receivable are converted into cash and the efficiency of funds management. Based on the accounts receivable turnover data from 2014 to 2024, the performance of the five enterprises in managing their accounts receivable varies (see Figure 2.6).

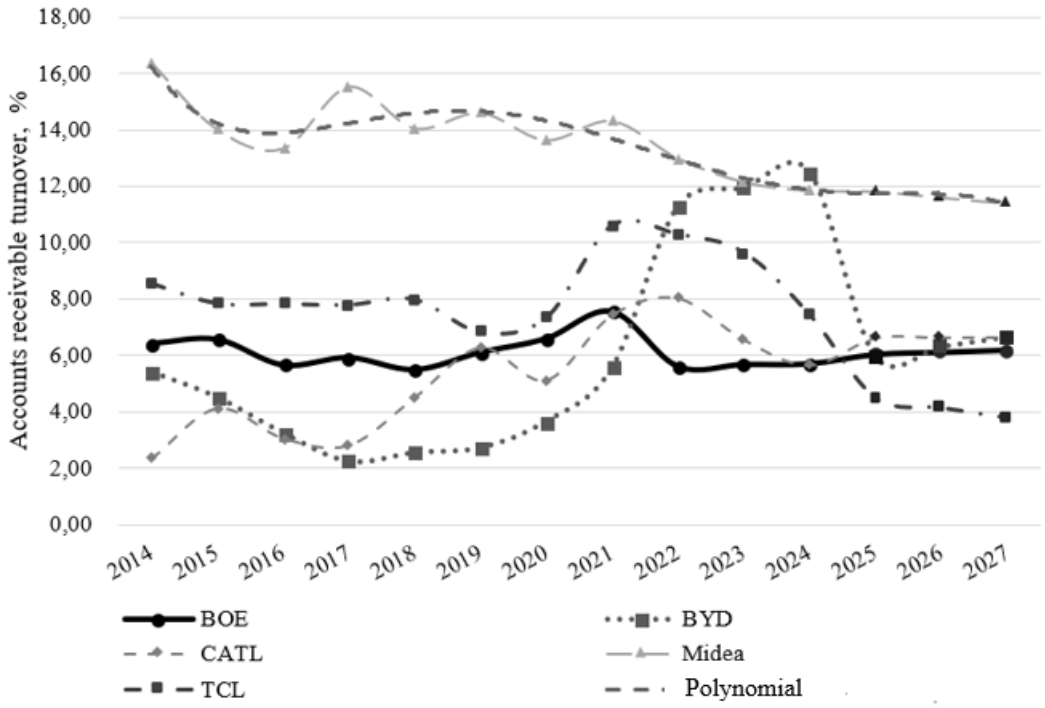


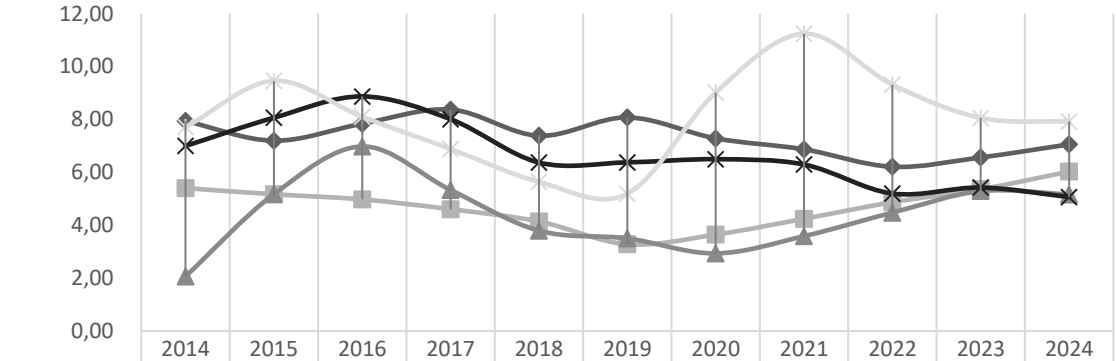
Figure 2.6 – Dynamics and forecast of accounts receivable turnover of five innovatively oriented industrial enterprises (2014–2027)

Source: adapted from [63].

According to the data from 2014 to 2024 in the chart, the accounts receivable turnover rate of each company shows different trends and capital recovery efficiency. BOE's turnover rate is low overall, 6,42 times in 2014. Although it once rose to 7,56 times in 2021, it fell to 5,60 times in 2022 and only 5,692 times in 2024, indicating that its capital recovery fluctuates and its efficiency needs to be improved. BYD performed outstandingly, with its turnover rate rising continuously from 5,43 times in 2014 to 12,52 times in 2024, and remaining at a double-digit level for three consecutive years since 2022, reflecting its strong collection ability and capital operation efficiency in the context of business expansion. CATL's receivables turnover rate showed a strong upward trend, rising from 2,33 times in 2014 to 8,04 times in 2022, before moderating

to 5,65 times in 2024. This improvement reflects the significant growth in its sales scale and increasingly efficient collection management as it expanded its customer base among global automakers. Midea showed a stable and high turnover capacity, which slightly decreased from 16,39 times in 2014 to 11,86 times in 2024. Although it has declined, it is still at the leading level in the industry. TCL's turnover rate fluctuated greatly, from 8,57 times in 2014 to 10,63 times in 2021 but then fell year by year to 7,45 times in 2024, indicating that its capital recovery situation is under certain pressure and uncertainty. Overall, BYD and Midea showed strong accounts receivable management capabilities. CATL demonstrated notable improvement in collection efficiency over the decade. BOE lagged behind in terms of collection efficiency and warrants continued attention.

Inventory Turnover is the ratio of a company's cost of sales to the average inventory balance, reflecting the efficiency of inventory management and asset liquidity. Figure 2.7 presents the inventory turnover data for the sample enterprises from 2014 to 2024, showing significant performance differences.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
BOE	7,938	7,195	7,836	8,372	7,382	8,075	7,283	6,868	6,209	6,563	7,056
BYD	5,401	5,17	4,975	4,605	4,142	3,28	3,644	4,244	4,869	5,36	6,026
CATL	2,063	5,17	6,977	5,333	3,793	3,501	2,934	3,587	4,475	5,289	5,165
Midea	6,994	8,062	8,868	8,008	6,369	6,375	6,495	6,294	5,196	5,424	5,068
TCL	7,71	9,46	8,097	6,881	5,641	5,189	9,015	11,24	9,311	8,056	7,916

Figure 2.7 – Trends in Inventory Turnover of Five innovatively oriented industrial enterprises, 2014–2024

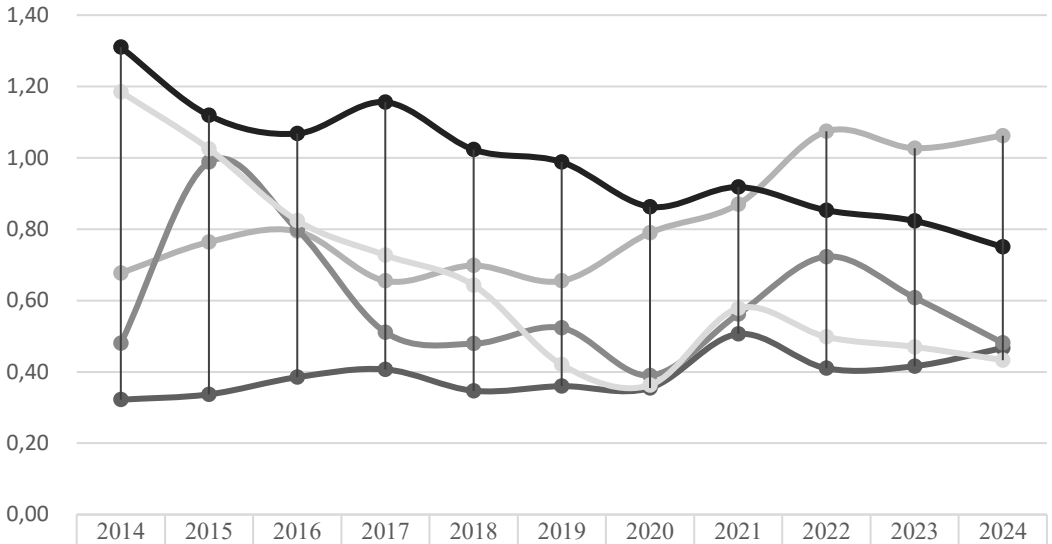
Source: Compiled by the author through corporate financial reports

The chart data shows that BOE's inventory turnover rate showed an overall downward trend from 2014 to 2024, from 7,94 times in 2014 to 6,21 times in 2022 and

slightly rebounded to 6,56 times in 2023 and 7,056 times in 2024. Although there was a slight rebound, the overall trend reflected that its inventory turnover efficiency fluctuated. BYD showed a relatively stable and gradually improving trend, from 5,40 times in 2014 to 5,36 times in 2023 after a short-term decline, and further increased to 6,026 times in 2024, showing that it continued to optimize inventory control and circulation efficiency. CATL's inventory turnover rate showed significant improvement over the decade, rising from 2,06 times in 2014 to a peak of 6,98 times in 2016, before settling at 5,17 times in 2024. This trajectory reflects the company's rapid scaling of production capacity and more efficient inventory management as its battery output grew, though the moderation in recent years suggests increasing complexity in supply chain coordination. Midea’s turnover rate is generally high, reaching 6,99 times in 2014, reaching a stage high of 6,50 times in 2020, and then declining to 5,068 times in 2024. Despite the decline, it still maintains a relatively good level in the manufacturing industry. TCL's performance fluctuates more significantly, rising from 7,71 times in 2014 to a peak of 11,24 times in 2021, and then declining to 7,916 times in 2024, indicating that its inventory management efficiency is somewhat unstable, which may be affected by changes in market demand or production rhythm.

Overall, BYD and Midea maintain good performance in inventory turnover, showing strong supply chain management and inventory scheduling capabilities. Although TCL and BOE are at an acceptable level overall, they need to be wary of potential inventory pressure caused by fluctuations in turnover efficiency. CATL's turnover efficiency has improved markedly over the period and is now broadly comparable with other manufacturing peers, reflecting the maturation of its production operations.

Total Asset Turnover is an indicator that measures the ratio between a company’s asset investment scale and its sales level. The higher the value of this indicator, the greater the return on investment in assets (see Fig. 2.8).



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
BOE	0,322	0,337	0,385	0,407	0,347	0,36	0,355	0,506	0,41	0,416	0,467
BYD	0,677	0,764	0,794	0,655	0,698	0,655	0,79	0,87	1,074	1,027	1,062
CATL	0,48	0,988	0,799	0,511	0,479	0,523	0,39	0,562	0,723	0,608	0,481
Midea	1,31	1,119	1,068	1,156	1,023	0,988	0,863	0,918	0,853	0,823	0,75
TCL	1,185	1,025	0,824	0,727	0,643	0,42	0,363	0,578	0,498	0,47	0,433

Figure 2.8 – Trends in Total Asset Turnover of Five innovatively oriented industrial enterprises (2014–2024)

Source: Compiled by the author through corporate financial reports

The chart data shows that BOE's total asset turnover rate has been rising steadily from 2014 to 2024, from 0,32 times in 2014 to 0,51 times in 2021 and 0,467 times in 2024. Although there are fluctuations, it generally reflects its continuous optimization in improving asset utilization efficiency. BYD has shown a more prominent growth trend, rising from 0,68 times in 2014 to 1,062 times in 2024, especially accelerating growth after 2021, reflecting its significant improvement in capital investment and resource allocation efficiency, which is also closely related to the rapid expansion of its new energy vehicle and battery business. CATL's total asset turnover rate declined from 0,48 times in 2014 to 0,39 times in 2020, before recovering to 0,72 times in 2022 and moderating to 0,48 times in 2024. This pattern is consistent with the capital-intensive nature of battery manufacturing, where large upfront asset investments temporarily suppress turnover ratios before capacity utilisation ramps up.

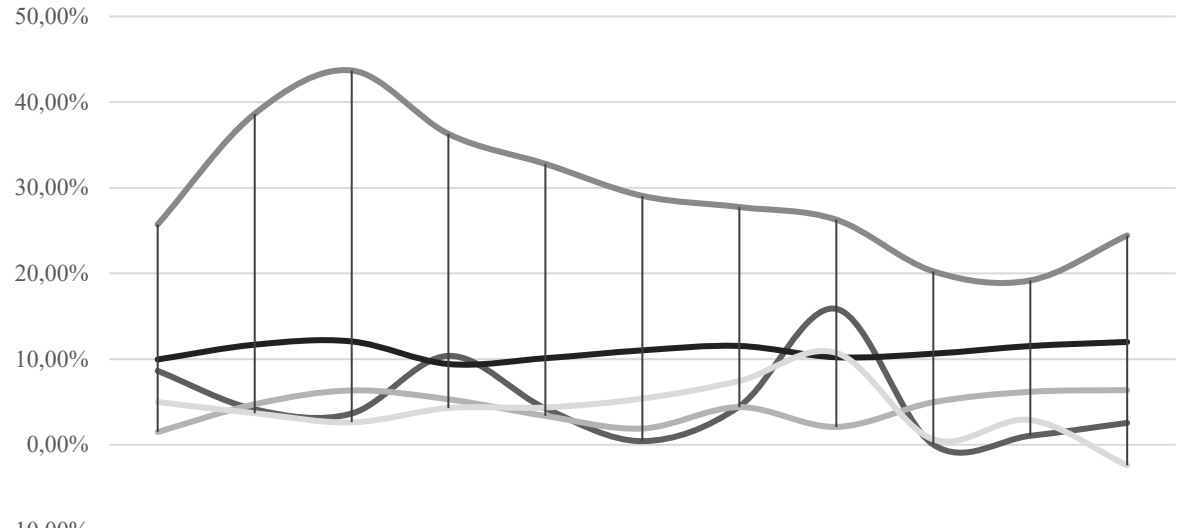
The recovery after 2020 reflects improved production efficiency as its gigafactories reached higher utilisation rates. Midea's asset turnover rate remains at a relatively high

level in the industry, at 1,31 times in 2014. Although it has been declining year by year, reaching 0,75 times in 2024, overall, its asset utilization efficiency is still at a relatively good level, demonstrating strong capital turnover and operational management capabilities. TCL, on the other hand, shows a clear downward trend, with an asset turnover rate of 1,185 times in 2014, a brief rebound to 0,58 times in 2021, but a drop to 0,433 times in 2024, indicating that it has certain management pressure in resource allocation and asset efficiency, or faces strong production capacity or inventory consumption problems. Overall, BYD performs best in improving the efficiency of total asset utilization, followed by Midea, while BOE shows a positive momentum of improvement. TCL needs to further optimize its asset structure to improve capital efficiency. CATL's turnover trajectory suggests that its heavy asset investment cycle is gradually yielding efficiency gains, and further improvement is expected as global capacity utilization continues to increase.

Profitability. Profitability refers to how much profit a company can generate for its owners. Profitability indicator analysis can not only reflect the company's operating performance and quality, but also find problems in the company's operating links. The company's profitability is measured by operating profit margin and profit margin indicators. Figure 2.9 presents the operating profit margin data of the sample enterprises from 2014 to 2024.

The chart data shows that BOE's net profit margin fluctuated significantly between 2014 and 2024. It was 8,63% in 2014. Although it reached a high level of 10,38% in 2017, it has fluctuated since then, falling to 0,43% in 2019 and approaching zero in 2022, at only 0,03%, reflecting that its profitability is susceptible to industry cycles and market changes. However, it briefly rebounded to 15,87% in 2021 and rebounded to 2,56% in 2024, indicating that the company still has a certain potential for profit recovery in its continuous adjustments and responses to challenges. BYD showed a stable and positive trend, reaching 1,50% in 2014, and then continued to grow overall, reaching 6,19% in 2023 and further increasing to 6,39% in 2024, reflecting the continuous improvement of its profitability in core businesses such as new energy

vehicles and energy storage. CATL’s operating profit margin has remained at a consistently high level throughout the analysis period, 25,73% in 2014, and while it declined somewhat from its peak of 43,70% in 2016, it has stabilized at around 24,44% in 2024. This reflects CATL's strong pricing power in the global battery market and its ability to maintain substantial margins even amid increasing competition from domestic rivals and rising raw material costs.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
BOE	0,0863	0,0414	0,0365	0,1038	0,0425	0,0043	0,0449	0,1587	0,0003	0,0105	0,0256
BYD	0,015	0,0474	0,0635	0,0531	0,0337	0,019	0,044	0,0209	0,0497	0,0619	0,0639
CATL	0,2573	0,3864	0,437	0,3629	0,3279	0,2906	0,2776	0,2628	0,2025	0,1919	0,2444
Midea	0,0996	0,1169	0,1207	0,0943	0,1011	0,1103	0,1154	0,1022	0,1064	0,1153	0,1201
TCL	0,0499	0,0369	0,0262	0,0429	0,0436	0,054	0,0746	0,1073	0,0063	0,029	-0,024

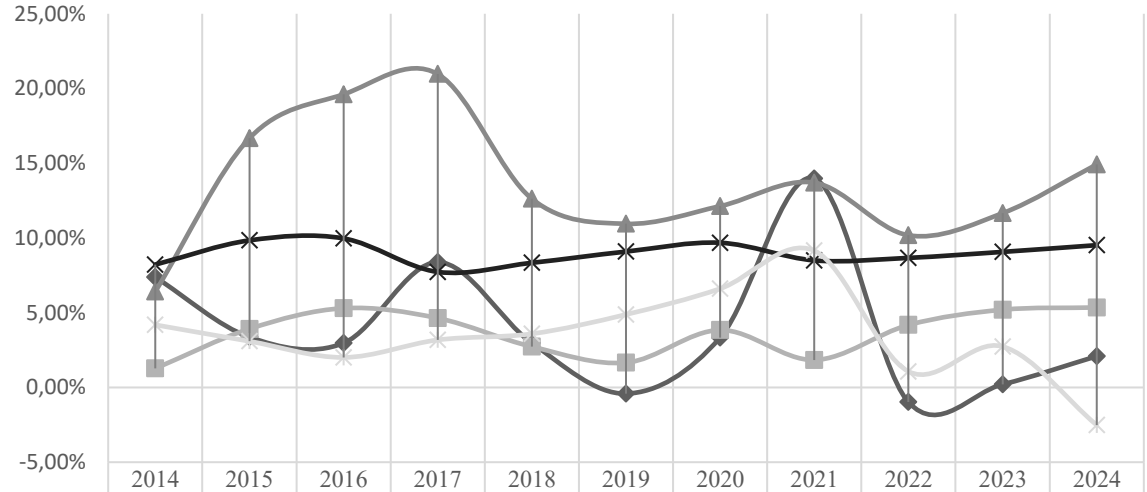
Figure 2.9 – Trends in Operating Profit Margin of Five innovatively oriented industrial enterprises (2014–2024)

Source: Compiled by the author through corporate financial reports

Midea has stable performance, with a net profit margin of more than 10% all year round, 9,96% in 2014, 11,53% in 2023, and 12,01% in 2024, showing the stability and maturity of its manufacturing efficiency, global supply chain layout and market demand management. TCL's net profit margin is weaker, 4,99% in 2014, reaching 10,73% in 2021, but then declining continuously, and even turned negative in 2024, at -2,40%, showing that it is under great pressure in cost control, product structure adjustment or market competition.

Overall, CATL leads the operating profit margin among the five companies with consistently high and stable margins, reflecting its dominant market position in the battery industry. BYD and Midea have performed steadily, and their sustained growth reflects their advantages in industrial layout and operational efficiency. In contrast, BOE's profitability fluctuates greatly, and TCL needs to pay attention to the sustainability and stability of its net profit to achieve long-term financial health.

Figure 2.10 is an analysis of the net profit margin data of five companies from 2014 to 2024, reflecting the differences and changing trends in the profitability efficiency of each company over the past decade.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
BOE	0,0738	0,0337	0,0297	0,0838	0,0297	-0,0041	0,0334	0,1398	-0,0098	0,0021	0,0209
BYD	0,0127	0,0392	0,053	0,0464	0,0273	0,0166	0,0384	0,0184	0,0418	0,052	0,0535
CATL	0,0641	0,1667	0,1961	0,2097	0,1262	0,1095	0,1213	0,137	0,1018	0,1166	0,1492
Midea	0,0822	0,0984	0,0997	0,0773	0,0834	0,0909	0,0968	0,085	0,0867	0,0907	0,0952
TCL	0,0419	0,0309	0,0201	0,0318	0,0359	0,0488	0,0661	0,0915	0,0107	0,0274	-0,0252

Figure 2.10 – Net profit margin trends of Five innovatively oriented industrial enterprises (2014–2024)

Source: Compiled by the author through corporate financial reports

The chart shows that BOE's net profit margin fluctuated significantly between 2014 and 2024. It was 7,38% in 2014, but it has declined several times since then, recording negative values of -0,41% and -0,98% in 2019 and 2022, respectively, showing that the company's profitability is vulnerable to shocks under industry adjustments or cost pressures. Although it once increased to 13,98% in 2021, overall, its profit level lacks

stability, indicating that it still has room for improvement in product structure optimization and cost control.

In summary, CATL leads in net profit margin among manufacturing enterprises, with its dominant position in the global battery industry translating into consistently strong profitability. BYD and Midea show stable and growing profit performance, and are representatives of strong profitability among physical enterprises. BOE and TCL's profit margins fluctuate greatly, especially TCL needs to be vigilant about the problem of profitability sustainability and urgently needs to optimize its core business and cost structure.

Growth Potential. Growth capability is to measure the current and future sustainable development capabilities of an enterprise by analyzing existing financial data. The growth capability of an enterprise is analyzed by the growth rate of total operating income and net profit. (see Figure 2.11; Figure 2.12).

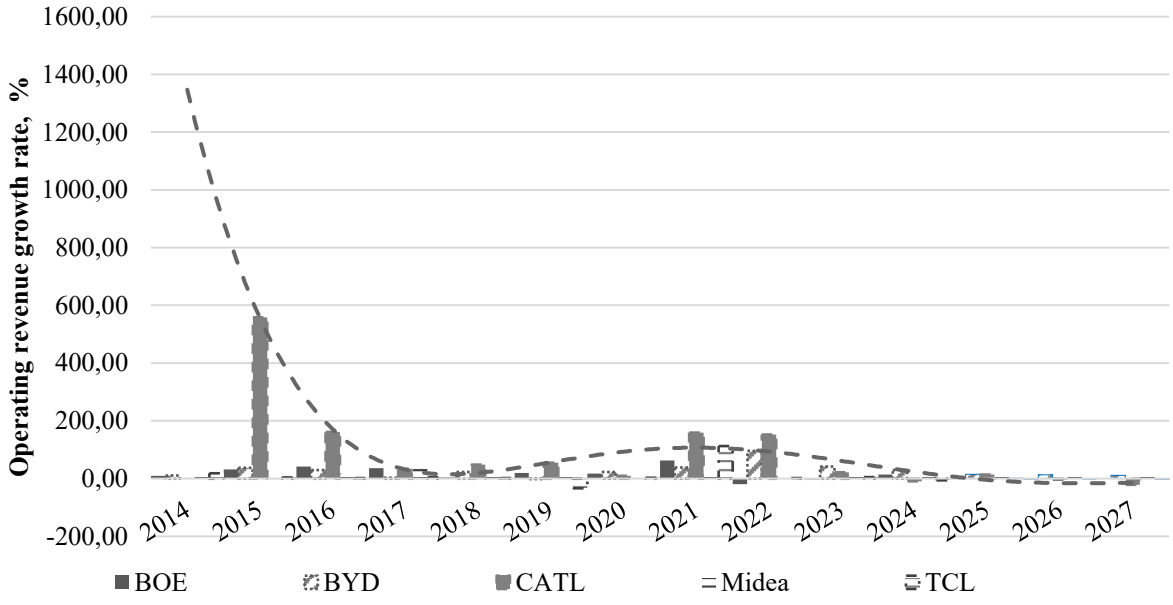
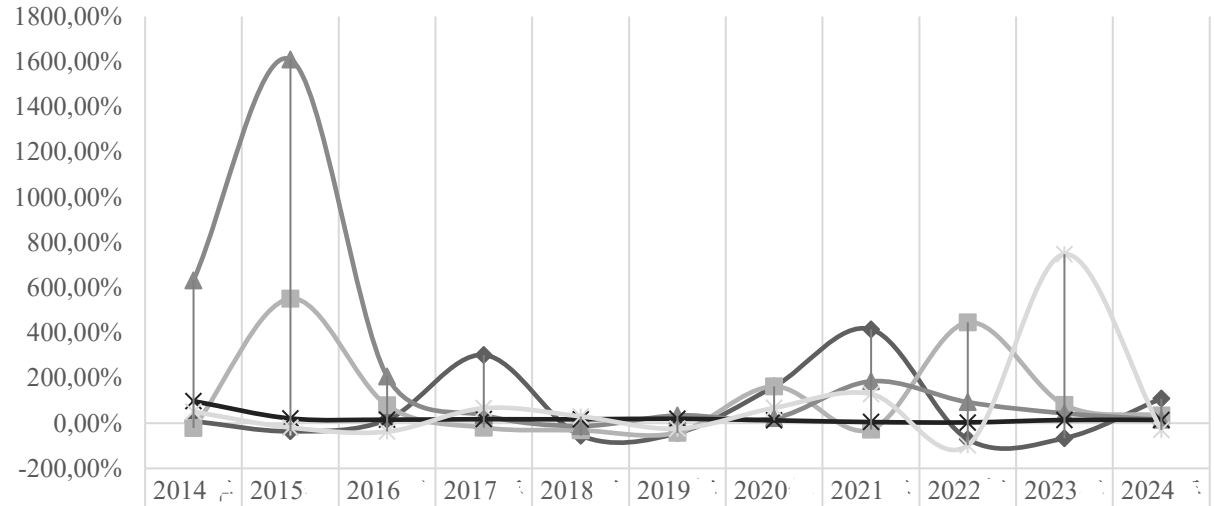


Figure 2.11 – Dynamics and forecast of the operating income growth rate of five innovatively oriented industrial enterprises (2014–2027)

Source: adapted from [63].

