An Exploratory Study of How Latecomers Transform Strategic Path in Catch-Up Cycle

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Abstract: In catch-up cycles, the industrial leadership of an incumbent is replaced by a latecomer. Latecomers from emerging economies compress time and skip amplitude by breaking the original strategic path and form a new appropriate strategic path to catch up with the incumbents. Previous studies have found that the original strategic path is difficult to break and difficult to transform. This paper proposes a firm-level framework and identifies the impetus and trigger factors for latecomers to transform the strategic path. The impetus is the mismatch between strategic mode and technological innovation capability. The trigger is the progressive industrial policy. Based on a Chinese rail transit equipment supplier's (China Railway Rolling Stock Corporation; CRRC) catch-up process, this paper finds that the strategic path transformation is an evolutionary process from mismatch to rematch between strategic mode and technological innovation capability. With the implementation of industrial policy, the technological innovation capability will change. The original strategic mode does not match with changed technological innovation capability, which leads to performance pressure. With the adjustment of industrial policy, a new strategic mode adapted to new technological innovation capability emerges. This paper clarifies the source that determines successful catch-up practices for latecomers and contributes to latecomers' sustainable growth in emerging economies.

Keywords: catch-up cycle; strategic path transformation; latecomer

1. Introduction

The catch-up cycle refers to the phenomenon of successful industrial leadership changes [1]. Latecomer firms achieve a substantial closing of the gap in technology and market share with incumbents. In this process, latecomers break the original strategic path and form new approaches to skip certain technology stages with time compression and amplitude leap [2]. Some latecomers in emerging economies have got close to or even overhauled the incumbents (e.g., high-speed railways, laser, and ultra-steel). However, the question has concerned: why such a catch-up did not happen in other latecomers [3]? Previous research has focused on explaining why paths are challenging to transform [4], whereas the causes of the path change have called for discussion, especially concerning how latecomers can maintain sustainable growth [5]. Facilitating the growth of latecomers may be of limited significance if it does not provide a clear perspective for latecomers to transform their strategic paths. This paper expands and deepens the cause of strategic path transformation in latecomers under the catch-up topics. Unlike some studies that emphasize the importance of new technology paradigms to transform the strategic path [6,7], we focus more on the factors that cause the industrial firm-level changes in emerging economies. Constrained by a weak technology foundation, these latecomers need continuous technology upgrading efforts to overcome resource shortages. By continuously improving technology and fully utilizing resources, the latecomers may obtain faster growth [8]. In catch-up cycles, the acquisition of sustainable competitive advantage

determines that latecomers reconfigure and continuously update to provide valuable and exceptional resources to promote faster innovation.

As a comprehensive business strategy tool, strategic mode (SM) defines the role that technological innovation can be a competition source to maintain product differentiation or cost advantage or to develop new products and businesses. Technical innovation capability (TIC; List of nomenclature is shown in Table A1 in Appendix A) reflects technological innovation's level and tendency to meet or create the market demand. Significantly, in emerging economies, latecomers often lose the motivation for technological innovation due to uncertain prospects and results [9]. The government tends to pool limited resources by industrial policy to help firms overcome the early huge investment and uncertainty of market prospects [10]. Therefore, it is essential for latecomers to achieve catch-up by strategic path transformation in order to improve resource utilization efficiency by optimally matching the SM and TIC to rapidly reduce technology differences and gaps with industrial policy guidance.

We elaborate on SM and TIC's relationship in catch-up cycles, how the relationship influences the strategic path transformation, and industrial policy's role in this process. An exploratory embedded single-case study is adopted in this paper. The case study object is China Railway Rolling Stock Corporation (CRRC), which is widely considered to have successfully caught up with high-speed railways as a latecomer from an emerging economy. We aim to answer two core questions for latecomers in catch-up cycles: "how" to transform the strategic path for more rapid progress; and "when" to transform effectively.