In summary, BYD has the strongest and most consistent operating income growth among the five companies, reflecting the strong driving force brought by high growth and high technology; CATL has demonstrated extraordinary growth momentum over

the decade, though its recent revenue contraction highlights the emerging challenges of market maturation and competitive pricing pressure. TCL has large growth fluctuations and relatively weak risk resistance; BOE and Midea are in the middle, and although there are bright spots in the years, their overall revenue growth is deeply affected by the industry environment, and they need to optimize their structure and enhance their sustainable growth capabilities in the future.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
BOE	0,0887	-0,3614	0,1505	3,0199	-0,5461	-0,4415	1,6246	4,1554	-0,7095	-0,6622	1,0897
BYD	-0,2161	5,5128	0,7894	-0,1951	-0,3163	-0,4193	1,6227	-0,2808	4,4586	0,8072	0,34
CATL	6,3221	16,0994	2,0643	0,3598	-0,1266	0,3464	0,2243	1,8534	0,9289	0,4358	0,1501
Midea	0,975	0,2099	0,1556	0,177	0,1705	0,1968	0,1244	0,0496	0,0343	0,141	0,1429
TCL	0,5093	-0,1936	-0,3759	0,663	0,3017	-0,2452	0,6763	1,2935	-0,974	7,476	-0,2938

Figure 2.12 – Trends in Net profit growth rate of Five innovatively oriented industrial enterprises (2014–2024)

Source: Compiled by the author through corporate financial reports

According to the chart data, BOE's net profit growth rate has fluctuated greatly in the past decade, with a growth rate of 301,99% in 2017 and 415,54% in 2021, reflecting explosive growth in the industry boom cycle. However, this performance is not sustained, with a sharp decline of -70,95% and -66,22% in 2022 and 2023, respectively, reflecting that its profitability is highly sensitive to market demand and industry cycles, and the quality of growth is still unstable. Although it rebounded in 2024 (108,97%), the overall fluctuation was drastic, indicating that the company's profit structure needs to be further optimized and stabilized.

BYD has shown a more continuous growth advantage throughout the cycle. The net profit growth rate reached 551,28% in 2015, 162,27% in 2020 and 445,86% in 2022, respectively, showing its strong profitability against the background of the rapid development of new energy business. Although negative growth occurred in 2019 and 2021 (-41,93% and -28,08%), overall, the company's profit performance is stable and resilient, and it will still maintain positive growth (34,00%) in 2024, highlighting its continued driving force in the expansion of its core business.

CATL's net profit growth rate showed remarkable volatility, with extraordinary growth of 1609,94% in 2015 and 206,43% in 2016 during its early expansion phase, before moderating significantly. Growth turned negative in 2018 (-12,66%) and again in 2019 (34,64% recovery), then surged to 185,34% in 2021 driven by the global EV boom. Net profit growth moderated to 92,89% in 2022 and 43,58% in 2023, before settling at 15,01% in 2024. This trajectory reflects CATL's transition from a high-growth startup phase to a more mature stage of development, with profit expansion increasingly driven by operational efficiency rather than pure revenue scaling.

Midea's growth rate is generally moderate. From 2014 to 2016, it rose steadily, reaching 97,50%, 20,99% and 15,56% respectively, showing its stable expansion under the traditional manufacturing industry. However, after 2020, the growth of net profit slowed down significantly, falling to 4,96% in 2021 and only 3,43% in 2022. Although it rebounded slightly to 14,10% in 2023, the growth momentum was slightly insufficient compared with the early performance, indicating that it needs to find new breakthroughs in smart manufacturing and consumer scenario innovation.

TCL's net profit growth rate is extremely volatile. In 2016 and 2017, it achieved growth of 66,30% and 30,17% respectively, but in 2019 and 2022, it showed a sharp negative growth (-24,52% and -97,40%). Although it rebounded to 747,60% in 2023 due to the low base, it quickly turned to -29,38% in 2024. Such fluctuations show that its business profitability is unstable, or there are still obvious shortcomings in product structure adjustment and cost control.

Overall, BYD has the most stable performance in terms of net profit growth. Benefiting from the rapid development of the new energy vehicle industry, its growth trend has continuity; although BOE has outstanding performance in some years, its overall volatility is large and it needs to improve the quality of growth; CATL has experienced extraordinary growth phases but is now transitioning to a more stable earnings profile as the battery market matures; Midea reflects the pressure of slowing growth of traditional manufacturing companies; TCL's growth fluctuations are extreme, indicating that it still needs to be deeply optimized in terms of strategic direction and profit structure. Notwithstanding BYD's growth stability, its composite competitiveness score ranks lowest among the five enterprises (Table 2.4), as the entropy weight method assigns significant weight to solvency and operational efficiency dimensions where BYD underperforms relative to peers. The composite score therefore captures competitive breadth across all four dimensions simultaneously, not growth momentum alone.

Given the non-linear and unstable indicator dynamics visualized in Figures 2.5, 2.6 and 2.11 [46; 63], this study employs the Entropy Weight Method (EWM) to determine the indicator weights objectively. Unlike expert-based or arbitrarily assigned weighting schemes, EWM derives weights directly from the data, assigning greater weight to indicators that exhibit higher differentiation across observations. This eliminates subjective bias and ensures methodological transparency and replicability.

The analysis is based on a panel dataset comprising 55 observations (five firms × eleven years, 2014–2024) across nine indicators organized into four competitive dimensions: Profitability (Operating Profit Margin, Net Profit Margin), Solvency (Debt-to-Asset Ratio, Current Ratio), Operational Efficiency (Inventory Turnover, Receivables Turnover, Total Asset Turnover), and Growth Potential (Revenue Growth Rate, Net Profit Growth Rate). The EWM calculation proceeds in four steps.

Step 1 – Min-Max Normalization. All raw indicator values are normalized to [0, 1]. For positive indicators (higher is better):

$$S_{ij} = \frac{x_{ij} - \min_j}{\max_j - \min_j} \quad . \tag{2.1}$$

For the negative indicator, Debt-to-Asset Ratio (lower is better):

$$S_{ij} = \frac{\max_j - x_{ij}}{\max_j - \min_j} \quad . \tag{2.2}$$

Step 2 – Entropy Calculation. The information entropy of each indicator is computed as:

$$H_j = -\frac{1}{\ln 55} \times \sum p_{ij} \cdot \ln(p_{ij}), \tag{2.3}$$

where p_{ij} is the proportion of the *i*-th observation's normalised value for indicator *j*:

$$p_{ij} = \frac{S_{ij}}{\sum_i S_{ij}} \quad . \tag{2.4}$$

Step 3 – Weight Derivation. The weight of each indicator is derived as:

$$w_j = \frac{(1 - H_j)}{\sum_k (1 - H_k)}. \tag{2.5}$$

This ensures all weights sum to unity.

Step 4 – Composite Score. Each firm's composite score is:

$$\text{Score}_i = \sum_j w_j \times \overline{S_{ij}} \ , \tag{2.6}$$

where s_{ij} is the firm's eleven-year average normalised value for indicator j. The resulting indicator-level entropy values, differentiation coefficients, and weights are presented in Table 2.2, and the aggregated dimension-level weights derived by summing the constituent indicator weights are shown in Table 2.3.

Table 2.2 – Entropy weight method: indicator entropy values, differentiation coefficients, and weights

Indicator	Type	Entropy (H_j)	Diff. Coeff. (d_j)	Weight (w_j)	Weight (%)
Profitability					
Operating Profit Margin	+	0,9301	0,0699	0,1236	12,36
Net Profit Margin	+	0,9625	0,0375	0,0664	6,64
Solvency					
Debt-to-Asset Ratio	−	0,9830	0,0170	0,0301	3,01
Current Ratio	+	0,9457	0,0543	0,0961	9,61
Operational Efficiency					
Inventory Turnover	+	0,9722	0,0278	0,0491	4,91
Receivables Turnover	+	0,9392	0,0608	0,1077	10,77
Total Asset Turnover	+	0,9294	0,0706	0,1250	12,50
Growth Potential					
Revenue Growth Rate	+	0,8963	0,1037	0,1835	18,35
Net Profit Growth Rate	+	0,8765	0,1235	0,2185	21,85
Total	9	–	0,5651	1,0000	100,00

Source: Author's calculations based on corporate financial reports (2014–2024).

Note: Type "+" = positive indicator (higher is better); "–" = negative indicator (lower is better); $d_j = 1 - H_j$. All weights sum to 1,0000.

Table 2.3 – Aggregated Dimension Weights Derived from the Entropy Weight Method

Dimension	No. of Indicators	Aggregated Weight (%
Profitability	2	19,00
Solvency	2	12,62
Operational Efficiency	3	28,18
Growth Potential	2	40,20

Source: Author's calculations. Dimension weights are the sum of constituent indicator weights from Table 2.2.

The EWM results reveal that Growth Potential receives the highest aggregated weight (40,20%), reflecting the greatest cross-firm variation in revenue and net profit growth rates over the eleven-year panel.

Operational Efficiency follows (28,18%), driven particularly by differences in receivables and total asset turnover. Profitability accounts for 19,00% of total weight, while Solvency receives the lowest weight (12,62%), indicating that the five firms are relatively similar in their debt and liquidity profiles. These data-driven weights provide a transparent and replicable basis for the composite score, superseding any subjective allocation.

Table 2.4 – Composite Competitiveness Scores and Rankings of Five innovatively oriented industrial enterprises (EWM)

Rank	Company	Composite Score	Key Observation
1	CATL	0.3553	Highest overall competitiveness; strong profitability and growth
2	Midea	0.3366	Excellent operational efficiency and stable profitability
3	TCL	0.2216	Moderate competitiveness; growth potential below peers
4	BOE	0.2100	Low composite score; profitability volatility is the main drag
5	BYD	0.2092	Lowest composite score; high growth but weak short-term efficiency

Source: Author's calculations. $C_i = \Sigma_j (w_j \times \bar{S}_{ij})$*, where* $\bar{S}_{ij}$ *is the eleven-year average normalised value for firm* i *on indicator* j.

Based on the composite scores, CATL ranks first (0,3553) due to its consistently strong profitability margins and high growth rates during the sample period. Midea ranks second (0,3366), supported by the highest operational efficiency among all five firms. TCL (0,2216), BOE (0,2100), and BYD (0,2092) occupy the lower tier, with BYD's low short-term efficiency and operational turnover metrics constraining its composite score despite its strong growth trajectory in recent years.

Table 2.5 – Key Competitive Weaknesses and Improvement Reserves Identified in innovatively oriented industrial enterprises

No.	Competitive Reserv	Summary of Problem Characteristics
1	Unstable profitabilit	Large fluctuations in net and operating profit margins; unstable profit mode
2	Low-quality and volatile growth	Volatile revenue and net profit growth; lack of sustainable growth strategies
3	Pressure on short-term solvency	Declining or low current ratio; liquidity risk management concerns
4	Risky debt structure	High debt ratios with reliance on external financing; elevated financial risk

Source: Developed by the author

If these areas can be effectively addressed, enterprises will be better positioned to realise their competitive potential and sustain their advantages in the international arena.

Financial and operational empirical data from 2014 to 2024 show that these five companies generally exhibit recurring competitive weaknesses, including large fluctuations in profitability, unstable growth trajectories, inefficient asset utilisation in certain firms, and variable short-term debt repayment capacity. These patterns are summarised in Table 2.5.

The weaknesses (Table 2.5) all fall within the domain of enterprise operation and strategic control, rooted in internal decision-making regarding capital structure, cost management, inventory policy, and debt management. Therefore, Section 2.3 will further explore each company's competitive reserves by identifying untapped potential and areas for improvement, providing a foundation for subsequent strategic optimisation.

2.3 Determining the reserves of competitive potential of innovatively oriented industrial enterprises in the context of global transformations

The identification of competitive reserves, as set out in this section, proceeds from the financial assessment conducted in Section 2.2. However, the context established in Section 2.1 is equally relevant here: the five enterprises under study operate in a

technology market in which artificial intelligence has become the principal driver of competitive differentiation. This has a direct bearing on where competitive reserves are located and how they can be mobilized. For enterprises active in the AI technology market, the most significant untapped reserves are not confined to balance sheet items alone – they include the capacity to integrate AI into operational processes, to commercialize AI-driven products and services, and to redirect financial resources freed through efficiency gains towards R&D investment in AI capabilities. The measures outlined below therefore treat AI-enabled transformation not as a separate strategic consideration, but as a concrete mechanism through which each of the four competitive dimensions can be strengthened.

The global environment in which these five enterprises compete has undergone profound structural shifts that directly reshape the location and accessibility of competitive reserves. Four transformations are of particular relevance [9; 10; 45]. First, the rapid diffusion of artificial intelligence is disrupting competitive hierarchies across all sectors in which the sample enterprises operate: AI-enabled manufacturing optimization, smart product development, and algorithm-driven supply chains are redefining cost structures and time-to-market, such that enterprises that fail to invest in AI capabilities risk seeing their efficiency and margin advantages erode faster than traditional financial indicators would suggest. Second, the reconfiguration of global supply chains under geopolitical pressure – including technology export controls, friend-shoring policies, and the decoupling of US-China technology ecosystems – has forced Chinese innovatively oriented industrial enterprises to accelerate domestic substitution in semiconductors, advanced materials, and precision components, creating both a new source of competitive pressure and a strategic reserve opportunity for enterprises capable of leading this substitution.

Third, the global green energy transition is reshaping demand trajectories for new energy vehicles, battery storage systems, and smart appliances, creating an asymmetric competitive landscape in which enterprises aligned with the transition (such as BYD and CATL) enjoy structural tailwinds, while those dependent on legacy product lines

face accelerating demand erosion. Fourth, China's own industrial upgrade agenda – moving up the value chain from low-margin assembly to high-margin innovation – introduces both regulatory support mechanisms and intensifying domestic competition, compressing margins for enterprises that cannot demonstrate genuine technological differentiation.

These four global transformation pressures converge on a single strategic imperative: the enterprises under study must mobilize their financial and operational reserves not merely to restore balance sheet health, but to fund the technological and organizational innovations necessary to remain competitive as their external environment shifts structurally. The identification of competitive reserves in this section is therefore conducted against this backdrop of global transformation. For each enterprise, the gap between its current financial position and the relevant industry benchmark (see Table 2.2) represents not only an internal inefficiency to be corrected, but an untapped reservoir of resources that, if mobilized, would expand that enterprise's capacity to adapt to, and benefit from, the transformations described above. An enterprise that successfully improves its solvency, operational efficiency, profitability, and growth trajectory does not merely achieve stronger financial metrics – it builds the structural resilience and strategic flexibility necessary to navigate the uncertainty of global transformation and to sustain its competitive position in international markets.

In the context of global change, innovatively oriented industrial enterprises, as the core force of technological innovation, must actively adapt to the impact of global change and seek new development space and competitive potential in the transformation. In order to implement the direction of improving the competitiveness of innovatively oriented industrial enterprises, their innovation process should be determined. The innovation process largely determines the intensity and nature of enterprise development and its competitiveness in domestic and foreign markets. Effective innovation development enables enterprises to enhance their international competitive position. The improvement of business activity level can not only drive the

improvement of competitiveness, but also help improve the economic stability of enterprises in a complex external environment. When determining the competitive reserve, it is necessary to consider the time to obtain actual economic benefits and the degree of uncertainty of their benefits (or the risk level of innovation investment) [64; 109].

Table 2.6 – Innovation orientation assessment of five sample enterprises (2017-2024)

Company	Main innovation areas	Average R&D spending, 2017–2024	R&D intensity, 2017 and 2024	Patents	Main innovations
BYD	Electric vehicles, batteries, vehicle software	RMB 17,5 billion; 2024: RMB 54,2 billion	3,0% to 6,97%; steady growth	More than 120000	Blade Battery; fifth-generation hybrid system; driver assistance; battery-as-a-service; DiSus body control
CATL	Batteries, energy storage, artificial intelligence in battery management	RMB 19,5 billion; 2024: RMB 18,6 billion	3,6% to 5,14%; generally upward	43354 applications	Solid-state batteries; AI-assisted factories; battery-as-a-service; Tener energy storage
BOE	Displays, augmented and virtual reality, flexible screens, smart manufacturing	About RMB 10,9 billion; 2024: about RMB 15 billion (estimated)	About 0,7% to 7,6%; strong growth	More than 100000 applications	Inkjet-printed screens; Mini-LED; silicon-based Micro-LED; AI-assisted yield optimisation
Midea	Smart appliances, industrial automation, artificial intelligence and connected devices	RMB 12,6 billion; 2024: more than RMB 16 billion	3,1% to about 3,9%; steady growth	More than 150000 applications worldwide	MEIA platform; KUKA robotics; connected zero-carbon factories; smart-home ecosystem
TCL	Displays, semiconductors, solar energy	RMB 5,5 billion; 2024: RMB 7 billion	3,2% to about 4,2%; moderate growth	Not disclosed	21,6-inch inkjet-printed screen; Mini-LED; augmented-reality glasses; smart manufacturing

Source: Compiled by the author based on corporate annual reports (2017–2024) disclosed on cninfo.com.cn and CNIPA patent database. R&D Intensity = R&D expenditure ÷ total operating revenue × 100%. 8-year average calculated from annual report disclosures for each fiscal year.

The use of competitive reserves is affected by the level of innovation activities. Fundamentally speaking, innovation activities are the process of transforming potential opportunities into real competitiveness. The effectiveness of this transformation determines whether an enterprise can achieve a real breakthrough. In this process, innovation can become a key factor in promoting competitiveness, but it can also weaken the strength of an enterprise due to improper implementation. Therefore, innovation activities act as a specific coefficient that can enhance or reduce the competitive potential of an enterprise. Innovation activities can be regarded as a "potential enhancement factor" From a strategic perspective, strengthening reserve utilization and increasing business activity are important measures to enhance a company's competitive potential and improve its overall strength.

I.V. Bagrova, L.V. Balabanova, A.E. Voronkova, T.O. Zagorna et al. [33] explore the issue of identifying competitive reserves and their potential for improvement. Only when a company possesses certain reserves can it improve its competitiveness. The concept of “reserve” itself can be understood from two perspectives:

1) Reserves in a narrow sense – inventory, the existence of which is essential for production and circulation (French "reserve" means "inventory"; Latin “reserve” means "reserve") [33]. They are essential for the continued development of production at the enterprise level, the industry level and the entire economy level;

2) Reserves in a broad sense – unused opportunities for enterprise development [49; 87]. This paper adopts the latter understanding of the concept of "reserves" in the study of enterprise competitiveness. Therefore, one of the important ways to realize the competitive potential of innovatively oriented industrial enterprises is the formation, identification and utilization of internal reserves. At the same time, internal reserves refer to a series of unused opportunities for reducing product costs, reducing enterprise debt ratios, and improving the utilization of fixed assets, material, labor and financial resources at a certain level of business activity [60]. Based on the evaluation of enterprise problems in Section 2.2 (see Table 2.2) and the ranking of the evaluation results (see Table 2.1).

Prior to identifying the competitive reserves of each enterprise, it is necessary to establish their innovation orientation – that is, the degree to which each company is strategically committed to innovation as a primary source of competitive advantage. Table 2.6 presents a comparative assessment of the five sample enterprises across key innovation indicators, substantiating their classification as innovatively oriented industrial enterprises and providing context for the reserve-based analysis that follows.

At one end of the spectrum, BYD and CATL demonstrate the highest innovation orientation across the eight-year observation period (2017–2024), characterised by substantial and consistently growing absolute R&D expenditure, rising R&D intensity relative to revenue, and extensive patent portfolios built around clearly defined proprietary technology platforms. BYD's R&D expenditure grew from RMB 3,8 billion in 2017 to RMB 54,2 billion in 2024 - a fourteen-fold increase – with R&D intensity rising from 3,0% to 6,97%, reflecting a sustained strategic commitment to innovation that underpins its global NEV sales leadership. CATL maintained the highest absolute R&D expenditure among the five enterprises over the period, averaging RMB 19,5 billion annually, with R&D intensity rising from 3,6% to 5,14% and an extensive patent portfolio of over 43000 applications, supporting its 37,9% share of the global EV battery market.

Midea occupies a strong intermediate position, combining the largest global patent portfolio among the five enterprises (over 150000 applications) with a steadily rising R&D expenditure trajectory from RMB 7,4 billion in 2017 to over RMB 16 billion in 2024. Although its R&D intensity ratio has grown more modestly (3,1% to approximately 3,9%), reflecting the scale effect of its rapidly expanding revenue base, the absolute commitment to innovation investment is broad-based – spanning consumer appliances, industrial automation, and robotics – providing a diversified foundation for sustained competitive advantage.

BOE and TCL, while demonstrating genuine and improving innovation investment over the eight-year period, exhibit more constrained trajectories. BOE's R&D intensity has risen sharply from approximately 0,7% in 2017 to approximately

7,6% in 2024, reflecting a deliberate technological repositioning from commodity LCD panels toward higher-value flexible OLED and AR/VR display segments, supported by over 100000 patent applications and world-first commercialisation of inkjet-printed OLED technology. TCL shows a more modest upward trend in R&D intensity (3,2% to approximately 4,2%), with absolute expenditure constrained by ongoing structural losses in its photovoltaic subsidiary. For both enterprises, the gap between innovation asset accumulation and financial performance is precisely the dimension that the reserve-based analysis in the following sections seeks to address.

Table 2.7 – Reserve-based measures and innovation linkages for optimizing enterprise competitiveness

No.	Area	Measures using reserves	Role in innovation
1	Solvency	Increase equity, retain profits and restructure selected debts to reduce leverage and financial risk.	Stronger solvency lowers debt servicing costs and frees funds for research and technology. Financially stable enterprises can finance longer innovation projects with less reliance on expensive borrowing [3].
2	Operational efficiency	Improve working capital management, collect receivables faster and streamline supply chains.	This releases cash from receivables and excess inventory for automation, digitalisation and intelligent supply chain systems, which further improve efficiency and reduce costs [102].
3	Profitability	Shift toward products with higher margins, reduce costs and expand recurring service income.	Higher margins provide internal funds for research and new products. Innovation raises profitability, which then supports further technological development [41].
4	Growth potential	Combine technological, financial and market reserves to expand sales, enter new markets and reinvest.	Growth spreads innovation costs across a larger sales base and improves returns on research. Commercialising solutions in new energy, intelligent manufacturing and artificial intelligence strengthens international competitiveness [41].

Source: Author's development

The reserve-based measures identified below should therefore be understood not merely as balance sheet optimization tools, but as instruments for creating the financial headroom necessary to support technology-driven competitive strategies. The four dimensions and their linkage to innovation are summarized in Table 2.7.

Before presenting the reserve-based measures, it is necessary to address the methodological choice to focus on financial indicators rather than innovation potential indicators (such as the number of patents, new product launches, or R&D expenditure ratios). Innovation potential indicators are undoubtedly relevant for assessing the long-term competitiveness of innovatively oriented industrial enterprises. However, the present study treats financial reserves as the foundational precondition for the realization of innovation potential: an enterprise with insufficient liquidity, an unsustainable debt burden, or negative profit margins lacks the internal resources required to fund R&D pipelines, bring new products to market, or attract the external capital that innovation activities require.

In this sense, financial health is not an alternative to innovation capacity but its necessary enabler. Moreover, financial indicators offer standardized, quantifiable metrics with established industry benchmarks, enabling objective cross-enterprise comparison – a feature that innovation potential indicators (which vary substantially in definition and measurability across sectors) do not consistently provide. The approach adopted here therefore reflects a deliberate sequencing: identifying and mobilizing financial reserves creates the structural conditions under which innovation potential indicators can subsequently improve. This connection is made explicit in the Innovation Linkage column of Table 2.7 and in the analytical summaries following each dimension. Based on the competitive reserves identified in Table 2.7, the following actions and measures are recommended to improve the economic efficiency and competitiveness of innovatively oriented industrial enterprises.

Solvency primarily depends on a company's liquidity and leverage structure, measured by indicators such as the current ratio and debt-to-equity ratio. Improving solvency relies on effective working capital management, timely debt reduction,

optimized capital structure, and maintaining a sustainable balance between liabilities and shareholders' equity.

As of the end of 2024, the current ratio indicators of the five sample companies are as follows: TCL, 0,86; BYD, 0,75; BOE, 1,244; CATL, 1,608; Midea, 1,106.

TCL's low current ratio indicates significant working capital pressure. It is recommended that the company consider securitizing a portion of its accounts receivable through an asset-backed vehicle, converting illiquid trade receivables into immediate cash inflows. TCL can further leverage its AI-driven demand forecasting capabilities – already deployed in its display and smart home divisions – to optimize inventory levels dynamically, reducing excess stock and the associated working capital tie-up. In parallel, renegotiating supplier payment terms to extend payables maturities, combined with AI-assisted lean inventory management, could further reduce pressure on current liabilities. Together, these measures are expected to meaningfully strengthen TCL's short-term liquidity position and bring its current ratio closer to the industry-standard healthy range of 1,2–1,5 [130].

BYD's relatively low current ratio reflects its high capital expenditures and aggressive growth trajectory. It is recommended that BYD implement a blockchain-based invoice discounting programme to accelerate monetization of accounts receivable – a process that can be further streamlined through the AI-powered financial management systems BYD has been deploying across its supply chain operations. Refinancing a portion of its short-term bank loans through medium-term notes or a revolving credit facility would further reduce current liabilities. Together, these measures are expected to meaningfully improve BYD's liquidity and bring its current ratio closer to the industry-standard healthy range of 1,2–1,5 [130].

BOE’s current liquidity position is adequate, but further working capital optimization is recommended. Pledging a portion of high-quality receivables for structured financing would provide immediate cash inflow and shorten receivables turnover days. BOE can also deploy its AI-based display yield optimization systems – developed for its panel production lines – to reduce inventory waste and improve asset

utilization, thereby strengthening working capital efficiency. Renegotiating an extension of accounts payable maturities with suppliers and converting a portion of short-term loans into long-term debt would further reduce current liabilities. Together, these measures are expected to further optimize BOE's balance sheet stability and consolidate its position within the healthy range.

CATL maintains a healthy current ratio of 1,608, reflecting its strong short-term liquidity. To further strengthen resilience, CATL can leverage its AI-powered battery management systems and predictive manufacturing analytics to reduce raw material buffer stock requirements, directly improving the composition of current assets. Additionally, deploying idle cash into short-term structured instruments and renegotiating extended payment terms with key battery raw material suppliers would further reduce short-term liabilities, bringing the current ratio closer to the 1,7–2,0 range typical of leading global capital-intensive manufacturers.

Midea Group's liquidity position is generally strong, but strategic improvements could further enhance its resilience. Midea has already invested heavily in AI-driven smart manufacturing systems across its appliance production network; extending these systems to enable real-time inventory optimization would allow the company to adopt a just-in-time model with greater precision, reducing inventory holdings and the corresponding short-term liabilities. In addition, offering early payment discounts to customers supported by Midea's AI-based customer credit scoring platform would accelerate cash inflows and strengthen the current asset base. These combined measures are expected to strengthen Midea's liquidity resilience and bring its current ratio toward the 1,2–1,5 benchmark [130].

These interventions are consistent with the working capital optimization theory based on empirical literature: securitization and accounts receivable financing can improve liquidity without increasing balance sheet debt, while accounts payable deferral and lean inventory practices can effectively reduce working capital [3; 102].

By strengthening liquidity and bringing the current ratio toward the industry-standard healthy range, companies can reduce short-term default risk and costly reliance

on short-term financing. Critically, the cash freed through these measures can be redirected toward long-term strategic investment – including R&D expenditure, technology licensing, and digitalization initiatives. For innovatively oriented industrial enterprises, solvency improvement creates the financial headroom necessary to fund the technological innovations that drive sustainable competitive advantage. Some propositions regarding the improving the current ratio indicators are given in Appendix B, Table B.1.

As of the end of 2024, the debt-to-asset ratio indicators of the five sample companies are as follows: TCL, 64,92%; BYD, 74,64%; BOE, 52,43%; CATL, 65,24%; Midea, 62,33%. In order to cope with high leverage ratios, the above five companies can adopt a structured deleveraging strategy based on targeted financing and asset optimization. The following suggestions combine empirical benchmarks and financial model logic to predict the specific decline in debt ratios in the next two to three years.

Midea could adopt a deleveraging strategy by retaining a significant portion of its annual earnings, channeling a portion of retained cash into AI infrastructure and smart manufacturing investment that simultaneously reduces future operating costs and strengthens the equity base.

Meanwhile, Midea could spin off its smart home or robotics subsidiaries or partially list them, improving its equity structure and freeing up capital without incurring additional debt. Together, these initiatives are expected to bring Midea’s debt ratio toward the 55–57% benchmark for diversified manufacturing conglomerates.

Measures aimed at the improving the debt ratio indicators are represented in Appendix B, Table B.2.

These measures are grounded in empirical financial theory: Akbar et al. [3] confirm the effectiveness of equity injections and asset disposals in reducing leverage. By strengthening their capital structures and reducing systemic financial risk, the five companies can lower their cost of capital, expand their capacity for debt-free innovation investment, and position themselves to pursue technology-intensive growth strategies that would otherwise be constrained by excessive leverage.

Operational efficiency reflects the efficiency with which a company uses its competitive reserves (including production, technology, and information resources) to create sustainable revenue streams. Improving operational efficiency depends on effectively deploying these reserves, optimizing working capital, streamlining production processes, and improving supply chain coordination to achieve long-term growth potential. In 2024, the accounts receivable turnover ratios of the sample companies were as follows: TCL, 7,45, BYD, 12,52, BOE, 5,692, CATL, 5,65, and Midea, 11,86. These data reflect the efficiency of each company in collecting trade receivables. A lower turnover ratio means slower collection, tying up working capital, reducing liquidity, and potentially increasing financial risk. Empirical finance literature suggests that improving turnover directly enhances free cash flow and reduces the need for external financing [130].

The following sections describe each company's strategy, including targeted actionable measures and the expected direction of improvement relative to industry benchmarks. TCL can shorten its collection cycle, thereby improving its capital efficiency and reducing its reliance on debt. One effective measure is to deploy an AI-driven customer credit scoring and dynamic risk assessment system to reform its credit policy, enabling faster and more accurate credit decisions that reduce overdue receivables. Combined with receivables securitization through asset-backed commercial paper, the company can meaningfully reduce outstanding sales turnover days and improve collection efficiency, freeing up working capital for reinvestment or debt repayment. In addition, TCL can introduce a tiered early payment discount system for B2B buyers, offering modest discounts for early settlement. This would shorten the average collection period and free up cash flow for reinvestment or debt repayment.

While BYD already demonstrates strong collection efficiency, it can further optimize its performance by extending the AI capabilities embedded in its vehicle software ecosystem to its financial operations. Specifically, implementing a blockchain-based invoicing and settlement platform integrated with AI-driven dispute resolution would reduce contested balances and accelerate payment processing, meaningfully

improving collection efficiency.

Another strategy is to renegotiate payment terms with auto dealers, shortening collection periods for a meaningful share of outstanding receivables. Together, these improvements could free up a significant amount of working capital annually, reducing the need for interest-bearing financing.

BOE's annual accounts receivable collection rate of approximately 5,7 times falls below the industry average for display and hardware manufacturers. To improve liquidity, the company could deploy AI-based cash flow forecasting tools to identify collection bottlenecks in real time, enabling proactive follow-up on overdue accounts. Combined with a reverse factoring programme with major panel customers, which would shorten invoice settlement periods, these measures would meaningfully accelerate collection efficiency.

CATL’s receivables turnover ratio of 5,65 reflects the long collection cycles typical of supplying large automotive OEMs. CATL can leverage its existing digital supply chain platform – which already integrates AI-based battery production scheduling with customer order management – to implement automated payment tracking and early-warning systems for accounts approaching overdue status. Combined with a reverse factoring programme with top-tier OEM customers, which would shorten settlement periods from 90 days to 30–45 days, these AI-enabled measures would meaningfully improve collection efficiency. with top-tier customers (approximately RMB 15 billion in receivables), shortening settlement periods from 90 days to 30–45 days.

A second measure is to tighten margin financing policies by reducing customer credit limits. Reducing margin liabilities by RMB 2 billion to RMB 3 billion will effectively shorten the repayment cycle. By 2026, the turnover rate is expected to reach approximately 6,8, freeing up approximately RMB 3 billion to 4 billion in accounts receivable. This will reduce interest costs and mitigate operational credit risk.

Midea's turnover rate is already high at nearly 12 times, but there is still room for further improvement. Midea has the advantage of an established AI platform across its

smart appliance ecosystem; extending this to include an AI-based invoice reconciliation and automated collections system would reduce manual processing time and shorten the average settlement period, further improving collection efficiency while reducing administrative costs.

Another initiative is offering early payment rebates to downstream buyers, which would reduce payment delays and accelerate cash conversion across the receivables portfolio. Together, these initiatives are expected to generate meaningful additional liquidity for redeployment into operational and strategic priorities.

Recommended reserve-based measures for improving accounts receivable turnover are highlighted in Appendix B, Table B.3.

Profitability is influenced by factors such as profit margin growth, which is determined by increased volume, reduced costs, increased sales revenue, improved product quality, and the utilization of fixed and working capital.

At the end of 2024, the net profit margins of the five sample companies showed significant variation: TCL (-2,52%), BYD (5,35%), BOE (2,09%), CATL (14,92%), and Midea (9,52%). CATL's strong net profit margin reflects its dominant market position and pricing power in the global battery supply chain. BYD and Midea's profit margins remained at the mid-single-digit level common in manufacturing; BOE lagged significantly behind; and TCL recorded a negative profit margin due to restructuring costs. Improving profitability is crucial for long-term competitiveness, and empirical literature shows that improved net profit margins facilitate reinvestment, reduce debt, and improve financial flexibility [54]. The profit margin optimization plans proposed by each company are detailed below, along with measurable measures and the expected impact on net profit margin by 2026.

TCL Technology must quickly restore profitability to reverse its current decline. A central lever is the deployment of AI-driven product development and manufacturing optimization in its semiconductor, photovoltaic, and Mini-LED display businesses. AI-assisted chip design tools and automated quality inspection systems can shorten product development cycles and reduce defect rates, shifting the revenue mix toward higher-

margin products. This strategic reorientation toward AI-enabled high-margin segments is expected to contribute meaningfully to a recovery in net profit margin.Recommended reserve-based measures for improving net profit margin are represented in Appendix B, Table B.4.

In 2024, the operating profit margins of the five companies are: BOE: 2,56%, BYD: 6,39%, CATL: 24,44%, Midea: 12,01%, and TCL Technology: -2,40%. CATL's strong operating profit margin reflects its pricing power and scale advantages in the global battery market. In contrast, TCL Technology is still struggling with structural losses. Academic research shows that improving operating margins by reducing costs, optimizing processes, or providing higher-value products can boost internal cash flow, enabling companies to reinvest and reduce their reliance on external financing [82].

Specific, measurable interventions for each company are outlined below, along with operating margin projections for 2026.

TCL faces significant challenges in restoring operating profitability and must prioritize structural transformation. A key enabler is applying AI-driven process automation to its Mini-LED and OLED production lines, which can reduce scrap rates, improve yield, and lower per-unit manufacturing costs – directly improving operating margins in these higher-value segments. Reallocating revenue toward these AI-optimized product lines, away from legacy consumer electronics, is expected to support TCL's return toward a positive operating margin consistent with the 1–2% benchmark for manufacturers undergoing business transformation.

BYD has a strong foundation in core profitability and is expected to further improve its operating margin through AI-enabled efficiency gains. BYD's AI-powered cell production and battery pack assembly systems already deliver industry-leading cost efficiency; further optimization through machine learning-based quality control and predictive maintenance can reduce per-unit manufacturing costs across its automotive revenue base. Combined with a focus on high-end overseas markets where AI-differentiated vehicle features command premium pricing, these measures are expected to meaningfully improve BYD's operating margin toward the 8–9% EV sector

benchmark [82].

BOE still has room to improve its operating performance through AI-powered upstream investment and service innovation. BOE's AI-based display calibration and defect detection systems, already in use across its production lines, can be further scaled to improve yield rates in its higher-margin flexible OLED and AR/VR panel businesses. Monetising existing hardware infrastructure through AI-enhanced long-term maintenance and remote diagnostics service contracts would add a high-margin recurring revenue stream. These changes are expected to bring BOE's operating margin toward the 4–5% hardware sector benchmark.

CATL’s operating profit margin of 24,44% is the highest among the manufacturing enterprises in the sample, supported by its AI-optimized cell formation and testing processes. To maintain this advantage, CATL should continue deepening its AI capabilities in gigafactory operations – including machine learning-based formation protocol optimization, AI-driven quality inspection, and predictive maintenance systems – which can further reduce per-unit production costs. Accelerating the transition to solid-state battery products, where CATL’s AI-assisted electrolyte and electrode development provides a technological lead, would sustain the company’s premium margin position as competition intensifies in conventional lithium-ion batteries.

Midea Group can improve its operating margin by monetizing investments in the MEIA AI platform. Integrated across manufacturing and smart home products, MEIA supports high-margin subscription services, including energy optimization, predictive diagnostics, and home automation, while AI-driven production automation can reduce operating costs. These initiatives could raise Midea’s operating margin toward the 14–16% benchmark for diversified appliance manufacturers [82].

The recommended reserve-based measures for improving operating profit margin are highlighted in Appendix B, Table B.5.

These interventions are consistent with empirical financial research showing that introducing high-margin services and improving cost efficiencies produces meaningful operating margin improvement in medium-to-large manufacturing enterprises [54].

Higher operating margins generate the organic free cash flow that innovatively oriented industrial enterprises require to sustain R&D pipelines, prototype new technologies, and bring innovative products to market without excessive dependence on external capital.

By improving operating profit margins, these companies can enhance their ability to generate organic free cash flow – the most flexible source of innovation funding. Unlike debt or equity financing, internally generated cash carries no fixed obligations, allowing enterprises to direct resources toward high-risk, high-reward technological innovation projects that are difficult to finance externally. This makes operating margin improvement a foundational enabler of the innovation-driven competitiveness that characterises world-class enterprises in the sectors under study.

In 2024, the total operating revenue growth rates of the sample companies varied significantly: BYD achieved a 29,02% growth rate, BOE and Midea achieved 13,66% and 9,47% growth rates, respectively, CATL recorded a -9,70% growth rate, and TCL's was -5,44%. This performance disparity highlights gaps in operations and strategies among the companies. Targeted interventions, given a certain level of business activity, could help improve this metric.

TCL's revenue declined significantly in 2024, reflecting the structural challenge of competing in commoditized consumer electronics. To revive growth, TCL should accelerate investment in AI-enabled product differentiation: deploying on-device AI in its Mini-LED and OLED televisions for personalized content recommendation and smart ambient adjustment, and integrating AI voice and vision capabilities into its smart home devices, would create defensible competitive features that support premium pricing and volume recovery. Additionally, introducing AI-powered remote diagnostics and predictive maintenance service contracts for its hardware portfolio would open a recurring revenue stream.

Empirical research confirms that product innovation has a significant positive contribution to revenue growth [41] and profitability. These AI-centred initiatives are expected to support a return toward positive revenue growth, consistent with the 5–10% benchmark for diversified technology manufacturers [41].

BYD’s strong growth performance is underpinned by its integrated AI capabilities across vehicle design, production, and in-car experience. To sustain this trajectory, BYD should deepen its AI-driven software-defined vehicle strategy: expanding over-the-air (OTA) AI feature updates, developing advanced driver assistance system (ADAS) subscription tiers, and scaling its AI-powered battery-as-a-service (BaaS) model globally. These software and service layers generate recurring AI-enabled revenue streams that are less exposed to hardware price competition. Additionally, establishing international joint ventures with regional AI and automotive partners to improve local responsiveness would further stimulate overseas demand. These initiatives are expected to sustain BYD's above-market growth trajectory, consistent with the 20–30% benchmark for high-growth EV sector leaders [41].

BOE's revenue growth rate of 13,66% reflects solid momentum, and the company can accelerate this by leveraging AI to move further up the display value chain. BOE's AI-powered display calibration algorithms and machine vision quality systems are core assets that can be embedded into its AR/VR and flexible OLED products as proprietary software features – differentiating these products from commodity alternatives and supporting premium pricing. Additionally, integrating AI-driven IoT connectivity capabilities into commercial display solutions would expand BOE's addressable market into smart retail, smart transportation, and digital signage. These AI-enabled diversification measures are expected to strengthen BOE's growth trajectory toward the 15–18% benchmark for display hardware sector leaders.

CATL’s revenue declined by 9,70% in 2024, reflecting the intensifying commoditisation of standard lithium-ion EV batteries. To reverse this trend, CATL should leverage its AI-driven battery management and energy storage optimisation systems as competitive differentiators in higher-growth segments. Specifically, deploying AI-powered grid-scale energy storage management systems (where CATL’s algorithms can optimise charge-discharge cycles for maximum grid stability) would accelerate penetration of the rapidly growing ESS market, reducing dependence on the EV battery cycle. Similarly, offering AI-enabled battery health monitoring and lifecycle

management as part of international OEM partnerships would differentiate CATL's offering beyond hardware and support expansion in overseas markets.

Midea Group's growth rate of 9,47% reflects the early commercial returns of its AI and IoT platform investments. The company is executing a deliberate transformation from appliance manufacturer to AI-powered smart home ecosystem provider: its MEIA AI system connects household appliances, learns user habits, and delivers personalised automation and energy management. As this ecosystem expands – with increasing device interconnection, growing subscription service revenue, and AI-driven cross-selling – it creates compounding growth momentum that is structurally more resilient than hardware sales alone. Additionally, AI-powered agile manufacturing and intelligent supply chain coordination can shorten time-to-market for new products. These AI-centred initiatives are expected to strengthen Midea's revenue growth trajectory toward the 8–12% benchmark for diversified smart appliance manufacturers.

Recommended reserve-based measures for improving revenue growth rate are represented in Appendix B, Table B.6. These interventions are grounded in empirical research demonstrating the positive impact of product and service innovation on revenue growth and long-term competitiveness [8; 41]. Revenue growth and innovation investment are mutually reinforcing: growth expands the revenue base over which R&D costs are amortised, improving innovation returns; while successful innovations open new markets and generate further revenue. By unlocking their growth reserves, the five enterprises can establish this virtuous cycle – translating financial improvements into technological advancement, and technological advancement into sustained international competitive strength.

We also believe that government support will help enhance the competitiveness of innovative companies, including through improved legislative frameworks, participation in national policies to support access to foreign markets, and participation in innovation development. Therefore, to improve the efficiency of innovative companies, it is necessary to significantly expand the scope for action across all factors and place greater emphasis on identifying and leveraging hidden reserves. Based on the conducted

research, it can be concluded that the proposed approach to studying the competitive potential of innovatively oriented industrial enterprises is an effective tool for determining the reserves that can be utilized to strengthen their competitive position under global transformation conditions.

Conclusions to Chapter 2

The analysis conducted in the second chapter made it possible to identify the main trends in the development of China's artificial intelligence market, determine the factors influencing the competitiveness of innovatively oriented industrial enterprises, and assess the competitive positions of five companies. The conclusions are as follows.

1. Based on the analysis and synthesis of statistical and forecast data on the global and Chinese artificial intelligence markets, in fulfilment of research task 4, the current state, trends, and development prospects of the AI market in China have been determined. The global AI market is projected to reach USD 3680,47 billion by 2034, with a compound annual growth rate of 21,2%, while the Chinese market is expected to expand from RMB 678 billion to RMB 1,1 trillion by 2029. These findings confirm the structural need for innovatively oriented industrial enterprises to develop systematic competitive positioning capabilities in AI-intensive sectors. The obtained result is useful for substantiating strategic priorities for strengthening enterprise competitiveness in the rapidly expanding AI market.

2. Based on the calculation and comparative analysis of enterprise indicators using the Composite Index Method and the improved Entropy Weight Method, in fulfilment of research task 5, the competitiveness of five representative Chinese innovatively oriented industrial enterprises – BYD, CATL, BOE, Midea, and TCL – has been assessed. Using 11-year panel data for 2014–2024, objective weights were determined for four dimensions: Growth Potential – 40,20%, Operational Efficiency – 28,18%, Profitability – 19,00%, and Solvency – 12,62%. The resulting competitiveness ranking placed CATL first (0,3553), followed by Midea (0,3366), TCL (0,2216), BOE

(0,2100), and BYD (0,2092). The obtained result provides an objective basis for comparing enterprises, identifying their relative competitive positions, and developing targeted measures to improve competitiveness.

3. Based on the comparison of enterprise indicators with industry benchmarks and the analysis of identified financial gaps, in fulfilment of research task 6, the competitive reserves of the five selected enterprises have been identified and quantified. As an element of scientific novelty, reserve-based improvement measures have been developed for solvency, operational efficiency, profitability, and growth potential, with each measure linked to a specific financial gap. The Innovation Linkage mechanism has also been established, demonstrating how the mobilisation of financial reserves creates the conditions for sustained innovation investment and stronger long-term international competitive positioning. The obtained result is useful for transforming identified financial gaps into practical improvement priorities and directing enterprise resources towards measures with the greatest competitive effect.

CHAPTER 3
DEVELOPMENT OF A SYSTEM OF ECONOMIC AND ORGANIZATIONAL MEASURES FOR ENSURING THE COMPETITIVENESS OF INNOVATIVELY ORIENTED ENTERPRISES BASED ON TECHNOLOGICAL INNOVATION, RESOURCE PROVISION, AND INTEGRATION OF ECONOMIC EFFORTS

3.1 Multivariate regression modeling of international competitiveness of innovatively oriented industrial enterprises based on technological innovation

In today's globalized and highly competitive business environment, technological innovation has become a key factor in shaping the international competitiveness of enterprises. With increasingly close market connections, enterprises need to not only develop new technologies but also commercialize them quickly to ensure competitive advantages [117]. By continuously improving technological capabilities, enterprises can improve operational efficiency, promote sustainable growth, and occupy significant market share in domestic and international fields [6]. In addition, empirical studies have shown that large R&D investment is often a prerequisite for improved export performance, thus consolidating the link between innovation and international market success [8]. Although a large amount of literature confirms the positive correlation between technological innovation and international competitiveness, there are still some key gaps. In other words, although previous studies have confirmed the general connection between innovation and competitive advantage, the underlying mechanisms by which firms transform their innovative activities into tangible competitive outcomes have not yet been fully elucidated. Elucidating these mechanisms is essential to building a more comprehensive theoretical framework that can guide academic research and practical decision-making [7; 44; 62]. To address this gap, our study focuses on Chinese A-share listed manufacturing companies from 2016 to 2021, a period characterized by rapid technological advancement and intensifying global competition. By examining the

relationship between technological innovation and international competitiveness in this context, we aim to provide new insights into the drivers and outcomes of innovation in the context of global transformation, offering guidance for managers and policymakers seeking to promote economic growth and enhance competitiveness amid rapid change.

In recent years, many scholars have devoted themselves to studying how corporate R&D investment can promote the improvement of internal operational efficiency and overall performance, thereby indirectly enhancing the competitiveness of enterprises in the global market. When examining the impact of operating performance on international competitiveness, researchers generally believe that internal operating efficiency and overall performance levels are the key to the success of enterprises in global market competition. Excellent operating performance is not only reflected in improving productivity and reducing costs, but also in improving product quality and accelerating market response. These factors enable enterprises to provide high-quality products with competitive prices in the international market, thereby establishing a unique competitive advantage.

Based on these insights, the following conceptual proposition is advanced:

Proposition 1: It is assumed that technological innovation positively affects the financial performance of enterprises, and that this improvement in financial performance constitutes the primary mechanism through which innovation investment translates into enhanced international competitiveness.

The role of enterprise scale in shaping the impact of technological innovation on international competitiveness has also attracted widespread attention in recent studies.

The research of Aarstad and Kvitastein [1] shows that the moderating effect of enterprise scale on R&D efficiency is particularly significant. Although R&D usually promotes technological progress, its impact varies among enterprises of different sizes. Smaller enterprises are often better able to convert R&D investment into innovative products due to their more flexible structure and more efficient decision-making process, thereby obtaining higher marginal benefits [112]. Therefore, the improvement of small enterprises is often greater than that of large enterprises, and enterprise scale has

a negative moderating effect on the relationship between technological innovation and international competitiveness. This negative moderating effect means that as the scale of enterprises increases, the beneficial effect of technological innovation on international competitiveness tends to weaken. In other words, the promoting effect of technological innovation is more obvious in smaller enterprises, which are more able to transform innovation into competitive advantages in the global market.