2. Literature and Research Framework

2.1. Catch-Up Cycle

Catch-up is the process of entities (generally referred to as firms) reducing or eliminating the gaps of technology and market share with the incumbents in a certain period [11]. Figure 1 shows the technology curve of latecomers from emerging economies and industrial incumbents over a catch-up cycle.
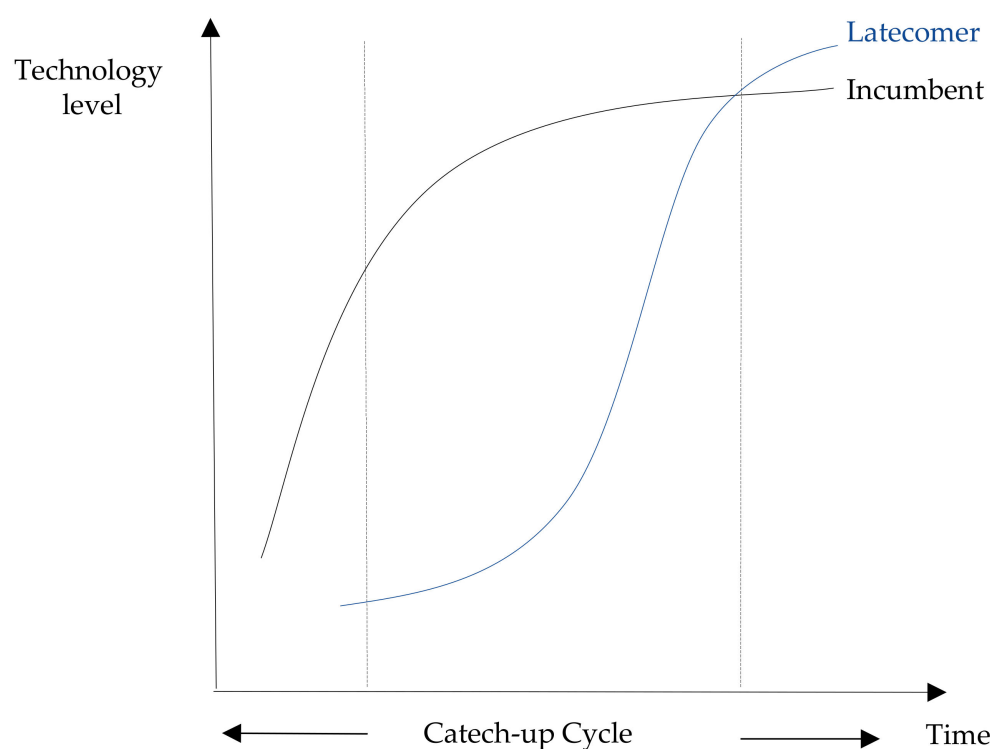
Figure 1. Catch-up cycle.

For firms in developed economies, catch-up is the relative speed in a race along a fixed trajectory, and their technological development is a cumulative one-way process, whereas, for firms in emerging economies, it is not. There are two main differences (technology and market) between latecomers in both economies. First, latecomers in emerging economies are often far from the sources of technology and R&D and lag in science, engineering, and technology. Second, latecomers in emerging economies are distanced from the mainstream international markets they hope to supply, often dealing with small, underdeveloped local markets and simple users. These disadvantages make the latecomers' competitive advantage in emerging economies lag behind the industrial incumbents in developed countries. For these latecomers in emerging economies, it puts more emphasis on catching or surpassing the incumbents through discontinuous technological progress [12]. They need to compress in time and leapfrog in amplitude.

Despite continuing high development assistance to compress time, many latecomers still have limited growth. The gap between latecomers and incumbents widens. Some good financial promotion policies (further opening up, easing access for foreign investment, promoting foreign investment facilitation, and liberalization) may not have yet achieved the sustainable upgrading of latecomers in the global value chain. Therefore, catch-up literature mainly focuses on how the firms and industries in emerging economies successfully compete with advanced countries' leaders [13]. Researchers initially suggested that latecomers could catch up by absorbing and adjusting the outdated version of existing technologies through the knowledge revolution [14]. Lee (2005), however, proposed different views: latecomers sometimes skip certain stages or even create their own paths [15], namely path creation and path skipping. Other scholars have explored the successive occurrence of catch-up [16]. In terms of internal conditions, research points out that catch-up is positively related to a firm's technological capabilities [17], and priority should be given to building technological innovation capabilities [18]. Licensed learning and technology transfer are also effective approaches [19,20]. The research on national innovation capability has shifted the focus of catch-up from resource endowment and comparative advantage to creating competitive advantage by institutional variables [21]. Further examples are provided by government policies in the Chinese telecommunications equipment industry [22].