Based on these insights, the following conceptual proposition is advanced:

Proposition 2: It is assumed that enterprise scale negatively moderates the relationship between technological innovation and international competitiveness, such that the positive effect of innovation investment on competitiveness is more pronounced in smaller enterprises than in larger ones.

Stage I. Data sources and models. We select data from Chinese A-share listed manufacturing firms for the period from 2016 to 2021. Regarding the generalisability of findings, the sample of Chinese A-share listed manufacturing firms constitutes a theoretically appropriate empirical window for studying innovatively oriented industrial enterprises. Listed manufacturing firms in China are disproportionately innovation-active relative to the broader enterprise population–they account for the majority of industrial R&D expenditure and patent filings nationally–and thus closely approximate the defining characteristics of innovatively oriented industrial enterprises as conceptualised in this study. The sample period is chosen for three reasons. First, 2016 marks the beginning of China's 13th Five-Year Plan, which explicitly elevated innovation-driven development as a national strategic priority and introduced a series of R&D incentive policies targeting manufacturing enterprises; studying this period thus captures firms' responses to a coherent and well-defined innovation policy environment, enhancing the internal validity of the analysis. Second, the period encompasses significant macroeconomic disruptions–including US-China trade tensions (2018–2019) and the COVID-19 shock (2020)–which introduce meaningful variation in firms' export performance and competitive conditions, strengthening the identification of the innovation-competitiveness relationship. Third, data completeness and consistency in

the CSMAR database are highest for this period, minimizing the risks of survivorship bias and attrition associated with extending the panel to earlier years.

The data were sourced from the China Stock Market & Accounting Research (CSMAR) Database, which is the gold standard data source for research on Chinese listed companies, offering verified financial, R&D, and export-related disclosures with high data quality and cross-period consistency. Starting from the full population of A-share listed manufacturing firms, ST and ST* firms were excluded to avoid the confounding influence of financially distressed companies whose R&D and export behaviors are driven by regulatory pressure rather than strategic innovation intent. Observations with missing values on any key variable were further removed. Continuous variables were winsorized at the 1st and 99th percentiles to mitigate the influence of extreme outliers. These procedures yielded a final sample of 7209 firm-year observations spanning 6 years (2016–2021), drawn from manufacturing firms across multiple sub-sectors, providing sufficient cross-sectional heterogeneity and time-series depth for two-way fixed effects estimation. Therefore, we utilize a two-way fixed effects model, incorporating both individual and time fixed effects, to construct the regression models, as shown in Equations (1).

$$TechComplex_{it}=\alpha_0+\alpha_1 RD_{it}+\alpha_2 X_{it}+\varphi_t+c_i+\varepsilon_{it} \quad (3.1)$$

Based on the analysis of the mechanisms and transmission pathways discussed earlier, technological innovation in firms positively impacts international competitiveness by enhancing operational performance. Therefore, operational performance is introduced as a mediating variable into the regression model, as follows:

$$ROA_{it}=\gamma_0+\gamma_1 RD_{it}+\gamma_2 X_{it}+\varphi_t+c_i+\varepsilon_{it} \quad (3.2)$$

$$TechComplex_{it}=\delta_0+\delta_1 RD_{it}+\delta_2 ROA_{it}+\delta_3 X_{it}+\varphi_t+c_i+\varepsilon_{it} \quad (3.3)$$

where i refers to all observed firms, t represents the observation time spanning

from 2016 to 2021, totaling 6 years.

While more recent data are desirable, the selected period ensures data completeness, consistency, and cross-country comparability, which are critical for multivariate regression analysis. More importantly, this study aims to examine the underlying mechanisms linking technological innovation to international competitiveness, rather than capturing short-term dynamics. Such relationships are generally stable over time, and thus the conclusions drawn from the selected dataset remain theoretically and empirically meaningful. Future research may extend the dataset to include more recent years to further validate the robustness of the findings.

$TechComplex_{it}$ represents export technology complexity of firm i in year t. RD_{it} represents the R&D intensity of firm i in year t. ROA_{it} represents the financial performance of the firm, that is, the asset reporting rate X_{it} includes control variables as described in Table 3.1, $\phi_t$captures the year effects, c_i represents the firm fixed effects, and ε_{it} denotes the random disturbance term.

Stage II. Variable Selection and Definition. There are various ways to express international competitiveness. Drawing on the approaches of Tsinopoulos et al. and Ardito et al. [6; 117], this study adopts export complexity as a proxy indicator of firms' international competitiveness, and treats it as the dependent variable in our research model. Export complexity not only reflects the diversity of a firm's products, but also captures the technological sophistication and value-added embedded in those products, thereby indirectly indicating the firm's competitive strength in global markets. Given that competition in international markets largely depends on technological advantages and innovation capabilities, export complexity, as a comprehensive indicator, effectively reflects a firm's performance in technological innovation and product differentiation. Based on these considerations, we argue that export complexity is a reasonable and effective measure of international competitiveness.

As Hausmann et al. establish, products differ systematically in the specialised knowledge and capabilities required for their production; firms that consistently export technologically complex products therefore demonstrate precisely the kind of dynamic

capability and resource depth that Chapter 1 identifies as the foundation of sustainable international competitiveness. In this sense, TechComplex is not merely a convenient empirical proxy, but a measure that is theoretically grounded in the competitiveness framework developed earlier in this dissertation.

To examine whether firm size moderates the relationship between R&D investment and international competitiveness, and following the methodologies of Lu and Wu [70], this study uses firm size–measured as the logarithm of total assets – as the moderating variable. This variable helps to reveal the differential effects of technological innovation investment on international competitiveness across firms of varying sizes.

Table 3.1 – Variable Definitions

Variable	Symbol	Definition
Export Technology Complexity	TechComplex	Natural logarithm of export technology complexity
R&D Intensity	R&D	R&D expenses / Total operating revenue
Number of Employees	ln_emp	Natural logarithm of the number of employees
Firm Age	lnfirm_age	Natural logarithm of firm age
Return on Assets	ROA	Net income after taxes / Average net assets
Firm Size	SIZE	Natural logarithm of firm size
Patent Output	Patent_output	Natural logarithm of the number of enterprise patent applications

Source: Compiled by the author

The specific description of the variables is shown in Table 3.1. The three control variables are included to isolate the effect of R&D intensity on export technology complexity from other firm-level factors known to influence innovation output and international competitiveness.

The number of employees (ln_emp) controls for firm scale as measured by labour input. Larger firms typically possess greater organisational capacity, more specialised divisions of labour, and stronger absorptive capacity for converting R&D into

exportable technological complexity; a positive relationship with TechComplex is therefore expected. Firm age (lnfirm_age) controls for accumulated experience and institutional knowledge. More established firms benefit from longer learning curves, deeper customer relationships, and more mature innovation management processes, suggesting a positive expected direction. Firm size (SIZE, measured as the logarithm of total assets) controls for financial capacity and market power.

Stage III. Data analysis. Before building the model, to verify the feasibility of the regression, this article conducted descriptive statistics and correlation analysis on the data.

Table 3.2 – Descriptive Analysis

VarName	Obs	Mean	SD	Min	Max
TechComplex	7209	18.082	1.342	9.971	22.802
R&D	7209	10.969	2.067	0.000	13.899
ln_emp	7209	7.550	1.125	3.497	12.211
lnfirm_age	7209	1.800	1.034	0.000	3.434
ROA	7209	0.048	0.097	-3,164	0.664
SIZE	7209	21.977	1.188	17.806	27.307

Source: Compiled by the author

Table 3.2 provides descriptive statistics for the dataset, comprising 7209 observations, which demonstrate its stability and suitability for subsequent regression analysis by presenting a comprehensive overview of the relevant variables. R&D intensity shows a mean of 10,969 and a substantial standard deviation of 2,067, reflecting significant variation in research and development expenditure. The technological complexity of exports averages 18,082, with a standard deviation of 1,342, highlighting a moderate level of technological sophistication within the sample. There are significant differences in R&D expenditures among the samples, with moderate but relatively stable levels of technological complexity. Understanding the relationship between technological innovation and international competitiveness requires further analysis in the following sections.

Table 3.3 reports the findings of the correlation analysis, revealing a significant positive correlation between R&D intensity and export technology complexity. Concurrently, employee numbers and the number of years since the establishment of the firm also demonstrate a notable positive correlation with both R&D intensity and export technology complexity. This suggests that larger and more established firms are more inclined to engage in substantial R&D investments, thereby yielding products with greater technological sophistication.

Table 3.3 – Correlation Analysis

	Tech Complex	R&D	ln_emp	lnfirm_age	ROA	SIZE
Tech Complex	1					
R&D	0,083***	1				
ln_emp	0,354***	0,151***	1			
lnfirm_age	0,196***	0,199***	0,424***	1		
ROA	0.011	0,037***	-0,030**	-0,196***	1	
SIZE	0,392***	0,279***	0,835***	0,481***	-0,031***	1

Source: Compiled by the author

The multicollinearity analysis presented in Tables 3.4 and 3.5 indicates an average Variance Inflation Factor (VIF) of 1,30 among the variables, signifying a low to moderate degree of multicollinearity that does not significantly compromise the reliability of the regression analysis.

Table 3.4 – Multicollinearity Analysis

Variable	VIF	1/VIF
R&D	1.45	0.690501
ln_emp	1.24	0.808154
lnfirm_age	1.22	0.819740
Mean VIF	1.30	

Source: Compiled by the author

The results of the Hausman test further corroborate the suitability of the fixed effects model over the random effects model in this study, with an F-test value of 16,38

and a probability value approaching zero, indicating that the fixed effects model is the more appropriate choice.

Table 3.5 – Hausman Test

Test	F-test	Prob > F	chi2(3)	Prob > chi2
F-test	16.38	0.0000		
Hausman Test			7.68	0.0000

Source: Compiled by the author

Stage IV. Benchmark Regression. Table 3.6 presents the regression analysis examining the impact of R&D investment on export technological complexity (TechComplex).

Overall, these results suggest that higher R&D intensity significantly enhances the technological sophistication of a firm's export products, thereby supporting the notion that R&D investment contributes positively to international competitiveness. A potential concern is reverse causality: more competitive firms generate higher revenues, enabling greater R&D investment. This study mitigates this concern through two design features.

Table 3.6 – Regression Analysis

Field	TechComplex		
	（1）	（2）	（3）
R&D	1,58e-10**	1,68e-10**	1,73e-10 **
	(2.09)	(2.22)	(2.31)
Constant	9,035***	8,818***	8,483***
	(42.99)	(49.20)	(39.18)
Control variables	-	Yes	Yes
Year fixed effects	-	-	Yes
Corporate fixed effects	-	-	Yes
Observations	7209	7209	7209
R^2	0.059	0.072	0.086

Source: Compiled by the author

First, the two-way fixed effects specification absorbs all time-invariant firm-level heterogeneity – including stable differences in competitive position and accumulated

capabilities – removing the most likely source of spurious correlation. Second, R&D intensity is measured as a ratio to total revenue, which eliminates the mechanical relationship between firm scale and absolute R&D spending. The consistency of the positive and significant R&D coefficient across all three specifications in Table 3.6 further supports the robustness of this relationship.

Stage V. Mechanism Analysis. Building on the preceding discussion, this study further investigates the mechanism through which corporate innovation enhances international competitiveness. R&D investment stimulates technological innovation by driving advancements in product development, process efficiency, and overall operational capabilities. These innovations subsequently bolster the firm's financial performance, as reflected by an improved Return on Assets (ROA), which signals enhanced profitability and a stronger asset utilization. This improved financial position equips the firm with the necessary resources and credibility to invest further in technological development and to expand its presence in international markets.

Table 3.7 – The intermediary effect of corporate financial performance

Field	（1）	（2）	（3）
	TechComplex	ROA	TechComplex
R&D	1,73e-10 **	9,36e-12***	1,61e-10**
	(2.31)	(2.62)	(2.15)
ROA	X	X	1,319***
	X	X	(5.34)
Constant	8,483***	0,023**	8,452***
	(39.18)	(2.26)	(39.10)
Control variables	Yes	Yes	Yes
Corporate fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	7209	7209	7209
R^2	0.086	0.064	0.089

Source: Compiled by the author

Table 3.7 presents the mediation analysis exploring the intermediary role of corporate financial performance (ROA) in the relationship between R&D investment and export technological complexity (TechComplex). In column (1), the regression of TechComplex on R&D reveals a statistically significant positive effect, with

a coefficient of 1,73e-10, indicating that increased R&D investment is associated with greater export complexity. In column (2), the regression of ROA on R&D shows that R&D investment has a significant positive impact on financial performance, thereby establishing that R&D contributes to improvements in ROA.

When both R&D and ROA are included in the regression of TechComplex, as shown in column (3), the coefficient on R&D decreases slightly to 1,61e-10 while ROA exerts a strong positive effect on export complexity. This reduction in the R&D coefficient upon the inclusion of ROA suggests that part of the effect of R&D on export complexity is transmitted through enhanced financial performance.

In essence, the results indicate that R&D investment not only directly promotes export technological complexity but also indirectly reinforces it by improving a firm's ROA, thereby substantiating the mediating role of corporate financial performance in the relationship between technological innovation and international competitiveness.

Stage VI. Further analysis. In the context of global transformation, the variation in firm performance is intricately linked to firm size. Firms of different sizes tend to allocate their resources and attention differently, particularly in terms of R&D investment, as highlighted by Aarstad, et al. [1].

This observation raises a critical question – does a firm's size moderate the relationship between R&D intensity and international competitiveness? To address this, our study develops a moderation model, with $SIZE_{it}$ serving as the key variable representing firm size. The model is formulated as follows:

$$TechComplex_{it}=\beta_0+\beta_1 RD_{it}+\beta_2 SIZE_{it}+\beta_3 SIZE_{it}*RD_{it}+\beta_4 X_{it}+\varphi_t+c_i+\varepsilon_{it}. \quad (3.4)$$

Overall, these findings offer a nuanced perspective on innovation in innovatively oriented industrial enterprises.

Table 3.8 – Heterogeneity of Firm Scale

	(1) No_int
R&D	-1,46e-10 * (0.000)
SIZE	0,823*** (0.037)
ln_emp	-0,506*** (0.037)
lnfirm_age	0,185*** (0.025)
_cons	-3,609*** (0.605)
N	7209
adj. R^2	0.106

Source: Compiled by the author

The baseline advantage in technological complexity held by larger firms is offset by the superior ability of smaller firms to translate R&D efforts into competitive international performance. This insight is crucial for policymakers and business strategists seeking to enhance international competitiveness, as it suggests that tailored R&D policies and support mechanisms that recognize the differing dynamics of firms based on size could lead to more effective innovation outcomes.

Stage VII. Robustness Check. A central concern in empirical studies of the innovation-competitiveness relationship is whether findings are sensitive to the choice of innovation proxy. The baseline specifications in Stages IV and V use R&D intensity – the ratio of R&D expenditure to total operating revenue – as the primary measure of technological innovation. While R&D intensity is the most widely adopted input-based innovation indicator in the literature [1; 7], it captures only the resource commitment dimension of innovation and may not fully reflect firms' realized innovation outputs.

To address this concern, the robustness check replaces R&D intensity with Patent_output – defined as the natural logarithm of the number of patent applications filed by firm i in year t – as an alternative proxy for technological innovation. Patent counts are a widely used output-based measure that captures the realized productivity of a firm's innovation activities, and thus provide a theoretically distinct operationalisation of the same underlying construct (Griliches, 1990). The dependent variable

(TechComplex), control variables, and fixed effects structure remain identical to the baseline model.

The results of the robustness check shows that the coefficient on Patent_output is 0,098 and is statistically significant at the 1% level ($t = 4,59$, $p < 0,01$), confirming that firms with greater patent output achieve significantly higher levels of export technology complexity. This direction is fully consistent with the baseline finding that R&D intensity positively affects international competitiveness, and the statistical significance of the innovation coefficient is notably stronger under this alternative specification than in the baseline model ($t = 2,31$ at the 5% level). The adjusted R^2 of 0,088 is virtually identical to the baseline estimate of 0,086, indicating that the overall explanatory power of the model is stable across specifications. The sample size remains at 7209 firm-year observations, confirming that patent disclosure data are complete across the full panel.

These results provide strong evidence that the core finding of this study – that technological innovation positively and significantly enhances international competitiveness, as measured by export technology complexity – is robust to the operationalisation of the innovation construct. Whether innovation is measured as an input (R&D intensity) or as an output (patent applications), the positive relationship with TechComplex is consistently confirmed. This robustness across two theoretically distinct innovation proxies substantially strengthens the empirical credibility of the baseline conclusions and supports the broader argument that systematic investment in technological innovation – regardless of how it is measured – is a significant driver of international competitiveness among innovatively oriented industrial enterprises.

Drawing on both the extensive literature and the empirical evidence presented in this study, we conclude that technological innovation is a key driver of international competitiveness. Our empirical analysis, based on data from Chinese A-share listed manufacturing firms from 2016 to 2021, reveals that increased R&D investment is associated with higher export technology complexity, which serves as a robust proxy for a firm's competitive capability in global markets. This finding is consistent with the theoretical frameworks of the Resource-Based View and dynamic

capabilities .Moreover, our mediation analysis indicates that the positive effect of R&D investments on export technology complexity is partly transmitted through improvements in firm operating performance, as measured by Return on Assets (ROA). This suggests that technological innovation enhances international competitiveness not only directly–through increased product sophistication and market differentiation–but also indirectly by improving a firm's financial health and operational efficiency.

In summary, our integrated analysis provides strong evidence that technological innovation, fueled by R&D investments, plays a critical role in enhancing a firm's international competitiveness. This effect is mediated by improvements in operating performance and moderated by firm size. These findings carry important policy implications: to foster global competitiveness, policymakers should consider tailored innovation policies that not only support R&D investments but also address firm-specific dynamics. In particular, measures that enhance the agility and absorptive capacity of smaller firms could yield substantial competitive gains, while larger firms may benefit from strategies aimed at reducing internal bureaucratic constraints. Future research should continue to explore these relationships across different industries and economic contexts, further refining our understanding of how technological innovation shapes competitive advantage in a rapidly evolving global marketplace.

Table 3.9 – Policy recommendations for enhancing technological innovation and international competitiveness

No.	Policy area	Empirical basis	Specific recommendations
1	2	3	4
1	R&D investment support	R&D expenditure significantly and positively affects export technology complexity, both directly and indirectly through improved ROA (Tables 3.5–3.7)	Introduce tax incentives, direct subsidies, and innovation grants to lower financial barriers to innovation; foster public-private partnerships and university-industry collaboration to accelerate commercialisation of technological breakthroughs.

End of Table 3.9

1	2	3	4
2	Size-differentiated innovation policy	Firm size negatively moderates the R&D–competitiveness relationship: smaller firms derive greater marginal returns from R&D investment (Table 3.8)	Design preferential tax treatments, simplified financing access, and targeted technical assistance for SMEs; for larger firms, focus on reducing bureaucratic constraints and encouraging internal process reform to unlock existing resource advantages.
3	Dynamic capability development	Mediation analysis confirms that R&D improves competitiveness partly through enhanced operating performance, indicating the importance of absorptive and integrative capabilities (Table 3.7)	Invest in continuous workforce training, establish innovation centres, and develop digital infrastructure supporting advanced data analytics and technology integration to strengthen firms' capacity to reconfigure resources in response to market disruptions.
4	Innovation ecosystem building	Robustness check confirms consistent positive effect of innovation on competitiveness across both R&D intensity and patent output proxies (Table 3.9), underscoring systemic rather than firm-level drivers	Promote industry clusters and innovation hubs enabling close collaboration among firms, research institutions, and government bodies; establish balanced IP regulatory frameworks that protect proprietary innovation without stifling knowledge spillovers
5	Policy monitoring and evaluation	Heterogeneity analysis reveals that innovation–competitiveness dynamics differ by firm size, necessitating adaptive rather than uniform policy approaches (Table 3.8)	Establish systematic mechanisms to assess the impact of innovation policies on R&D investment, ROA, and export technology complexity; use performance data to enable iterative policy refinement aligned with evolving global market conditions

Source: Completed by the author

Based on the empirical findings and the extensive literature reviewed in this study, the following policy recommendations are proposed to enhance technological innovation and, consequently, the international competitiveness of innovatively oriented industrial enterprises. These recommendations are summarised in Table 3.9.

These policy recommendations are designed to create an enabling environment that fosters technological innovation and enhances international competitiveness.By increasing R&D investment, providing tailored support based on firm size, building dynamic capabilities, nurturing innovation ecosystems, and implementing robust evaluation mechanisms, policymakers can help firms – particularly innovatively oriented industrial enterprises – effectively translate innovation into sustainable competitive advantage on the global stage.

3.2 Resource provision of market adaptability of innovatively oriented industrial enterprises in the system of increasing their competitiveness

Resource provision refers to the overall system of all resources – including financial, human, material and information resources – that are actually available to the enterprise and are systematically managed and optimally allocated to support its competitive objectives [34; 47; 50; 85]. For innovatively oriented industrial enterprises, adequate resource provision is a prerequisite for achieving market adaptability and long-term competitiveness, as it ensures that the enterprise possesses the necessary conditions to pursue economic, social, and innovation goals simultaneously [17; 76].

The resource provision recommendations developed in this section are grounded in the specific competitive reserve findings of Section 2.3, which identified the key financial, operational, and growth gaps facing each of the five sample enterprises. Rather than proposing generic measures applicable to all enterprises uniformly, the recommendations are calibrated to reflect three dimensions of heterogeneity that materially affect the relevance and sequencing of resource provision strategies.

First, company size: consistent with the moderating effect of firm size identified in the regression analysis of Section 3.1, larger enterprises (such as BYD and Midea) benefit from resource provision strategies that optimise existing large-scale systems and reduce bureaucratic inefficiency, while smaller or more agile enterprises (such as TCL and BOE in their current restructuring phase) require strategies that build foundational financial resilience and accelerate product mix transformation. Second, innovation cycle stage: enterprises in early-stage technology investment phases require greater emphasis on financial reserve-building and R&D pipeline protection, while enterprises in commercialisation phases benefit more from operational efficiency and market expansion measures. Third, geopolitical exposure: Chinese innovatively oriented industrial enterprises operate under specific external constraints – including US export controls on advanced semiconductors, restrictions on technology transfer, and the broader decoupling of Chinese and Western technology ecosystems – that directly affect their access to critical inputs, overseas markets, and international financing. These constraints make the domestic substitution of key technologies, the diversification of supply chains, and the cultivation of alternative international partnerships strategically urgent dimensions of resource provision that do not apply to enterprises in less geopolitically exposed environments. The following sections address each resource category with these contextual factors in mind.

It's worth noting that in the process of improving corporate competitiveness, companies can strengthen their market adaptability by providing resource provision in multiple areas, including finance, technology, functions, human resources, and information.

I. Financial resource provision. The financial measures described in this section aim to enhance the company's overall market adaptability and financial stability by optimizing its cash flow structure, financial risk identification, and capital allocation efficiency. Based on the analysis in Chapter 2, this article summarizes the main financial management issues currently facing innovatively oriented industrial enterprises:

- insufficient short-term debt repayment capacity, with both the quick ratio and

cash ratio being low;

- some companies have a structural dependence on bank loans;
- profitability fluctuates significantly, significantly impacted by capital expenditures.

To address these issues and enhance the company's financial resilience and market adaptability, the following measures are recommended:

1. In enhancing financial adaptability, optimizing the composition of tangible and intangible value, while reducing reliance on physical production, is an effective approach to improving financial flexibility.

For innovative companies, core competitiveness often stems from R&D capabilities, technological innovation, and the accumulation of intellectual property. However, due to current industry chain divisions and commercialization limitations, many innovative companies still rely on physical assets such as hardware equipment, terminal devices, and testing platforms to translate technology into market applications. This "tangible asset-oriented" business model exposes companies to higher costs of raw materials, inventory pressures, and exchange rate risks, particularly in the context of global supply chain fluctuations.

Therefore, to improve financial adaptability and resource allocation efficiency, companies should drive a shift in their product value structure from a focus on "hardware-heavy" to a "hardware-software integration" model. This can be achieved through three main strategies:

First, increase the value share of digital components within overall products. For example, integrating self-developed algorithms, sensor systems, or edge computing units into traditional hardware products can enhance added value and reduce reliance on imported components. Second, develop fully digital products or services, such as industrial software, data analytics platforms, API licenses, SaaS tools, etc. This will reduce the cash outflows and asset occupancy associated with physical manufacturing. Finally, implement subscription-based or service-oriented delivery models (Product-as-a-Service). For instance, through platform-based equipment leasing, remote

upgrades, or online support, companies can shift their revenue structure from one-time sales to recurring payments.

Huawei Cloud, for instance, transitioned from hardware-centric ICT infrastructure sales toward an 'Everything as a Service' subscription model. According to Huawei's 2023 Annual Report, this strategic shift contributed to cloud computing revenue growth of 21,9% year-on-year, reaching CNY 55,3 billion, demonstrating the significant improvement in revenue stability and capital efficiency that service-based models can deliver compared to one-time hardware sales.

In conclusion, innovative companies should leverage their technological advantages to systematically restructure their product portfolio and value models, reducing reliance on physical production. This shift will allow companies to transition from an "asset-intensive" to a "knowledge-intensive" financial model, enabling them to better navigate market uncertainties.

2. Establish a flexible employment mechanism and control labor cost flexibility through service outsourcing. To address the financial pressures caused by high salary ratios, it is recommended to develop a human resources model that combines core employees with external staff. Specific approaches include:

Outsourcing non-critical positions such as design, content operations, digital marketing, and data annotation to freelancers or external service providers on a project-based basis; introducing performance-based outsourcing mechanisms to compensate employees based on results and reduce fixed expenses; and establishing a corporate talent sharing platform to balance staff scheduling and costs. This can effectively reduce fixed salary costs, improve the controllability of labor costs, and enhance the company's adaptability to order fluctuations.

3. Improve working capital turnover and strengthen capital self-circulation capabilities. For companies with short-term debt and insufficient liquidity, operational efficiency should be improved by accelerating accounts receivable collection and inventory turnover. Recommendations include:

Implement a credit control mechanism: shorten payment terms and strengthen

collection efforts; implement a dynamic inventory management system to reduce excess raw materials and work-in-progress; and introduce a sales forecasting model to guide procurement and production planning, thereby improving capital efficiency. Efficient capital turnover can not only alleviate a company's dependence on external financing, but also help improve its profit quality and credit rating.

4. Building a Dynamic Financial Risk Identification and Management System to Enhance Resilience. Innovative companies often face more complex and sensitive financial risks due to their business models, which typically involve low asset intensity, high cash flow volatility, and long repayment cycles. This is especially true during the early or expansion phases, where significant expenditures in R&D, technology validation, and market development can lead to liquidity strain, asset-liability imbalances, and a decline in debt-servicing capacity. Therefore, it is recommended that innovative companies establish a dynamic financial risk identification and management system. Through multi-dimensional data monitoring and proactive response mechanisms, this system can structurally improve financial stability. Specific measures include:

– implementing a financial early warning system - develop a dynamic alert model based on core financial indicators, such as quick ratio, debt-to-equity ratio, and operating cash flow/interest coverage ratio. If key parameters breach risk thresholds, internal risk management processes are triggered, such as freezing large non-essential expenditures or adjusting budget allocations.

– optimizing capital structure – control the proportion of short-term debt to avoid over-reliance on high-leverage operations. For high-growth businesses, equity-based financing tools (such as convertible bonds, private equity, or venture capital) should be prioritized to reduce financial pressure and debt servicing burdens.

– introducing sensitivity analysis and stress testing - Conduct multi-scenario profit simulations and liquidity assessments based on sensitive factors like revenue, exchange rates, raw material prices, and financing costs. For example, evaluate the potential funding gap and self-rescue capacity under scenarios such as a 20% revenue

drop or a 200 basis point increase in financing costs.

– establishing financial risk reserve mechanisms - during high-growth periods, companies should establish specific reserves or insurance funds to address unexpected financial expenditures resulting from potential technology failures, market pullbacks, or regulatory changes.

For example, an innovative medical device company built a rolling 12-month cash flow forecasting model and conducted scenario testing based on "15% revenue decline + 1-month delay in receivables." This approach effectively identified potential liquidity risks and allowed the company to take proactive measures, such as credit extensions and adjustments to the financing structure, thus avoiding a liquidity crisis.

5. Optimize the capital budget allocation structure. Establish a capital budget allocation structure based on the company's financial structure. Capital budget allocation should focus on core businesses, short-term high-potential projects, and long-term development projects. Specific optimization measures are listed in Table 3.10.

Table 3.10 – Budget allocation plan for innovatively oriented industrial enterprises

Business Strategy	Project Expenditure	Budget Allocation (%)	Flexibility Range
Core Business	Management Expenses	15%	0%
	Sales Expenses	20%	
	Development Expenses	32%	
Short-TermHigh-Potential Projects	Management Expenses	5%	4%-8%
	Sales Expenses	8%	
Long-Term High-Potential Projects	Management Expenses	4%	4%-8%
Other Projects	Management Expenses	2%	0%
	Sales Expenses	3%	
	Development Expenses	4%	

Source: Author's compilation

For short-term, high-potential projects – typically involving new product development and near-term market expansion – it is recommended to allocate management expenses at approximately 5% and sales expenses at approximately 8% of the relevant project budget, with a flexibility range of 4%–8% to accommodate the inherently uncertain pace of project progress and market response. The elevated flexibility range reflects the dynamic nature of these projects and the need to scale funding quickly when market opportunities arise.

For long-term development projects, which have longer payback periods but represent the company's future growth pillars, a management expense allocation of approximately 4% is recommended, with a flexibility range of 4%–8%. A dedicated fund should be established for these projects, with dynamic budget adjustments triggered by predefined project milestones to ensure long-term objectives are achieved without over-committing resources prematurely.

For other projects, which typically contribute less to overall growth, management expenses, sales expenses, and development expenses are recommended at approximately 2%, 3%, and 4% respectively, with no flexibility allowance (0), reflecting the lower strategic priority of these activities. Resources released from these lower-return projects should be reallocated to the high-potential categories above. By implementing this differentiated budget structure – grounded in established innovation portfolio theory and calibrated to the operational characteristics of innovatively oriented industrial enterprises in China's technology manufacturing sector – companies can achieve cost optimization, stable cash flow, rational asset allocation, and proactive risk control, thereby strengthening both financial resilience and long-term market adaptability.

II. Technology resource provision. As innovatively oriented industrial enterprises enhance their competitiveness, the introduction and integration of technology not only becomes a key resource provision but also helps them better adapt to market changes [41; 47; 50]. The following recommendations address three key areas: conducting technology needs assessments and selection, establishing partnerships with technology

suppliers, and developing a gradual technology introduction plan. These recommendations will guide innovatively oriented industrial enterprises in effectively introducing and applying technology, as shown in Figure 3.1. Implementing the following measures will help determine the technological readiness of innovatively oriented industrial enterprises to adapt to new market demands.

1. Implement a comprehensive technology needs assessment and selection process to ensure that technology selection aligns with corporate strategy. Innovative companies should develop a multi-dimensional technology assessment framework that encompasses a comprehensive review of existing business processes, a scientific forecast of future market conditions and business needs, and a comprehensive evaluation of potential technology solutions. This assessment process should encompass multiple dimensions, including technology maturity, compatibility with existing systems, scalability, cost-benefit analysis, and the potential impact of implementation on organizational structure and culture. A cross-functional team of experts should be assembled to oversee the implementation of this assessment framework, ensuring that the selected technology not only meets the company's immediate needs but also aligns with its long-term strategic planning.

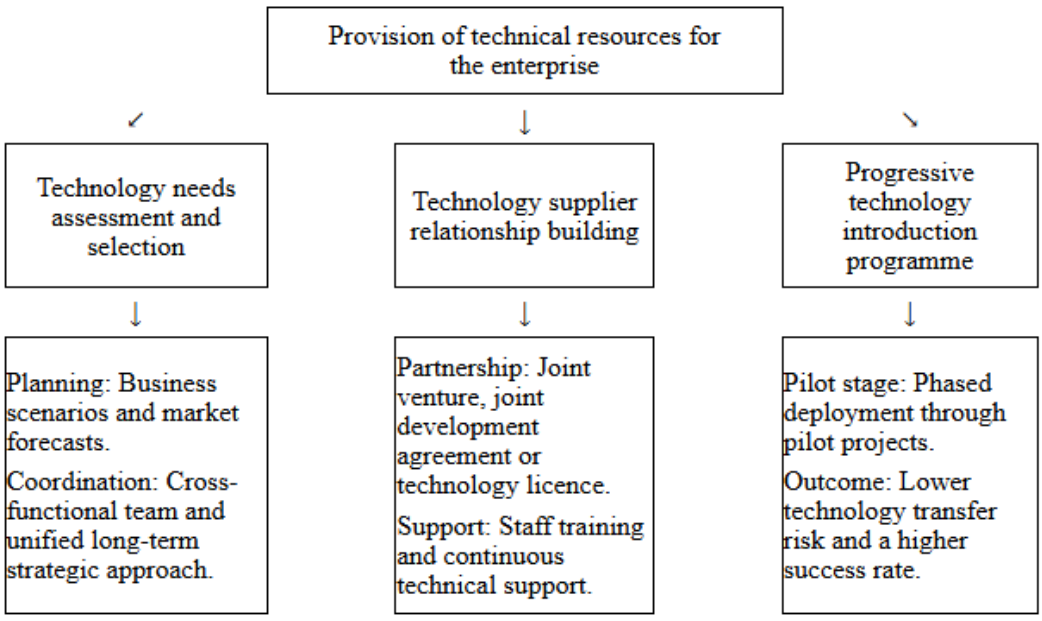


Figure 3.1 – Flowchart of enterprise technology strategy promotion

Source: Developed by the author

2. Establish strong and lasting partnerships with technology suppliers. These relationships are formed to ensure the effective deployment, operation, and maintenance of the technology and to enable joint strategic alliances to address future market challenges. Collaboration can take various forms, such as joint ventures, joint R&D agreements, or technology licensing agreements, aiming to share risks and benefits while fully leveraging the partners' expertise and skills in the technology field. Furthermore, the cooperation agreement should include clear provisions for personnel training and ongoing technical support. This ensures that companies can quickly identify and resolve potential technical issues during technology deployment and implementation, thereby accelerating technology integration and application, and improving overall operational efficiency and innovation capabilities. Through such partnerships, innovative companies will be able to more effectively advance their strategies and maintain a competitive advantage in the global market.

3. Develop a gradual technology introduction plan and adopt a phased approach to technology introduction. Given the complexity of technology and the potential risks of introduction, this study recommends that innovative companies adopt a gradual approach to planning and implementing technology introduction. A phased technology introduction plan should be developed, including initial, manageable pilot projects to collect operational data and feedback, providing valuable lessons learned for the next phase of deployment. This plan can also validate and test the applicability and effectiveness of the new technology on a smaller scale. Based on the results of the initial implementation, companies can systematically expand the scope of application of the new technology, gradually improving their overall level of technology application. Through this strategic, gradual introduction plan, innovative companies can reduce the risks of technology introduction, increase the success rate of technology transfer, and enhance their competitiveness in the industry through continuous learning and adaptation.

Implementing these tasks will help improve the technological innovation level of innovatively oriented industrial enterprises. Technological innovation can enhance

enterprise competitiveness by reducing production costs and improving product differentiation.

III. Functional resource provision. During our research of sample companies, we identified several issues contributing to their low competitiveness. These barriers to competitiveness include issues directly related to their core businesses. Therefore, from a strategic management perspective, implementing a company's business activities based on a diversified business strategy can effectively optimize resource allocation, explore new business growth areas, and enhance the company's market adaptability and long-term competitive advantage. As an effective risk hedging mechanism and growth engine, a diversified business strategy is increasingly gaining attention from corporate managers. Diversification not only helps mitigate the risks of cyclical industry fluctuations faced by companies, but also provides ample space for horizontal expansion, resource synergy, and business model innovation, as shown in Figure 3.2.

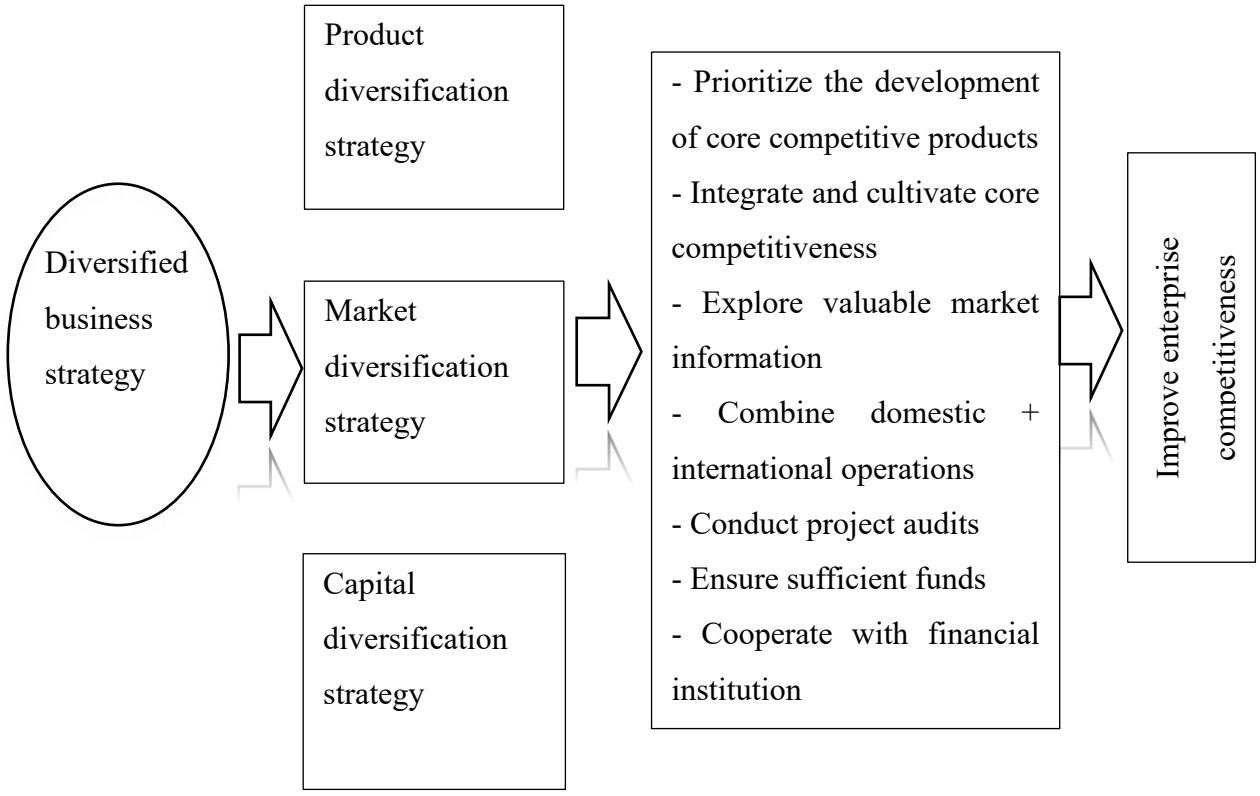


Figure 3.2 – Support measures for innovatively oriented industrial enterprises' diversification strategies

Source: Developed by the author

Measures to Support Product Diversification Strategy. The first measure is to prioritize the development of related products that leverage the company's core competencies. This approach allows companies to minimize the costs associated with implementing a product diversification strategy by sharing management experience, business models, sales channels, and after-sales services, thus enhancing the company's core competitiveness in related fields [95; 131]. For example, TCL Group, a listed company primarily engaged in the production, manufacturing, and sales of home appliances, capitalized on its strengths in its core business and strategically entered related sectors during its diversification process. Over time, the company has solidified its leadership position in the home appliance industry. It is important to maintain an appropriate level of diversification and strengthen the integration, cultivation, and development of the company's core competencies. This includes adjusting the industrial structure, optimizing resource allocation, and improving the concentration of diversified industries. The company should focus its advantages and allocate resources and capital to key industries and flagship projects, accelerating industrial upgrades and expanding market reach.

1. Market diversification strategy measures. The first measure is identifying valuable market information. Companies should assign specialists for market segmentation and research insight extraction. The second measure combines domestic and international operations. Domestic expansion must align with national strategies and regional economic planning, focusing on high-growth areas. Proactively entering high-potential markets secures a competitive edge [57].

2. Capital diversification strategy measures. The first is conducting accounting and auditing for all online/offline projects to guarantee initial liquidity and working capital. The second is ensuring timely, adequate capital injection. Partnering with financial institutions helps companies leverage global financing advantages via loans, guarantees, and consulting, boosting bidding competitiveness.

IV. Human resource provision. Legal frameworks must adapt to digital economy trends by updating the Labor Code, clarifying remote rights, standardizing international

self-employed relations, and enabling digital contract signing. Industrial firms should implement talent attraction programs and incentive mechanisms to fill skill gaps. Monitoring involves tracking labor and educational markets, identifying high-potential talent for digital teams, and providing professional development. Human resource provision should be organised as a continuous cycle that links the enterprise's innovation objectives with the competencies required for their implementation. The first stage of this cycle is competence mapping. Enterprises should identify the technological, analytical, managerial, and international business competencies required for current projects and compare them with the capabilities of existing personnel. This assessment makes it possible to determine which competence gaps can be addressed through internal training, which require external recruitment, and which can be covered through temporary cooperation with universities, research centres, engineering companies, or specialised consultants. Such differentiation is particularly important for innovatively oriented industrial enterprises because the demand for competencies changes together with the technological content of products and the transition from individual hardware solutions to integrated digital services.

The second direction is the development of flexible mechanisms for forming project teams. Cross-functional teams that combine engineering, production, finance, marketing, and data analysis specialists can reduce the time between the identification of a market opportunity and the commercialisation of an innovation. Their effectiveness depends on a clear distribution of responsibilities, access to common information, and the use of performance indicators linked not only to the completion of individual tasks but also to the achievement of innovation objectives. For projects involving external partners, enterprises should additionally define procedures for protecting intellectual property, exchanging technical information, and evaluating the contribution of each participant. This allows external knowledge to be used without weakening control over strategically important technologies.

The third direction concerns the retention and renewal of critical knowledge. Enterprises should maintain internal knowledge bases containing technical solutions,

project results, causes of implementation delays, and lessons obtained from unsuccessful experiments. Regular transfer of this knowledge between experienced employees and new specialists reduces dependence on individual experts and preserves organisational continuity. Training programmes should therefore include not only general digital skills but also enterprise-specific competencies related to the operation of technological platforms, data interpretation, international quality standards, and the commercialisation of innovation results. Taken together, these measures strengthen the ability of enterprises to reconfigure their human resources in response to technological and market changes and thereby support long-term market adaptability.

V. *Information resource provision*. This area leverages digital transformation to enhance competitiveness by analyzing document flows and predicting market trends. Technology selection must utilize cloud computing, big data, and AI for cross-system data sharing [113; 118], evaluated by maturity, stability, and security. Data governance ensures data accuracy, completeness, and privacy across all stages using advanced collection tools, processing platforms, encryption, and access controls. Increased financial and technological investment is vital for sustainable digital transformation.

Information resource provision should ensure that managerial decisions are based on timely, comparable, and verifiable data. For this purpose, innovatively oriented industrial enterprises should form an integrated information environment that combines data from production systems, R&D projects, sales channels, supply chains, financial reporting, and external markets. The integration of these sources makes it possible to evaluate an innovation not only by its technical characteristics but also by its cost, implementation period, expected demand, and contribution to international competitiveness. Particular attention should be paid to the compatibility of information systems because fragmented databases and inconsistent indicators limit the ability of managers to compare projects and redistribute resources promptly.

A unified data governance procedure should cover data collection, verification, storage, access, and use. Responsibility for data quality should be assigned to specific functional units, while common definitions should be established for indicators used by

different departments. For example, R&D expenditure, project completion, technological readiness, commercialisation results, and customer response should be measured according to consistent rules. This is necessary to prevent situations in which financial, production, and innovation units evaluate the same project using incompatible information. Access rights should correspond to employees' functions and the strategic importance of the data, while regular audits should identify incomplete, duplicated, or outdated information.

Information security is an integral part of this system. The expansion of digital platforms, cloud services, and external technological cooperation increases the number of channels through which commercially sensitive information may be transferred. Enterprises should therefore classify information according to its level of confidentiality, apply differentiated access controls, maintain records of data operations, and establish procedures for responding to security incidents. These measures are particularly important for intellectual property, product development data, supplier information, and materials related to international partnerships. Protection mechanisms should not obstruct legitimate information exchange but should ensure that external cooperation does not create an uncontrolled risk of technological knowledge loss.

The information system should also support the monitoring of external changes. Market, technological, regulatory, and competitive signals should be collected systematically and incorporated into strategic decision-making. Monitoring may include changes in customer demand, the emergence of substitute technologies, patent activity, supply chain disruptions, export restrictions, and the actions of major competitors. The analytical processing of these signals enables enterprises to revise innovation priorities before adverse changes are reflected in financial results. Thus, information resource provision performs both an operational function, supporting current decisions, and a strategic function, enabling the enterprise to anticipate changes and adapt its resource allocation accordingly.

In addition to financial investments, optimizing and integrating internal resources is key in the context of digital transformation. The effective utilization of resources is

essential for improving organizational performance. Companies should conduct a thorough review and integration of internal resources, optimizing processes, streamlining organizational structures, and enhancing employee skills to maximize resource utilization. Additionally, strict resource management systems should be established to ensure that resources are allocated rationally and used effectively, providing ongoing support for digital transformation. While increasing investment, it is also crucial to focus on risk management and cost control.

To meet the demands of digital transformation, innovative companies must adjust their organizational structure. This includes promoting a flatter and more flexible organizational structure to break down traditional hierarchical barriers, improve decision-making efficiency, and foster innovation capabilities. Cross-departmental collaboration teams and agile workgroups should be established to expedite business process optimization and restructuring, improving transformation efficiency. Additionally, companies should focus on employee training and skill development. Special funds and scholarships should be set up to encourage employees to participate in digital training and certification, enhancing their digital skills and knowledge. At the same time, companies should strengthen internal talent development and career progression opportunities, providing employees with ample opportunities for growth and promotion. By improving training and advancement mechanisms, companies can boost employee engagement and creativity, offering strong talent support for digital transformation. During the organizational restructuring process, companies should also pay attention to communication and collaboration with employees. Regular employee meetings and team-building activities should be organized to enhance cohesion and a sense of belonging among staff. Additionally, employee feedback mechanisms should be established to encourage employees to offer suggestions for improvements, continuously enhancing the organizational structure and team-building efforts.

The core of digital transformation lies in process optimization and automation. Innovative companies should introduce automation tools and technologies, such as robotic process automation (RPA) and business process management (BPM), to

automate business processes, reduce manual intervention, and improve operational efficiency. In the process optimization phase, companies should focus on standardizing and streamlining business processes. By mapping existing processes, identifying bottlenecks and issues, and proposing optimization solutions, companies can continuously improve and refine their operations. Moreover, companies should introduce advanced management principles and tools, such as lean management and Six Sigma, to support ongoing business process improvement.

When implementing automation, companies should carefully select and integrate automation tools. By leveraging cutting-edge automation technologies, businesses can ensure the automation of key processes. It is also essential to maintain and upgrade these automation tools to ensure their stability and reliability. Through process optimization and automation, companies can achieve standardized, regulated, and intelligent operations, providing strong support for their digital transformation efforts.

During the research process, various aspects of resource provision were examined, leading to the conclusion that resource provision requirements are constantly changing. It is also important to clarify and understand these changes in order to provide a theoretical basis and practical recommendations for further developing enterprise resource provision, taking into account the elements proposed in the strategic approach. Successful enterprise resource provision management can include the introduction of modern production technologies, the implementation of investment projects for enterprises of various organizational and legal forms, the development of new mathematical models for assessing enterprise resource provision capabilities, the generation and processing of information for management decisions, and the prevention of enterprise crises, thereby ensuring stable development.

The proposed components of resource provision should not be considered separately because the effectiveness of each component depends on the condition of the others. Financial resources create opportunities for technological modernisation, personnel development, and the implementation of information systems. Technological resources determine the requirements for employee competencies and the volume and

structure of data required for managerial decisions. Human resources ensure the practical application of technologies and the interpretation of information, while functional provision coordinates the actions of departments involved in innovation, production, finance, and market development. Consequently, a shortage or imbalance in one component may limit the effectiveness of the entire resource provision system even when the remaining components are sufficiently developed.

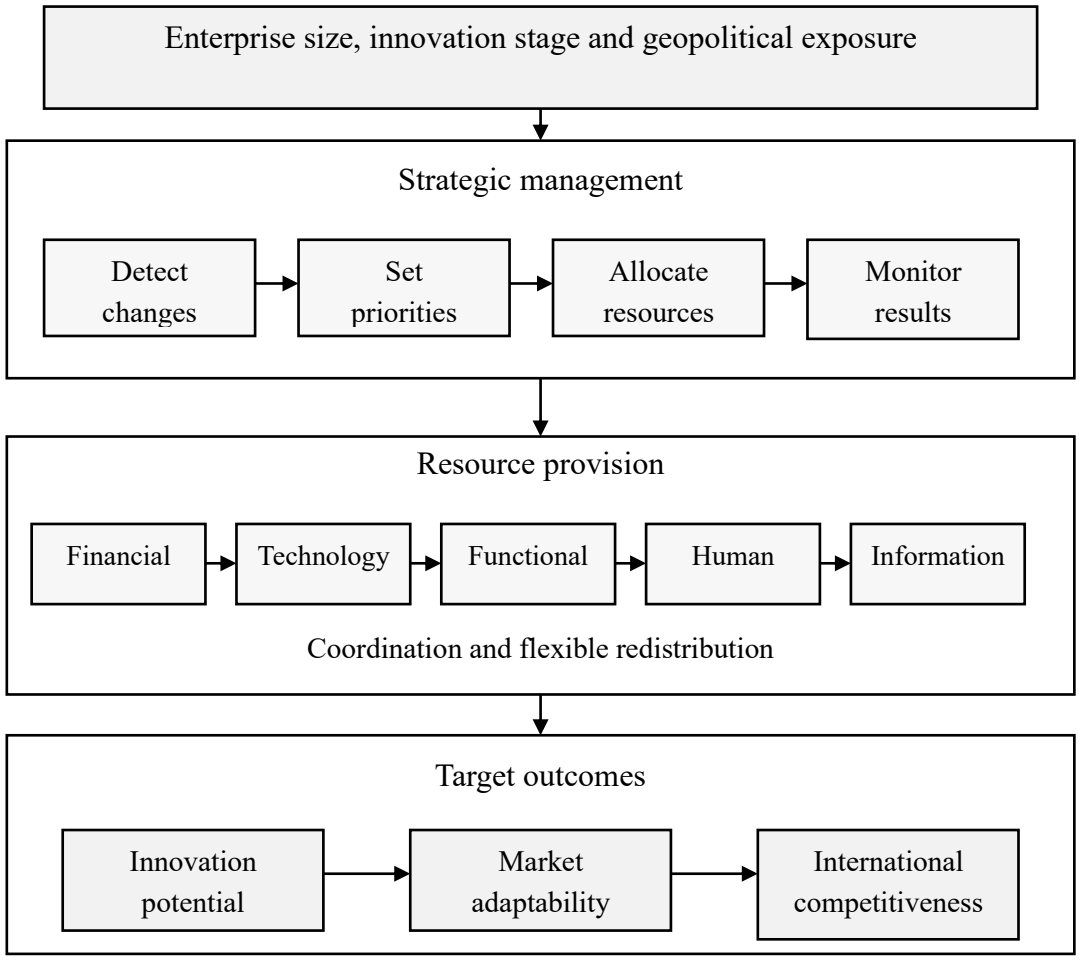


Figure 3.3 – Resource provision framework for strengthening market adaptability

Source: developed by the author

The sequence of resource allocation should be determined by the enterprise's current competitive reserve profile. Financially constrained enterprises should first stabilise cash flows and protect the financing of strategically important innovation projects. Enterprises with sufficient financial capacity but limited technological independence should concentrate resources on critical technologies, supplier diversification, and the development of internal R&D capabilities.

Where technological assets already exist but their commercial results remain insufficient, priority should be given to information support, market analysis, and cross-functional coordination between R&D, production, and sales units. This sequencing links resource provision directly to the weaknesses identified through competitiveness assessment and prevents resources from being distributed uniformly across activities with different strategic importance.

The proposed resource provision framework (Fig. 3.3) links the enterprise's response to changes in the external environment with the coordinated use of its resource base and is applied with regard to enterprise size, innovation-cycle stage, and geopolitical exposure. The strategic management subsystem ensures the recognition of market and technological signals, revision of strategic priorities and innovation objectives, allocation of resources, implementation of managerial decisions, and monitoring of results. The resource provision subsystem integrates five interdependent components: financial, technological, functional, human, and information resources. Their interaction is supported through functional coordination and the flexible redistribution of resources in accordance with current strategic priorities. The consistent operation of these subsystems strengthens the enterprise's innovation potential, improves its market adaptability, and supports sustainable international competitiveness. The feedback loop indicates that the results achieved should be used to adjust managerial decisions and resource allocation when market conditions or technological development trajectories change.

Resource provision should therefore be reviewed regularly rather than treated as a fixed structure. Changes in demand, technology, regulation, or international supply chains may alter the relative importance of individual resources and require their redistribution. Periodic assessment should compare the resources used with the innovation objectives achieved, identify bottlenecks, and determine whether internal resources should be supplemented through cooperation or integration. This approach connects the resource provision framework developed in Section 3.2 with the integration strategies examined in Section 3.3.

3.3 Integration of economic efforts of innovatively oriented industrial enterprises

The competitive environment of innovatively oriented industrial enterprises is shaped not only by internal capabilities but also by the architecture of economic relationships they construct with partners, suppliers, competitors, and platforms across the value chain. Building on the competitiveness assessment and reserve identification conducted in Chapter 2, this section translates those analytical findings into concrete integration strategies for each of the five sample enterprises – BYD, CATL, BOE, Midea, and TCL. Five principal integration pathways are examined: vertical integration, horizontal integration, strategic alliances and long-term contractual relationships, open innovation and digital ecosystem integration, and cross-border international integration. For each pathway, enterprise-specific recommendations are derived from the financial performance data established in Section 2.2 and the competitive reserve gaps identified in Section 2.3.

The selection of an appropriate integration strategy for each enterprise should be guided by its financial capacity, technological maturity, competitive reserve profile, and the degree of market uncertainty it faces.

I. Vertical Integration. Vertical integration enables enterprises to control multiple stages of the production and distribution process, reducing transaction costs and supply chain vulnerability [26; 36; 103; 123]. For innovatively oriented industrial enterprises, backward integration into critical inputs and forward integration into distribution and services are particularly valuable when inputs are scarce, price-volatile, or geopolitically exposed. Research confirms that firms with higher degrees of vertical integration gain advantages in reducing transaction costs and improving information flow along the supply chain, thereby lowering financial risk and strengthening competitive resilience [73]. Table C.1 of Appendix C presents enterprise-specific vertical integration recommendations for the five sample enterprises, derived from the competitive reserve gaps identified in Section 2.3.

The vertical integration priorities differ significantly across the five enterprises in line with their respective financial positions and competitive reserve gaps. BYD and CATL, as the largest and most financially capable enterprises, are positioned to pursue equity-based upstream integration into raw material supply. BOE and Midea face more specific integration opportunities tied to their existing asset bases – BOE in display materials and system integration, Midea in robotics and IoT semiconductors. TCL's immediate priority is divestiture of loss-making subsidiaries before committing capital to new integration investments, reflecting the principle that effective vertical integration requires a solid financial foundation.

II. Horizontal Integration. Horizontal integration consolidates enterprises operating at the same stage of the value chain, generating economies of scale, market power, and shared innovation capacity. For innovatively oriented industrial enterprises, horizontal integration is particularly strategic in the context of technology standardisation battles and price wars driven by market fragmentation. By aligning parallel business units, enterprises can unlock economies of scope that drive efficiency, innovation, and market dominance through the sharing of resources, knowledge, and capabilities. Table C.2 of Appendix C presents enterprise-specific horizontal integration recommendations. To avoid relying on a single-year snapshot, the horizontal integration recommendations in Table C.2 of Appendix C are formulated on the basis of the longitudinal competitiveness assessment conducted in Chapter 2. Specifically, the recommendations draw on the 2014–2024 trends in profitability, solvency, operational efficiency, and growth potential, as well as the competitive reserve gaps identified in Section 2.3. The 2024 indicators are used only as the most recent reference point, while the strategic logic of each recommendation is grounded in the longer-term financial and operational trajectory of each enterprise.

The horizontal integration recommendations are calibrated to each enterprise’s financial position and competitive context. BYD and CATL, as market leaders, can use horizontal consolidation offensively to reshape industry structure in their favour. BOE and Midea are positioned for selective horizontal integration that strengthens their

respective platform ecosystems. TCL, given its current financial constraints, should pursue horizontal cooperation through agreements rather than equity-based integration until its restructuring programme restores a positive financial foundation.

III. Strategic Alliances and Long-Term Contractual Relationships. Strategic alliances and long-term contractual relationships provide enterprise-level resource access and market security without the capital intensity of full integration. For innovatively oriented industrial enterprises, alliances are especially valuable in technology-intensive domains where no single enterprise possesses all necessary competencies, and where collaborative knowledge exchange accelerates innovation cycles beyond what internal development could achieve. Research confirms that enterprise alliance capabilities have a significant positive impact on technology innovation performance, with empirical findings concerning Chinese manufacturing enterprises [23; 39; 55; 75; 105]. Table C.3 of Appendix C presents enterprise-specific alliance and contractual recommendations grounded in the competitive reserve gaps identified in Section 2.3.

The alliance recommendations are directly linked to the reserve gaps identified in Section 2.3. BOE's receivables turnover deficit drives the recommendation for reverse factoring programmes with major customers. CATL's revenue decline drives the recommendation for ESS utility alliances. TCL's immediate profitability constraint drives the emphasis on cost-reduction procurement alliances rather than growth-oriented alliances. This alignment between the Section 2.3 diagnostic findings and the Section 3.3 integration recommendations ensures that the proposed alliances address genuine competitive weaknesses rather than generic best-practice prescriptions.

IV. Open Innovation and Digital Ecosystem Integration. Open innovation, originally conceptualised by Chesbrough [24], posits that enterprises should integrate external ideas and internal capabilities across multiple pathways to market, recognising that no single enterprise can possess all relevant knowledge.

Table 3.11 – Integration strategy matrix: five sample innovatively oriented industrial enterprises to five integration pathways

Enterprise	Vertical Integratic Priority	Horizontal Integration Priority	Strategic Alliance Priority	Open Innovation Priority	Cross-Border Priority
BYD	Upstream lithium & separator ownership; ADAS software internalisation	Domestic NEV consolidation; commercial vehicle entry	Overseas OEM long-term supply; Huawei ADAS alliance	Open BaaS digital platform; charging network ecosystem	European & SEA manufacturing expansion; OEM JVs
CATL	Solid-state electrolyte subsidiary; battery recycling integration	Domestic battery industry consolidation; BMS software M&A	ESS utility alliances; international OEM supply contracts	Battery AI-as-a-service; solid-state innovation challenges	European gigafactories; Indonesian materials JV; licensing
BOE	Display materials subsidiary; commercial display system integration	Display peer joint procurement; AR/VR modul consolidation	Reverse factoring with Apple/Samsung; AR/VR co-development alliances	Open display developer platform; industrial internet participation	India & Vietnam assembly; technology licensing; AR/VR partnerships
Midea	KUKA robotics integration; IoT semiconductor design centre	Premium appliance brand acquisitions; energy software M&A	Energy company alliances; semiconductor supply agreements	Open MEIA ecosystem; industrial AI programme; smart city platforms	KUKA cross-selling; MEIA international expansion; SEA/ME distribution
TCL	Mini-LED component integration; photovoltaic divestiture	Cooperative procurement (no equity M&A); pre-competitive R&D pool	Joint procurement with BOE/Tianma; retail service contracts	AI TV platform revenue sharing; semiconductor design ecosystem	OEM supply agreement renewal; IP licensing; standards body participation

Source: Compiled by the author based on Sections 2.2, 2.3, and 3.3 analysis

Digital ecosystem integration extends this to platform-based architectures where multiple actors co-create value through shared digital infrastructure. Digital transformation improves firms' sensitivity to market segments, facilitates symbiotic innovation ecosystems that stimulate cross-boundary cooperation, and is particularly conducive to accelerating product iteration aligned with market demand [22; 25]. Table C.4 of Appendix C presents enterprise-specific open innovation and digital ecosystem recommendations.

While Table 3.11 presents a comprehensive integration option set for each enterprise, effective strategic implementation requires the identification of priority pathways based on each enterprise's current financial position and competitive reserve profile established in Chapter 2.

The open innovation recommendations leverage each enterprise's existing technological assets to create new revenue streams and accelerate capability development. BYD and CATL are positioned to monetise their AI and platform investments through open ecosystem strategies. BOE and Midea have developed proprietary AI capabilities that can be extended to third-party users.

V. Cross-Border International Integration. Cross-border international integration enables innovatively oriented industrial enterprises to access international markets, resources, and talent in ways that strengthen both global competitive positioning and domestic innovation capacity. For Chinese innovatively oriented industrial enterprises, international integration has become strategically urgent in the context of geopolitical technology export controls, tariff barriers, and the diversification of global supply chains away from China-centric concentration. International strategic alliances have been demonstrated to significantly improve firms' innovation performance, particularly in increasing overseas market share and international revenue growth, with technological cooperation and supply chain coordination playing crucial mediating roles. Table C.5 of Appendix C presents enterprise-specific cross-border integration recommendations.

The international integration recommendations are calibrated to each enterprise's current international maturity and financial capacity. BYD and CATL, as enterprises with the most urgent international growth needs and the financial capacity to pursue equity-based international investments, are recommended to accelerate overseas manufacturing expansion. BOE and Midea are positioned for selective international expansion leveraging existing assets. TCL's recommendations focus exclusively on contractual forms of international integration that generate income without capital expenditure, consistent with its current restructuring constraints.

VI. Summary: Integration Strategy Matrix for Five Sample Enterprises. Table 3.12 consolidates the integration recommendations across all five pathways and five enterprises, providing a strategic matrix that enables cross-enterprise and cross-pathway comparison. The matrix reveals a clear pattern of differentiation driven by each enterprise's financial position and competitive reserve profile established in Chapter 2.

Table 3.12 – Generalised integration strategies for different groups of innovatively oriented industrial enterprises

Group of innovatively oriented industrial enterprises	Typical characteristics	Recommended integration strategy	Scientific implication
1	2	3	4
Market-leading and fast-growing enterprises	Strong revenue growth, large market share, and high innovation investment.	Prioritise vertical integration and cross-border international integration.	Such enterprises should use integration to secure resources, reduce geopolitical risk, and transform scale advantages into sustainable international competitiveness.
Technology-leading but growth-pressured enterprises	Strong technological assets, but declining or unstable growth.	Prioritise strategic alliances and international partnerships.	Strategic alliances allow firms to access new markets, technologies, and distribution channels without excessive capital burden, thereby strengthening dynamic capabilities.

End of Table 3.12

1	2	3	4
Profitability-constrained or restructuring enterprises	Weak margins, low liquidity, and unstable profitability.	Prioritise low-capital alliances, joint procurement, and contractual cooperation.	Asset-light cooperation enables financially constrained enterprises to improve competitiveness while avoiding excessive investment risk.
Technology-asset-rich but commercially constrained enterprises	Strong patents, R&D capability, or technological base, but limited commercialisation.	Prioritise licensing, co-development, and open innovation platforms.	Commercialising existing technological assets through external cooperation improves the conversion of innovation potential into market performance.

Source: Compiled by the author based on the competitive reserve profiles identified in Chapter 2.

The generalised framework presented in Table 3.12 demonstrates that integration strategies should not be applied uniformly to all innovatively oriented industrial enterprises. The appropriate integration pathway depends on the enterprise's competitive profile, including its growth stage, financial stability, technological asset base, and internationalisation capacity. Thus, the proposed framework provides not only practical recommendations for the analysed enterprises but also a scientific classification of integration strategies for innovatively oriented industrial enterprises operating under conditions of technological transformation and global market uncertainty.

The following priority assessments are derived from that diagnostic foundation. BYD should prioritise vertical integration and cross-border international integration. BYD's debt-to-asset ratio of 74,64% - the highest among the five enterprises – reflects its aggressive capital expenditure strategy, making upstream resource integration the most urgent integration priority to reduce input cost exposure. Simultaneously, its 29,02% revenue growth rate demonstrates the financial capacity and market momentum to accelerate overseas manufacturing expansion in Europe and Southeast Asia, mitigating tariff barriers before they constrain its international expansion trajectory. CATL should prioritise strategic alliances and cross-border international integration. CATL's 9,70%

revenue decline in 2024 – the only revenue contraction in the sample – signals acute exposure to domestic battery price competition. Long-term ESS utility alliances and international OEM supply contracts directly address this growth reversal, while overseas gigafactory investment in Europe secures the international revenue base that domestic market saturation can no longer provide.

BOE should prioritise strategic alliances and open innovation and digital ecosystem integration. BOE's receivables turnover ratio of 5,692x falls significantly below the 7–9x industry benchmark, making reverse factoring alliances with major panel customers the most impactful near-term measure. Its existing AI display calibration and machine vision assets provide the foundation for an open developer platform that can generate software licensing revenue without the capital intensity of further hardware investment.

Midea should prioritise open innovation and digital ecosystem integration and cross-border international integration. Midea's MEIA AI platform represents a strategically mature asset that is currently under-monetised; opening it as an ecosystem platform to third-party device manufacturers would generate network effects and subscription revenue at minimal incremental cost. The KUKA acquisition provides a ready-made international manufacturing footprint and industrial customer base that can be leveraged for cross-selling smart factory solutions in European markets.

TCL should prioritise vertical integration (specifically divestiture) and strategic alliances for cost reduction. TCL's negative net profit margin of −2,52% and negative operating margin of −2,40% indicate that capital-intensive integration pathways are not viable until financial restructuring is complete. The priority is divesting the loss-making photovoltaic subsidiary (RMB 9,82B loss in 2024) to eliminate the primary source of margin drag, combined with low-cost joint procurement alliances with BOE and Tianma to reduce input costs without new capital commitment.

Although Tables C.1–C.5 provide enterprise-specific recommendations for the five analysed companies, their scientific value can be strengthened by generalising these recommendations into broader strategic patterns applicable to different groups of

innovatively oriented industrial enterprises. Therefore, based on the competitive reserve profiles identified in Chapter 2 and the integration pathways discussed in Section 3.3, Table 3.12 summarises the optimal integration strategies for different types of innovatively oriented industrial enterprises. This generalisation transforms the practical company-level recommendations into a broader methodological framework that can be applied beyond the five sample enterprises.

The generalised framework in Table 3.12 shows that integration strategies should not be uniformly applied to all innovatively oriented industrial enterprises. Instead, the appropriate integration pathway depends on the firm's competitive profile, including its growth stage, financial stability, technological asset base, and internationalisation capacity. In this sense, the proposed framework contributes not only practical recommendations for the analysed companies, but also a scientific classification of integration strategies for innovatively oriented industrial enterprises under conditions of technological transformation and global market uncertainty.

The practical selection of an integration strategy should be carried out in several consecutive stages. At the first stage, the enterprise should identify the competitive reserve that cannot be realised effectively through internal resources alone. This reserve may concern access to critical inputs, technological knowledge, production capacity, distribution channels, international markets, or complementary digital assets.

At the second stage, the enterprise should evaluate alternative integration pathways according to financial capacity, the required degree of control, implementation speed, reversibility, technological risk, and exposure to international restrictions. These criteria make it possible to distinguish situations in which ownership-based integration is justified from those in which contractual cooperation or participation in an open ecosystem provides a more proportionate response.

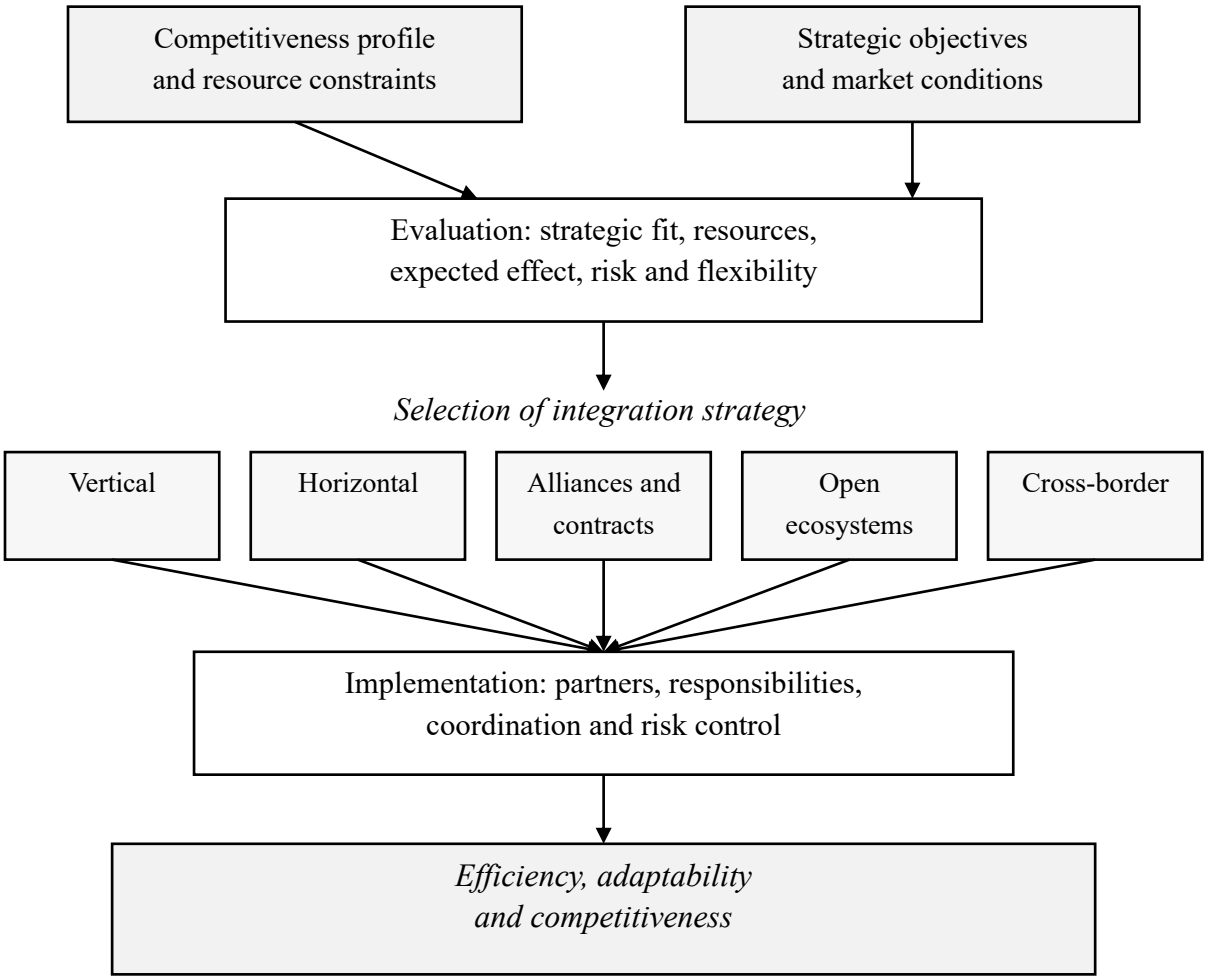


Figure 3.4 – Sequence for evaluating, selecting, and implementing an integration strategy

Source: developed by the author

The proposed sequence provides a consistent procedure for selecting an integration strategy in accordance with the enterprise's actual competitive reserves and development priorities. The process begins with an assessment of the enterprise's competitiveness profile, resource constraints, innovation objectives, market changes, and internationalisation priorities. The available integration options are compared according to their strategic fit, resource requirements, expected effects, risks, and the required degree of control and flexibility. The selected strategy is implemented through partner selection, allocation of responsibilities and resources, coordination of joint activities, and risk management. Its effectiveness is assessed by changes in access to technologies and markets, innovation commercialisation, operational efficiency, market adaptability, and international competitiveness. The feedback loop allows the enterprise

to revise the selected strategy when the expected results are not achieved or external conditions change.

Vertical integration is appropriate when the enterprise requires stable access to strategically important inputs or needs greater control over production and distribution. However, it requires substantial capital and may increase fixed costs; therefore, it should be selected only when the expected reduction in supply risk and transaction costs is consistent with the enterprise's financial capacity. Horizontal integration is suitable when scale, standardisation, or the consolidation of parallel capabilities can improve operating efficiency and market position. Its application requires an assessment of whether the expected synergies exceed the costs of combining organisational structures and whether the enterprise can avoid duplicating assets and functions.

Strategic alliances and long-term contractual relationships are preferable when enterprises need complementary resources but cannot justify the cost or risk of ownership-based integration. They allow access to technology, knowledge, financing, or markets while preserving organisational independence. Open innovation and digital ecosystem integration are most appropriate when value creation depends on the participation of multiple developers, suppliers, users, and service providers. These strategies can accelerate innovation and create additional revenue streams, but they also require clear rules for data access, intellectual property, technical standards, and the distribution of commercial benefits. Cross-border integration should be selected when international production, market access, or cooperation with foreign partners directly supports the enterprise's competitive priorities. Its expected advantages should be evaluated together with tariff, regulatory, currency, geopolitical, and coordination risks.

After selecting a preferred pathway, implementation should begin with a limited project or clearly defined group of activities. This makes it possible to verify the expected benefits, identify coordination problems, and adjust the cooperation model before committing additional resources. The agreement or implementation plan should specify the resources contributed by each participant, decision-making procedures, responsibility for results, intellectual property arrangements, performance indicators,

and conditions for revising or terminating cooperation. Such provisions are especially important for innovation projects, where the final technological and commercial outcomes may be uncertain at the beginning of cooperation.

The effectiveness of the selected integration strategy should be assessed using a combination of financial, operational, innovation, and market indicators. Financial indicators may include the cost of obtaining resources, capital requirements, cash-flow effects, and return on invested funds. Operational indicators should reflect delivery stability, production efficiency, implementation time, and the use of shared capacity. Innovation indicators should measure access to new knowledge, the speed of product development, patent or technology outputs, and the commercialisation of joint results. Market indicators should include international revenue, access to new customer groups, and changes in competitive position. Regular monitoring of these indicators enables the enterprise to determine whether the integration strategy is realising the competitive reserves identified in Chapter 2 or whether its configuration should be revised.

Accordingly, the integration strategy should be selected by comparing the enterprise's competitive constraints, available resources, required level of control, and expected economic effect. This preserves the differentiated approach applied to BYD, CATL, BOE, Midea, and TCL and extends the proposed framework to other innovatively oriented industrial enterprises. The empirical findings demonstrate that innovation investment affects international competitiveness through several interrelated channels. R&D intensity strengthens enterprises' technological capabilities and supports the production of technologically complex exports, while improved financial performance facilitates the commercialisation of innovation outcomes. At the same time, firm size may weaken the positive effect of R&D investment because of higher coordination costs and organisational inertia. The resulting mechanism is presented in Figure 3.5. The innovation linkage mechanism explains how measurable financial and operational reserves can be converted into stronger long-term international competitive positioning.

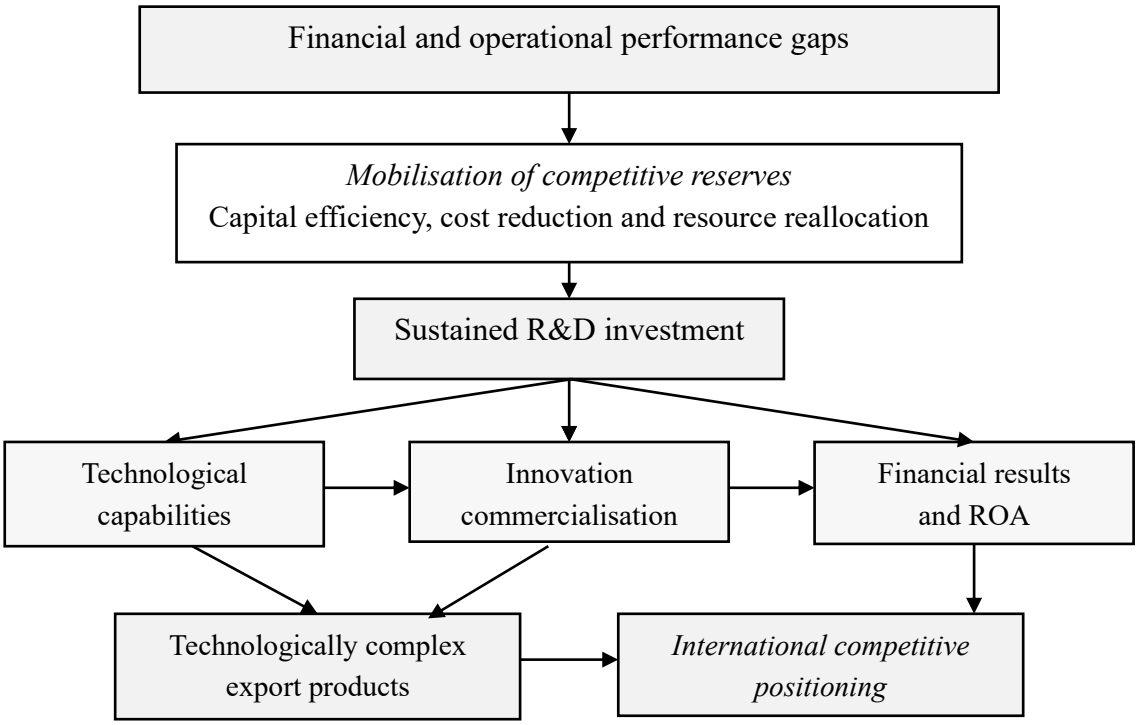


Figure 3.5 – Innovation linkage mechanism connecting competitive reserves with international competitive positioning

Source: developed by the author

The process begins with the identification of performance gaps in profitability, solvency, operational efficiency, and growth potential. Measures aimed at improving capital efficiency, reducing costs, strengthening cash generation, and reallocating resources mobilise the reserves required for sustained R&D investment. R&D investment supports the development of technological capabilities, the creation and commercialisation of innovations, and improved financial performance. These effects contribute to the production of technologically complex export products and strengthen the enterprise's position in international markets. Performance feedback is used to reassess the original gaps and adjust the measures for mobilising competitive reserves.

Conclusions to Chapter 3

As a result of addressing the objectives of the third chapter, the following conclusions of theoretical and practical significance were drawn.

1. Based on the author's econometric analysis of panel data from 7209 Chinese

A-share listed manufacturing firms for 2016–2021, in fulfilment of research task 7, a multivariate regression model of the international competitiveness of innovatively oriented industrial enterprises has been developed using two-way fixed effects (improved). R&D intensity is positively associated with export technology complexity directly and indirectly through ROA, while firm size negatively moderates this relationship. The model enables enterprises and policymakers to assess how innovation investment is related to export competitiveness and to differentiate support measures by firm size.

2. Based on the author's systematisation of enterprise resource needs and the empirical findings of Chapter 3, in fulfilment of research task 8, the resource provision framework for innovatively oriented industrial enterprises has been further developed across five interrelated dimensions: financial, technological, functional, human, and information provision. The framework is useful for identifying resource gaps and targeting enterprise and government support toward the factors associated with stronger market adaptability and international competitiveness.

3. Based on the author's comparative evaluation of five integration pathways and the competitive reserve profiles of five sample enterprises established in Chapter 2, in fulfilment of research task 9, the methodological approach to evaluating and selecting integration strategies for innovatively oriented industrial enterprises has been improved. Enterprise-specific priorities were determined, and it was established that integration architecture should be dynamically aligned with each enterprise's financial capacity. The approach ensures continuity between competitiveness diagnostics and strategic choice, enabling enterprises to select feasible integration strategies instead of relying on generic recommendations.

CONCLUSIONS

As a result of this research, a scientific and applied problem has been solved concerning the development of theoretical foundations, scientific and methodological provisions, and practical recommendations for ensuring the international competitiveness of innovatively oriented industrial enterprises in the context of global transformations, digital economy development, and Industry 4.0. The following conclusions of theoretical and practical orientation have been formulated, corresponding to the nine research tasks set in the introduction:

1. Based on the analysis of scientific literature, theoretical studies, and contemporary research in the field of competitiveness and innovation management, the essence of the international competitiveness of innovatively oriented industrial enterprises was clarified and a refined conceptual framework was developed. The proposed interpretation extends existing approaches by emphasizing the role of R&D intensity, technological complexity of exports, intellectual property accumulation, and the ability to transform innovation activities into financial performance, thereby deepening the theoretical understanding of competitive advantage formation under conditions of technological transformation and global market dynamism.

2. Based on a critical review and systematization of scientific and methodological approaches to competitiveness assessment, the strengths and limitations of existing evaluation methods were identified. This made it possible to establish the methodological foundations for a multidimensional assessment of enterprise competitiveness that more adequately reflects the complexity of competitive performance in conditions of globalization, uncertainty, and rapidly changing market environments.

3. Based on the integration of the Resource-Based View, the Dynamic Capabilities Framework, and the Open Innovation Concept, theoretical and methodological provisions for ensuring the competitiveness of innovatively oriented industrial enterprises were further developed. The framework explains how enterprises

can strengthen sustainable international competitiveness through the strategic orchestration of resources, adaptive capabilities, and external knowledge within collaborative ecosystems.

4. Based on the analysis of statistical data, industry reports, and analytical materials concerning the artificial intelligence market in China, its current state, key development trends, and future prospects were identified. This provided an empirical basis for understanding the external environment of innovatively oriented industrial enterprises and identifying the opportunities and challenges associated with their international competitive positions.

5. Based on the analysis of enterprise performance indicators and the application of composite index methodology, an integrated method for assessing the competitiveness level of innovatively oriented enterprises was improved. By combining profitability, solvency, operational efficiency, and growth potential dimensions and applying entropy weighting procedures, the proposed approach enabled objective ranking and benchmarking of enterprises, as well as the identification of their competitive strengths and weaknesses.

6. Based on the assessment of enterprise competitiveness and the examination of performance reserves, the key sources of competitive potential available to innovatively oriented enterprises were identified and evaluated. This made it possible to determine priority areas for strengthening competitiveness in the context of global transformations, digitalization processes, and increasing technological complexity of international markets.

7. Based on the econometric analysis of panel data from 7209 Chinese A-share listed manufacturing enterprises for 2016–2021, a multivariate regression model of international competitiveness was developed and tested. The results indicate a statistically significant positive association between R&D intensity and export technology complexity, the mediating role of ROA, and the negative moderating effect of firm size, providing an empirical tool for competitiveness analysis and size-differentiated decision-making.

8. Based on the analysis of scientific sources, enterprise resource management practices, and competitiveness determinants, the resource provision framework for innovatively oriented industrial enterprises was further developed across five interrelated dimensions: financial, technological, functional, human, and information provision. The framework links identified resource gaps with market adaptability, innovation continuity, and international competitive positioning.

9. Based on the evaluation of integration mechanisms and economic cooperation practices among innovatively oriented enterprises, strategic approaches to the integration of economic efforts were substantiated. The developed methodological approach encompasses vertical integration, horizontal integration, strategic alliances, open innovation ecosystems, and cross-border integration, enabling enterprises to generate synergistic effects, strengthen collaborative competitive advantages, and enhance their long-term competitiveness in international markets.

10. The conducted research comprehensively achieved its stated objective of developing theoretical foundations, substantiating scientific and methodological provisions, and formulating practical recommendations for ensuring the international competitiveness of innovatively oriented industrial enterprises. The obtained results expand the theoretical understanding of competitiveness, improve methodological tools for its assessment and modelling, and provide practical mechanisms for enhancing enterprise adaptability, innovation performance, and sustainable competitive development under conditions of globalization, technological transformation, and dynamic market uncertainty.

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APPENDICES

Appendix A

Implementation of the research results

UKRAINE

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NATIONAL TECHNICAL UNIVERSITY OF UKRAINE
"IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE"
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ex. № 28.02/44/2026 from 12.05.2026

CERTIFICATE
of implementation into the scientific activity of the Department of International Economics
of the Faculty of Management and Marketing of the National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute" of the scientific results of the dissertation on the topic
"Ensuring the international competitiveness of innovatively oriented industrial enterprises"
of a student of the third (educational and scientific) level of higher education,
specialty 051 Economics, field of knowledge 05 Social and Behavioral Sciences,
He Jingwen

The expert commission of the Department of International Economics of the Faculty of Management and Marketing confirms the implementation into the **scientific activity** of certain scientific results of the dissertation of the student of the third (educational and scientific) level of higher education, He Jingwen. In particular, these results were incorporated into the research project 0123U101154 "Transformation of International Activities Based on Industry 4.0 / 5.0 and Circular Economy".

Dean of the Faculty of Management and Marketing,
Igor Sikorsky Kyiv Polytechnic Institute,
D.Sc. (Econ.), Professor — Maryna KRAVCHENKO

Deputy dean for scientific activity
of the Faculty of Management and Marketing,
D.Sc. (Econ.), Professor — Olha VOVK

Head of the Department of International Economics,
D.Sc. (Econ.), Professor,
Guarantor of the educational program — Serhii VOITKO

UKRAINE

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

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CERTIFICATE

of implementation into the educational process of the Department of International Economics of the Faculty of Management and Marketing of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" of the scientific results of the dissertation on the topic "Ensuring the international competitiveness of innovatively oriented industrial enterprises" of a student of the third (educational and scientific) level of higher education, specialty 051 Economics, field of knowledge 05 Social and Behavioral Sciences,

He Jingwen

The expert commission of the Department of International Economics of the Faculty of Management and Marketing confirms the implementation into the educational process under the educational program "International Economics" (specialty 051 Economics, field of knowledge 05 Social and Behavioral Sciences) of certain scientific results of the dissertation of the student of the third (educational and scientific) level of higher education, He Jingwen. In particular, these results were incorporated into the educational component "Competitiveness of International Business", within which the discussion task "Determining the Reserves of Competitive Potential of Innovation-Oriented Enterprises" was introduced into Topic 3.2 "Development of an International Competitive Strategy". The specified scientific results correspond to the subject area of the educational program and the syllabus of the educational component.

Dean of the Faculty of Management and Marketing,
Igor Sikorsky Kyiv Polytechnic Institute,
D.Sc. (Econ.), Professor — Maryna KRAVCHENKO

Deputy dean for academic and methodological work
of the Faculty of Management and Marketing,
Ph.D. in Physics and Mathematics,
Associate Professor — Ivan FARTUSHNYI

Head of the Department of International Economics,
D.Sc. (Econ.), Professor,
Guarantor of the educational program — Serhii VOITKO

CERTIFICATE

on the Implementation of Research Results of the Dissertation

(confirming practical application of scientific results at the enterprise)

Dissertation author: He Jingwen

Dissertation topic: "Ensuring the International Competitiveness of Innovation-Oriented Enterprises"

Degree: Doctor of Philosophy (Ph.D.) in specialty 051 "Economics"

Institution: National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"

Scientific Supervisor: Anna Kukharuk, Ph.D. in Economics, Associate Professor, Department of International Economics

This Certificate confirms that the research results obtained in the above-mentioned doctoral dissertation have been reviewed, adopted, and implemented in the practical activities of our enterprise.

1. Enterprise Name: Hangzhou Ruifan Education Technology Co., Ltd.

2. Legal Address: Room 1401-15, Jinyazhuang Building, No. 26 Jiefang Road, Shangcheng District, Hangzhou, Zhejiang Province, China

3. Legal Representative: Ke Hui

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Implemented Research Results:

The following scientific and methodological developments were reviewed, evaluated, and applied in the enterprise's strategic management and operational activities:

Result 1. *Resource Provision System for Market Adaptability of Innovation-Oriented Enterprises*

The dissertation proposes a comprehensive resource provision system encompassing ten categories of resources (financial, technical, human, information, material, investment, intangible, spatial, time, natural, and legal), with concrete improvement measures for each. The financial optimization strategy — transitioning from a hardware-heavy model to a hardware-software integration model and adopting subscription/SaaS delivery — together with human capital development recommendations, were implemented in our enterprise's operations.

Practical benefit: Reduced income volatility, shortened payment cycles, and improved capital allocation efficiency. The digital transformation roadmap facilitated integration of AI, big data analytics, and cloud computing, enhancing operational responsiveness and market adaptability.

Result 2. *Integration of Economic Efforts for Synergistic Development of the Competitive Environment*

The dissertation analyzes three vertical integration mechanisms — new enterprise establishment, strategic alliances, and mergers & acquisitions — demonstrated through case studies of CATL, BYD, and Gotion High-Tech. Backward vertical integration into upstream raw materials mitigates price fluctuations, reduces procurement costs by up to 20%, and establishes long-term supply chain stability, substantiating the strategic and economic value of integration for competitiveness enhancement.

Practical benefit: The vertical integration framework informed our supply chain strategy and partnership decisions, improving supply chain security and procurement cost efficiency for critical materials.

Result 3. *Comprehensive Competitiveness Assessment Composite Index Method*

A composite competitiveness index integrating four dimensions was adopted as an analytical benchmarking tool: profitability (ROE, ROA, gross/net profit margins), solvency (current ratio, debt-to-

asset ratio), operational efficiency (receivables, inventory, and total asset turnover), and sustainability (R&D investment ratio, employee training investment). The method enables systematic ranking, benchmarking, and identification of competitive strengths and weaknesses across multiple dimensions.

Practical benefit: Applied to our enterprise's performance benchmarking process, the framework supported evidence-based strategic planning and provided a robust tool for ongoing competitiveness monitoring and improvement.

The models, methodologies, and recommendations developed in the dissertation of He Jingwen are well-grounded, innovative, and directly applicable to enterprises operating in technology-intensive, innovation-driven sectors. We confirm that the implementation of the aforementioned research results has yielded measurable positive effects on our enterprise's competitiveness and strategic management practices.

Implementation commencement date: 01.07.2025 – 31.12.2025

Director / Legal Representative: 柯慧

Full Name: Ke Hui

Enterprise: Hangzhou Ruifan Education Technology Co., Ltd.

(Official Seal of the Enterprise)

Date: 31/ 12 / 2025

(This Certificate is valid only when bearing the official seal / stamp of the enterprise.)

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Від 07 квітня 2026р.

ДОВІДКА

Видана здобувачці третього (освітньо-наукового) рівня вищої освіти спеціальності 051 Економіка, галузі знань 05 Соціальні та поведінкові науки, кафедри міжнародної економіки Національного технічного університету України «Київський політехнічний інститут імені Ігоря Сікорського» Хе Цзінвен (He Jingwen) в тому, що результати її дисертаційної роботи на тему «Ensuring the international competitiveness of innovatively oriented industrial enterprises» («Забезпечення міжнародної конкурентоспроможності інноваційно-орієнтованих промислових підприємств»), а саме

> обгрунтування положень з визначення резервів підвищення конкурентоспроможності інноваційно орієнтованих підприємств на основі оптимізації фінансових показників, підвищення операційної ефективності, покращення структури капіталу та активізації інноваційної діяльності

мають практичну цінність та враховані у процесі стратегічного планування діяльності підприємства з метою посилення його конкурентного потенціалу на інноваційній основі.

Директор ТОВ «ЕЛЬФАПАК» **ДМИТРО Змітрович**

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Appendix B

Table B.1 – Reserve-based measures to improve the current ratio

Firm	2024	Target	Gap	Measures	Calculation and result
TCL	0.86	1,2–1,5	−0,34 to −0,64	Securitize receivables (about RMB 30 billion); extend payment terms by 15–20 days; reduce inventory by about RMB 5 billion.	Receivables: 22,1 × 30% = RMB 6,6 billion cash. Payables: 80 × 15–20 ÷ 360 = RMB 3–4 billion additional float. Inventory: 45 × 10% = RMB 4,5 billion. More than RMB 15 billion is released; each RMB 10 billion raises the ratio by 0,05–0,07.
BYD	0.75	1,2–1,5	−0,45 to −0,75	Discount invoices (about RMB 10 billion); refinance about RMB 15 billion of short term debt with medium term notes.	Receivables: 62,1 × 16% = RMB 10 billion. Refinancing: 210 × 7% = RMB 15 billion less in current liabilities. Each RMB 10 billion reclassified raises the ratio by about 0,008, based on current liabilities of RMB 1240 billion.
BOE	1.244	1,2–1,5	Within target	Use structured receivables financing (about RMB 8 billion); convert about RMB 5 billion of short term loans into long term debt.	Receivables: 34,9 × 23% = RMB 8 billion. Loan conversion: 70 × 7% = RMB 5 billion. The measures preserve the benchmark ratio and release funds for research and development.
CATL	1.608	1,7–2,0	Within target	Deploy about RMB 10 billion of idle cash; extend supplier payment terms to create about RMB 8 billion of additional float.	Cash: 235 × 4% = RMB 9–10 billion deployed in short term instruments. Payables: 130 × 6% = RMB 8 billion additional float, reducing the net working capital requirement.
Midea	1.106	1,2–1,5	−0,09 to −0,39	Reduce inventory through just in time management (about RMB 4 billion); accelerate about RMB 6 billion of receivables through early payment incentives.	Inventory: 60 × 7% = RMB 4 billion. Receivables: 34,5 × 17% = RMB 6 billion accelerated. The combined effect moves the ratio toward 1,2.

Source: author's calculations from 2024 corporate reports and financial statements on cninfo.com.cn (Shenzhen Stock Exchange).

Table B.2 – Reserve-based measures to improve the debt ratio

Firm	2024	Target	Gap	Measures	Calculation and result
TCL	64,92%	55–60%	+4,92 to +9,92 points	Raise RMB 100–150 billion in equity; spin off underperforming divisions.	Assets total about RMB 290 billion; the benchmark requires RMB 14–29 billion more equity. Raising RMB 100–150 billion increases equity from about RMB 101 billion to RMB 200–250 billion and lowers the ratio to 55–60%. Spinning off the photovoltaic subsidiary with a book value of RMB 80–100 billion provides a further improvement.
BYD	74,64%	60–65%	+9,64 to +14,64 points	Issue RMB 80–100 billion in hybrid capital; retain about RMB 45 billion in profits.	Assets total about RMB 1175 billion; the benchmark requires RMB 113–173 billion more equity. Hybrid capital plus two year retention of about 40% of RMB 40,3 billion in annual profit produces RMB 120–145 billion. Each RMB 10 billion increase reduces the ratio by about 0,85 percentage points.
BOE	52,43%	50–55%	Within target	Retain RMB 12–16 billion in profits; monetize strategic assets worth about RMB 10 billion.	Assets total about RMB 576 billion. Two-year retention: RMB 4,1 billion net profit × 70% = RMB 6–8 billion annually, or RMB 12–16 billion in total. Joint-venture stakes are valued at RMB 8–12 billion. The measures strengthen equity while preserving the benchmark ratio.
CATL	65,24%	60–62%	+3,24 to +5,24 points	Issue RMB 50–80 billion in hybrid capital; retain about RMB 36 billion over two years.	Assets total about RMB 942 billion; a 3–5 percentage point reduction requires RMB 28–47 billion more equity. Issuance plus retention of RMB 50,7 billion × 35% × 2 years yields RMB 85–116 billion. Each RMB 10 billion increase reduces the ratio by about 1,06 percentage points.
Midea	62,33%	55–57%	+5,33 to +7,33 points	Retain about RMB 40 billion in profits; partially list subsidiaries to raise RMB 40–60 billion.	Assets total about RMB 582 billion; the benchmark requires RMB 31–43 billion more equity. Two-year retention of RMB 39 billion × 50% gives about RMB 39 billion. Subsidiary listings bring the combined increase to RMB 79–99 billion, providing a buffer for asset growth.

Source: author's calculations from 2024 corporate reports and financial statements on cninfo.com.cn (Shenzhen Stock Exchange).

Table B.3 – Recommended reserve-based measures for improving accounts receivable turnover

Company	2024AR Turnove	Industry Benchmark	Reserve Gap	Recommended Measures	Calculation Basis
TCL	7,45x	10–12x	−2,55 to −4,55x	Receivables securitisation (~20–30B RMB); tiered early-payment discount for B2B buyers	AR balance RMB 22,1B; securitising 90–135% of AR balance (~20–30B) through an ABS programme converts receivables to immediate cash. At 2024 revenue RMB 164,8B, each 30-day reduction in collection period = AR reduction of ~13,7B, improving turnover by ~0,6x. Target: reduce avg collection days from ~49 to ~30–36 days
BYD	12,52x	10–12x	Above benchmark	Blockchain-based invoice settlement (~20B RMB annual); dealer payment term renegotiation (~15B RMB)	AR balance RMB 62,1B; blockchain settlement platform estimated to process ~32% of annual AR (~20B) with 15-day faster settlement vs current. Dealer renegotiation on ~120B dealer receivables × ~12,5% reduction in avg terms = ~15B freed. BYD already above benchmark; measures maintain efficiency at scale
BOE	5,692x	7–9x	−1,31 to −3,31x	Reverse factoring with panel customers (~10B RMB); early-payment incentives (~6B RMB)	AR balance RMB 34,9B; reverse factoring programme with Apple/Samsung/Xiaomi covering ~10B in high-quality receivables shortens avg settlement from 90 to 30–45 days. Early payment discounts (0,5–1% for 30-day early payment) on ~6B B2B receivables reduces avg collection cycle. Combined effect: +1,0–1,5x turnover improvement
CATL	5,65x	7–9x	−1,35 to −3,35x	Reverse factoring with OEM customers (~15B RMB); tiered early-payment incentives	AR balance RMB 64,2B; reverse factoring on top-5 OEM accounts (~15B, representing ~23% of total AR) at 30–45 day settlement vs current 90-day terms reduces avg collection days by ~15–20 days. Revenue RMB 362,2B ÷ 360 days × 15-day improvement = ~15B AR reduction = +0,4x turnover improvement toward 6,0–6,5x
Midea	11,86x	10–12x	Within range	AI-based invoice reconciliation (~50B RMB portfolio); early-payment rebates (~10B RMB)	AR balance RMB 34,5B; AI reconciliation system applied to full AR portfolio (~50B including trade credit lines) reduces dispute-related delays estimated at 3–5 days avg, freeing ~0,4–0,7B. Early-payment rebates on ~10B downstream buyer balances maintain current ratio above benchmark. No structural gap; the current strategy maintains performance

Source: Author's compilation based on corporate annual reports (2024). Calculation basis: monetary estimates derived from each company's 2024 balance sheet and income statement figures disclosed on cninfo.com.cn (Shenzhen Stock Exchange).

Table B.4 – Recommended reserve-based measures for improving net profit margin

Company	2024 Margin	Industry Benchmark	Reserve Gap	Recommended Measures	Calculation Basis
TCL	−2,52%	1–2%	−3,52 to −4,52	Product mix shift to high-margin OLED/Mini-LED (~60B RMB revenue); divestiture of loss-making divisions (~80–100B RMB)	2024 revenue RMB 164,8B; high-margin display segment (est. 15–18% gross margin) currently ~30% of revenue. Increasing to ~55–60% adds ~40B in higher-margin revenue. Photovoltaic loss ~9,82B removed via divestiture. Net effect: +3–4 pp net margin improvement toward 1–2% target
BYD	5,35%	7–8%	−1,65 to −2,65	Overseas market expansion (~80B RMB incremental revenue); vertical supply chain cost reduction (~2% on RMB 600B revenue)	Overseas revenue premium est. +2–3 pp vs domestic margin; incremental ~80B overseas revenue × 2pp premium = ~1,6B additional profit. Supply chain COGS reduction: RMB 600B manufacturing COGS × 2% efficiency = ~12B savings. Combined: ~13,6B net profit increase on ~800B revenue base = +1,7 pp net margin
BOE	2,09%	4–5%	−1,91 to −2,91	Investment in AR/VR and flexible OLED panels (~20B RMB revenue); value-added service contracts (~10B RMB)	AR/VR and flexible OLED est. gross margin ~18–20% vs LCD ~8%; incremental ~20B revenue × 10pp margin premium = ~2B profit improvement. Service contracts: ~10B recurring revenue at est. 15% net margin = ~1,5B. Total profit improvement ~3,5B on ~200B revenue = +1,75 pp net margin improvement
CATL	14,92%	16–17%	−1,08 to −2,08	Battery-as-a-Service (BaaS) scaling (~20B RMB); vertical integration in lithium processing (~5–8B RMB savings)	BaaS software/service revenue est. 25–30% net margin vs hardware ~14%; incremental 20B BaaS revenue × 12pp premium = ~2,4B profit. Lithium integration: est. RMB 5–8B input cost reduction on ~80B raw material spend. Combined ~7–10B profit improvement on ~380B revenue = +1,8–2,6 pp, meeting 16–17% target
Midea	9,52%	12–14%	−2,48 to −4,48	Subscription-based smart home services (~20B RMB revenue); lean automation savings (~1,5% on RMB 300B)	Smart home subscription at est. 20% net margin: 20B × 20% = ~4B incremental profit. Lean automation on RMB 300B manufacturing cost base × 1,5% = ~4,5B savings. Combined ~8,5B improvement on ~420B revenue = +2,0 pp, supporting movement toward 12% benchmark

Source: Author's compilation based on corporate annual reports (2024). Calculation basis: monetary estimates derived from each company's 2024 balance sheet and income statement figures disclosed on cninfo.com.cn (Shenzhen Stock Exchange).

Table B.5 – Recommended reserve-based measures for improving operating profit margin

Company	2024 Margin	Industry Benchmark	Reserve Gap	Recommended Measures	Calculation Basis
TCL	−2,40%	1–2%	−3,40 to −4,40 pp	Portfolio reallocation to high-margin segments (~30B RMB); divestiture of low-margin consumer electronics (~20–30B RMB)	Operating loss 2024: ~RMB 4,0B on revenue RMB 164,8B. Reallocation of ~30B revenue to high-margin display (op. margin ~8–10%) from legacy electronics (op. margin ~−5%) = improvement of ~4B operating profit. Consumer electronics divestiture removes ~3–4B annual operating losses
BYD	6,39%	8–9%	−1,61 to −2,61 pp	COGS reduction via procurement efficiency (−1,5% on RMB 200B); premium overseas market EV revenue (~10B RMB)	Manufacturing COGS ~RMB 650B; procurement efficiency on ~200B addressable spend × 1,5% = ~3B savings. Premium overseas Evs at higher ASP: ~10B additional revenue at ~12% op. margin = ~1,2B incremental op. profit. Combined ~4,2B improvement on ~777B revenue = +0,54 pp, cumulative with other initiatives toward 8–9%
BOE	2,56%	4–5%	−1,44 to −2,44 pp	AR/VR panel investment (~10B RMB, ~8% margin); hardware maintenance service contracts (~5B RMB, 15% margin)	AR/VR panels: RMB 10B revenue × 8% op. margin = ~0,8B operating profit. Service contracts: RMB 5B × 15% op. margin = ~0,75B. Combined ~1,55B improvement on ~200B revenue = +0,78 pp. Additional yield improvement from AI manufacturing reduces per-unit cost ~1–2%, contributing further margin improvement
CATL	24,44%	24–26%	Within range	Solid-state battery R&D investment (~30B RMB); AI-driven gigafactory cost optimization (~3–5% per-unit reduction)	Solid-state R&D: ~30B investment maintains technology premium positioning; at current 646 GWh capacity, 3–5% per-unit cost reduction = ~10–17B cost savings on ~320B manufacturing COGS. Sustains operating margin within 24–26% benchmark range as pricing pressure intensifies in standard lithium-ion segment
Midea	12,01%	14–16%	−2,01 to −3,99 pp	Subscription smart home services (~5B RMB, 20% margin); lean manufacturing automation (~2% cost reduction on RMB 150B)	Subscription services: RMB 5B × 20% op. margin = ~1B. Lean automation on RMB 150B manufacturing cost × 2% = ~3B savings. Combined ~4B improvement on ~410B revenue = +0,98 pp per measure set, supporting path toward 14% benchmark over 2–3 years

Source: Author's compilation based on corporate annual reports (2024). Calculation basis: monetary estimates derived from each company's 2024 balance sheet and income statement figures disclosed on cninfo.com.cn (Shenzhen Stock Exchange).

Table B.6 – Recommended reserve-based measures for improving revenue growth rate

Compa	2024 Growth Rate	Industry Benchmark	Reserve Gap	Recommended Measures	Calculation Basis
TCL	−5,44%	5–10%	−10,44 to −15,44 pp	Product innovation in high-end OLED/Mini-LED; service contracts for hardware products (~15% of portfolio)	2024 revenue RMB 164,8B declining from prior year. Service contracts on ~15% of hardware portfolio (~25B) at ~10% annual growth = ~2,5B incremental. High-end display premiumisation adds an estimated +3–5% revenue recovery. Combined: return to +5% growth represents ~8B incremental revenue on current base
BYD	29,02%	20–30%	Above benchmark	Software-defined vehicle features and BaaS subscriptions; international joint ventures and regional assembly plants	2024 revenue RMB 777,1B. BaaS subscription: est. 500000 fleet vehicles × RMB 5000/year = ~2,5B new recurring revenue. International JVs in Hungary/Thailand/Brazil: est. capacity 300000 vehicles × RMB 150000 ASP = ~45B incremental revenue at full ramp. Sustains 20–30% growth trajectory
BOE	13,66%	15–18%	−1,34 to −4,34 pp	Flexible display and AR/VR module expansion; yield management and capacity optimisation strategies	2024 revenue RMB 198,4B. AR/VR display market growing ~35% pa; BOE capturing 5% share = ~3–5B incremental revenue. Flexible OLED for smartphones: each 1% share gain in China OEM market ≈ ~4B revenue at current panel prices. Yield improvement reduces defect cost ~1,5B, improving effective revenue per line
CATL	−9,70%	10–15%	−19,70 to −24,70 pp	Overseas market penetration (~80–100B RMB new contracts); ESS grid storage expansion (~50–60B RMB)	2024 revenue RMB 362,2B declining from peak. Overseas gigafactory contracts: European OEM multi-year supply agreements est. RMB 80–100B annual contracted volume at full ramp. ESS market growing ~40% pa globally; CATL targeting 50–60B ESS revenue by 2026 (from ~25B in 2024), reducing EV cycle dependency
Midea	9,47%	8–12%	Within range	AI and IoT platform integration across home appliance portfolio; lean and agile manufacturing adoption	2024 revenue RMB 409,4B. MEIA ecosystem: each 1% increase in smart appliance attachment rate across ~200M addressable Chinese households = ~2B incremental subscription/service revenue. Overseas expansion: target 8–12% international revenue growth on ~160B overseas base = ~13–19B incremental. Within benchmark; the current strategy maintains the trajectory

Source: Author's compilation based on corporate annual reports (2024). Calculation basis: monetary estimates derived from each company's 2024 balance sheet and income statement figures disclosed on cninfo.com.cn (Shenzhen Stock Exchange).

Appendix C

Table C.1 – Vertical integration recommendations for five sample innovatively oriented industrial enterprises

Company	Current Position (2024)	Recommended Vertical Integration Measures	Expected Integration Outcome
1	2	3	4
BYD	Current ratio: 0,75; Debt ratio: 74,64%; Revenue growth: 29,02% – strong growth but high leverage constrains acquisition capacity	Deepen backward integration into lithium carbonate and separator manufacturing through wholly-owned subsidiaries; convert existing minority stakes in battery material suppliers into majority ownership; establish dedicated EV software subsidiary to internalise ADAS development and reduce dependence on third-party software vendors	Reduces critical input cost exposure; lowers debt-to-equity ratio pressure through internalised margin capture; accelerates software-defined vehicle roadmap by 2–3 years; partially offsets leverage risk through improved operating margin
CATL	Operating margin: 24,44% – highest of five; Revenue declined 9,70% in 2024 due to commodity battery price pressure	Accelerate upstream integration into lithium mining and nickel smelting beyond existing JV positions; establish wholly-owned solid-state electrolyte production subsidiary to protect next-generation battery IP; develop battery recycling subsidiary to capture end-of-life material value and reduce virgin material dependency	Secures raw material supply at cost below market price; protects solid-state battery technology from leakage through wholly-owned structure; creates circular supply chain that reduces input cost by an estimated 15–20% over 5 years; positions CATL for margin leadership as commodity battery competition intensifies

End of Table C.1

1	2	3	4
BOE	Net margin: 2,09%; AR turnover: 5,692x – below benchmark; Revenue growth: 13,66%	Establish wholly-owned flexible OLED substrate and encapsulation material subsidiary to reduce reliance on Japanese and Korean specialty material suppliers; forward-integrate into commercial display system integration by acquiring or establishing system integrators for smart retail and transportation display markets	Reduces specialty material procurement cost and supply disruption risk; improves AR turnover by converting panel supply relationships to integrated system contracts with higher switching costs; shifts BOE from commodity supplier to solution provider, improving net margin toward the 4–5% hardware sector benchmark
Midea	Net margin: 9,52%; Current ratio: 1,106 – near benchmark; Op. margin: 12,01%	Deepen integration of KUKA robotics capabilities into Midea's own manufacturing processes; establish smart home chip and sensor design subsidiary to reduce dependence on external semiconductor suppliers for IoT devices; forward-integrate into after-sales service network through wholly-owned service centres in key markets	Leverages KUKA acquisition synergies not yet fully realised; reduces semiconductor input cost and supply risk for IoT appliance lineup; after-sales integration improves customer lifetime value and provides high-margin recurring revenue stream complementary to hardware sales
TCL	Net margin: -2,52%; Operating margin: -2,40% – both negative; Revenue declined 5,44%	Divest or spin off loss-making photovoltaic subsidiary (reported loss of RMB 9,82B in 2024) to eliminate drag on consolidated margins; simultaneously deepen backward integration in Mini-LED component manufacturing to secure supply for core display business; establish semiconductor design centre focused on display driver ICs to reduce dependence on external suppliers	Eliminates the primary source of TCL's negative margin; refocuses capital on core display and semiconductor competencies; Mini-LED integration reduces component cost and improves gross margin toward the 1–2% positive operating margin benchmark for restructuring manufacturers

Source: Developed considering [26; 73; 123]

Table C.2 – Horizontal integration recommendations for five sample innovatively oriented industrial enterprises

Enterprise	Longitudinal Strategic Context, 2014–2024	Recommended Horizontal Integration Measures	Expected Integration Outcome
1	2	3	4
BYD	Sustained revenue growth over 2014–2024, with 2024 revenue growth of 29,02%; global NEV market leader – approaching dominance in the domestic market	Selectively acquire or merge with domestic EV peers facing financial distress to consolidate market share and eliminate fragmented price competition; pursue horizontal integration with bus and commercial vehicle manufacturers to extend dominance from passenger vehicles into commercial EV segment	Increases domestic NEV market share toward 40%+ threshold that triggers pricing power; eliminates margin-eroding competitors; commercial vehicle horizontal expansion diversifies revenue beyond passenger cars and improves utilisation of battery manufacturing capacity
CATL	Strong profitability and market leadership over the 2014–2024 period, but revenue declined by 9,70% in 2024 due to battery price competition	Pursue selective horizontal mergers with smaller Chinese battery manufacturers to consolidate the domestic battery industry, reducing fragmented competition that is driving the price war; acquire or merge with battery management system (BMS) software companies to consolidate the software layer of the battery ecosystem	Industry consolidation reduces the number of competitors willing to accept below-cost pricing; BMS software horizontal integration positions CATL as an integrated hardware-software battery provider rather than a commodity cell supplier, improving pricing power and margin resilience

End of Table C.2

1	2	3	4
BOE	Persistent profitability volatility and below-benchmark receivables turnover over the 2014–2024 period; 2024 net margin: 2,09%, AR turnover: 5,692x	Pursue horizontal merger or strategic partnership with domestic display peers (e.g., CSOT/TCL, Tianma) in specific product segments to jointly negotiate better pricing with panel equipment suppliers; consolidate AR/VR display module manufacturing with complementary domestic manufacturers	Reduces capital equipment cost through consolidated procurement; strengthens negotiating position with Apple, Samsung, and other major customers; creates scale sufficient to sustain R&D investment in next-generation flexible and AR/VR display without each firm bearing full development cost
Midea	Stable profitability and operational efficiency over 2014–2024; 2024 net margin: 9,52%; global No. 1 smart home brand	Selectively acquire complementary smart home appliance brands in categories where Midea lacks coverage (e.g., premium kitchen appliances, health-monitoring home devices); pursue horizontal integration with energy management software companies to strengthen the MEIA AI ecosystem	Expands smart home ecosystem coverage, increasing cross-selling opportunities across a broader product range; energy management software integration strengthens recurring subscription revenue potential; premium brand acquisitions improve average selling price and net margin without requiring new manufacturing investment
TCL	Recurrent profitability volatility over 2014–2024, with restructuring pressure in 2024; operating margin: −2,40%	Limited horizontal M&A capacity given current financial losses; focus on horizontal cooperation agreements (not acquisitions) with BOE and other display peers for joint procurement of panel manufacturing equipment and materials; pool R&D resources in pre-competitive display technology areas such as quantum dot and micro-LED	Achieves scale benefits in equipment and material procurement without capital commitment that TCL cannot currently afford; shared pre-competitive R&D reduces individual R&D expenditure while maintaining access to next-generation display technology; preserves optionality for more active horizontal integration once restructuring restores profitability

Source: Compiled by the author based on company financial reports and longitudinal competitiveness indicators for 2014–2024, as analysed in Sections 2.2 and 2.3.

Table C.3 – Strategic alliance and contractual recommendations for five sample innovatively oriented industrial enterprises

Enterprise	Alliance Priority (from 2,3 analysis)	Recommended Strategic Alliance & Contractual Measures	Expected Integration Outcome
1	2	3	4
BYD	AR turnover: 12,52x – above benchmark; strong but exposed to EV market cycle	Establish long-term battery supply agreements (5–10 year take-or-pay contracts) with overseas OEMs entering EV market (Toyota, Stellantis, VW affiliates); form strategic alliance with Huawei on intelligent driving software and with NVIDIA on AI chip integration for vehicle computing platforms; sign multi-year lithium supply offtake agreements with South American producers	Diversifies revenue beyond domestic Chinese EV market; reduces revenue cyclicality through long-term contracted volumes; intelligent driving alliance accelerates software-defined vehicle capabilities without full acquisition cost; lithium offtake contracts reduce raw material price exposure
CATL	Revenue declined 9,70% – needs new growth markets urgently	Form strategic alliances with global energy utilities for grid-scale ESS deployment on a project-by-project revenue-sharing basis; establish long-term R&D collaboration agreement with leading solid-state electrolyte research universities (MIT, ETH Zurich, Tsinghua); sign battery supply framework agreements with international automakers entering EV market in Europe and Southeast Asia	ESS utility alliances open a high-growth adjacent market without full capital commitment; university R&D alliance reduces solid-state battery development cost while maintaining CATL IP ownership; international OEM supply agreements rebuild revenue growth lost from domestic battery price war

Continuation of Table C.3

1	2	3	4
BOE	Receivables turnover: 5,692x – below 7–9x benchmark	Introduce reverse factoring programme with major panel customers (Apple, Samsung, Xiaomi) to shorten receivables settlement from 90 to 30–45 days; form R&D alliance with leading AR/VR hardware companies (Meta, Apple, domestic peers) for co-development of display optics; sign long-term display supply agreement with Chinese EV manufacturers for in-vehicle display panels	Reverse factoring directly addresses the AR turnover gap identified in Section 2.3; AR/VR co-development alliance reduces BOE's solo R&D investment risk in an uncertain market; EV display supply agreement creates a new growing revenue stream diversifying from consumer electronics dependency
Midea	Op. margin: 12,01% – approaching but below 14–16% benchmark	Form strategic alliance with energy companies (State Grid, China Southern Power) for smart home energy management integration and demand response programmes; establish long-term component supply agreements with semiconductor foundries for IoT chip supply continuity; sign AI model co-development agreement with leading Chinese AI companies to enhance MEIA platform intelligence	Energy company alliances enable Midea to position MEIA as an energy management platform, opening subscription revenue from utility companies and smart city programmes; semiconductor supply agreements reduce the component shortage risk that disrupted appliance production in 2020–2022; AI co-development alliance improves MEIA capabilities faster than internal development alone

End of Table C.3

1	2	3	4
TCL	Net margin: -2,52% - must restore profitability before expanding alliances	Form strategic procurement alliance with BOE and Tianma for joint purchasing of panel manufacturing chemicals and gases, immediately reducing input costs without capital commitment; establish R&D cooperation agreement with CSOT (TCL subsidiary) and academic institutions for Mini-LED and Micro-LED joint development; sign long-term service contract with major retail chains for display product maintenance and upgrade programmes	Joint procurement alliance provides immediate cost reduction benefit while TCL is restructuring; R&D cooperation reduces individual development cost burden for next-generation display technologies; service contract revenue provides a stable, high-margin income stream that partially offsets hardware margin weakness during restructuring

Source: Developed considering [55; 75; 105; 128]

Table C.4 – Open innovation and digital ecosystem recommendations for five sample innovatively oriented industrial enterprises

Enterprise	Digital Asset Base	Recommended Open Innovation & Digital Ecosystem Measures	Expected Integration Outcome
1	2	3	4
BYD	AI-powered manufacturing; BaaS platform; ADAS development	Open BYD's charging network infrastructure as a platform for third-party energy service providers and EV fleet operators; establish open API ecosystem around BYD's vehicle software platform to attract third-party application developers; launch BaaS digital platform enabling subscription-based battery monitoring and lifecycle management services for fleet customers	Charging network becomes a revenue-generating platform asset rather than a cost center;2/ developer ecosystem increases software-defined vehicle value without additional BYD R&D investment; BaaS digital subscription creates recurring revenue stream uncorrelated with hardware sales cycles, directly addressing revenue stability identified as a reserve gap in Section 2.3

Continuation of Table C.4

1	2	3	4
CATL	AI-optimised gigafactory; solid-state R&D; battery management AI	Open CATL's battery management AI platform as a service to third-party battery users (industrial, marine, aerospace) beyond automotive; establish innovation challenge programme with startups and universities for solid-state electrolyte materials; participate in national and international battery recycling ecosystem platforms to secure end-of-life material flows	Battery management AI-as-a-service creates a new B2B software revenue stream; innovation challenge attracts external solid-state research at lower cost than fully in-house R&D; recycling ecosystem participation secures lithium recovery at below-mining cost, reducing long-term input cost exposure
BOE	AI display calibration; machine vision quality systems; AR/VR R&D	Launch open display technology platform enabling third-party AR/VR hardware developers to access BOE's display calibration algorithms and optical specifications as a development service; establish joint innovation lab with smart retail and transportation companies to co-develop AI-enhanced commercial display applications; participate in national industrial internet platform to connect BOE's manufacturing data with upstream material suppliers	Open developer platform creates software licensing revenue from display technology IP; joint innovation labs provide funded co-development of high-value application segments that BOE cannot develop alone; industrial internet participation improves supply chain coordination and reduces inventory cost
Midea	MEIA AI platform; KUKA robotics; 5G-enabled factories	Open MEIA AI platform to third-party smart home device manufacturers, creating a multi-brand smart home ecosystem that increases MEIA's network value; establish industrial AI co-innovation programme with manufacturing enterprises seeking to adopt AI-driven production	Open ecosystem strategy transforms MEIA from a proprietary platform to an industry standard, creating network effects that increase switching costs and platform revenue; the industrial AI programme commercialises KUKA capabilities in adjacent markets.

End of Table C.4

1	2	3	4
TCL	Mini-LED technology; semiconductor design; AI TV platform	Open TCL's AI television recommendation platform to third-party content and service providers under a revenue-sharing model; participate in national semiconductor design ecosystem to access shared EDA tools and foundry relationships at lower cost than individual procurement; establish Mini-LED open standard consortium with display peers to accelerate market adoption	AI TV platform revenue sharing creates content ecosystem revenue without additional content investment; semiconductor design ecosystem reduces TCL's chip development cost burden during financial restructuring; Mini-LED open standard accelerates market development, expanding TCL's addressable market faster than proprietary standard approaches

Source: Developed considering [128]

Table C.5 – Cross-border international integration recommendations for five sample innovatively oriented industrial enterprises

Enterprise	International Position	Recommended Cross-Border Integration Measures	Expected Integration Outcome
1	2	3	4
BYD	Global NEV sales leader; expanding overseas manufacturing; 29,02% revenue growth driven partly by exports	Establish regional EV assembly plants in Hungary (Europe), Thailand (Southeast Asia), and Brazil (Latin America) to circumvent tariff barriers; form battery supply joint ventures with European OEMs to create mutual economic dependency that provides geopolitical protection; establish R&D centre in Germany to access European automotive engineering talent	European and Southeast Asian localisation reduces tariff exposure and qualifies for local procurement preferences; OEM joint ventures create political stakeholder relationships that reduce regulatory risk; German R&D centre accelerates premium vehicle capability development.

Continuation of Table C.5

1	2	3	4
CATL	Global battery market share 37,9%; revenue declined 9,70% – needs international growth urgently	Accelerate overseas gigafactory construction in Germany and Hungary to serve European OEM customers directly; form battery supply and technology licensing agreements with North American and Indian battery manufacturers seeking CATL's manufacturing expertise; deepen JV positions in Indonesian nickel mining to secure upstream materials for global production	European gigafactories directly address the revenue growth reversal by capturing OEM supply contracts currently restricted by EU battery regulations; North American and Indian licensing generates royalty revenue from markets where full manufacturing presence is constrained; Indonesian materials JV secures upstream supply for the global production scale CATL requires
BOE	Revenue +13,66% – approaching but below 15–18% benchmark; strong display IP	Establish display module assembly operations in India and Vietnam to serve regional OEM customers and reduce dependence on Chinese export logistics; form technology licensing agreements with display manufacturers in emerging markets (India, Southeast Asia) seeking to upgrade display quality; pursue strategic cooperation with international AR/VR companies for display supply and technology co-development	Regional assembly reduces logistics cost and improves delivery speed for Southeast Asian and Indian customers; technology licensing generates royalty revenue from display IP in markets where BOE lacks full manufacturing presence; AR/VR international partnerships position BOE for the next display technology cycle beyond LCD panels

End of Table C.5

1	2	3	4
Midea	Global No.1 smart home brand; KUKA acquired in 2017 – international manufacturing base established	Leverage KUKA's European industrial customer relationships to cross-sell Midea's smart factory solutions; expand the localisation of the MEIA AI platform for European and North American smart home markets with region-specific compliance and language support; form distribution alliances with regional home appliance retailers in Southeast Asia and Middle East for faster market penetration	KUKA cross-selling realises the acquisition synergies not yet fully captured; MEIA internationalisation expands the addressable market for subscription services beyond China; regional distribution alliances accelerate overseas revenue growth toward the 8–12% benchmark identified in Section 2.3
TCL	Revenue declined 5,44%; restructuring – limited international investment capacity	Focus on cross-border contractual relationships rather than equity investments during restructuring: renew and expand long-term OEM display supply agreements with international television brands (Philips, RCA) to maintain export revenue; form technology licensing agreement with international Mini-LED manufacturers to generate royalty income from TCL's display IP; participate in international display standards bodies to protect TCL's technology interests at minimal cost	OEM supply agreement renewal maintains export revenue without new investment during restructuring; IP licensing generates royalty income that contributes to TCL's margin recovery without capital expenditure; standards body participation protects TCL's competitive position in next-generation display specifications at negligible cost

Source: Developed considering [23; 39]