Andrea and Roberta showed how new technologies opened up Italian firms' opportunities in the wine sector at the institutional level [23]. R&D cooperation with public scientific institutions can be used as a supplementary tool to provide opportunities for latecomers to access the required technologies and become a way for them to obtain low-risk technologies at a reasonable cost [24]. As the development of China's high-speed railway has been widely regarded as a successful catch-up for latecomers, research has focussed on explaining the reasons for this achievement. The reasons cover technology capability foundation [25], government or policy guidance [26], choice of technology strategy [27], formation of incentive mechanisms [28], strengthening basic research [29], and the establishment of cooperative networks [30]. However, little literature has put the factors or variables into the actual process of high-speed rail development to analyze their mechanisms. Such explanations leave the key variables that determine the success of China's high-speed railway catch-up unclear.

2.2. Strategic Path Transformation

A strategic path is a process of forming a stable strategic mode (SM). Strategic path transformation is the activity to redeploy or replace a firm's current SM to change its path dependence [31]. In catch-up cycles, latecomers explore new ways to compete through transformation [32]. Existing research has investigated the management cognition, conversion content, and learning process in strategic path transformation.

Regarding management cognition, the importance of changes in politics, technology, and competition in the corporate environment to the strategic path transformation is emphasized [33]. Other research has distinguished the technological development trajectory of latecomers, including repeated imitation, creative imitation, and original innovation, to

explain the changes in corporate strategy [34]. The transformation relates to the techno-
logical innovation capability, which is closely concerned with competitive advantage [35],
affects the entire organization [36], and is essential for breaking the path of dependence
and ensuring long-term survival [37]. In the learning view, the strategic path is composed
of different processes or describes the trajectory of potential action patterns [38], which will
lead to the transformation as the company learns [39].

2.3. SM and TIC

Strategic mode (SM) represents the decisions of the corporate innovation asset portfo-
lio. It is determined by the evolutionary path it has adopted or that is going to proceed [40].
Technological innovation capability (TIC) is the capability of firms to improve technological
innovation. Firms with TICs can create new value by developing new products, services
and exploring new skills. In catch-up cycles, the acquisition of sustainable competitive
advantage determines that latecomers reconfigure and continuously update to provide
valuable and unique resources to promote faster innovation.

Meanwhile, as a comprehensive business strategy tool [41], SM defines the role that
technological innovation can be a competition source to maintain product differentiation
or cost advantage or to develop new products and businesses. In essence, the value of
the latecomers' technological innovation does not lie in the predetermined technical level
but in efforts to absorb and adjust the demands of resource advantages. In these effort
activities (e.g., development, selection, improvement, etc.), SM links with TICs. Existing
research has carried out many analyses on the relationships between SM and TIC.

Research has focused on the factors that promote TIC formation and continuity under
a particular SM. The analysis of various opportunity windows needs to be determined by
examining the capabilities of latecomers and their SM nature [42]. The link between inde-
pendent innovation capability and innovation strategy is essential for effective innovation
management [43]. The strategy specifies the extent to which the adoption of innovation
and performance development enables the company to allocate resources faster than its
competitors to improve its market position [44]. Strategy determines the appropriate allo-
cation of resources, products, processes, and systems. Still, when faced with uncertainty,
technological innovation capabilities determine the extent to which an organization uses
innovation to adapt or change its environment and how the organization uses innovation to
develop corporate performance [45]. TIC is considered to meet the firm's SM requirements
and adapt to special conditions and competitive environment by adopting different scopes
and levels [46]. There is also analysis that TIC is the interaction of technical engineers,
innovation management, technological systems, and scientific theories, which is SM [47].
In catch-up cycles, the latecomers' SM trajectories are more complicated because their
challenge is the relative speed of improvement. For incumbents, technological innova-
tion generates new knowledge by mining existing knowledge stock [48], but latecomers
promote research and invention by introducing experience from leading firms due to the
advantage of backwardness [49]. Therefore, establishing a TIC system that enhances the
learning capability and enhances local exposure to incumbents' knowledge becomes the
critical step for successful catch-up [50]. The analysis of various windows of opportunity is
determined by examining the nature and type of capabilities, SM, and other sector system
components' response to the windows of opportunity in catch-up cycles [51].

2.4. Industrial Policy

Industrial policy is a form of government intervention that helps the economy catch-
up in a relatively short time [52]. In catch-up literature, industrial policy is considered as
a window of opportunity to guide and promote the upgrading of industrial structure to
generate new economic growth points [53] in order to achieve sustainable economic devel-
opment and avoid the "middle-income trap" [54]. The government concentrates resources
on the industries to be supported, which is conducive to accelerating economic growth.
However, some firms cause losses on the pretext of insufficient subsidies [55], resulting in

moral hazard and corporate efficiency problems [56]. Thus, the effectiveness of industrial policy is always situational and stage-specific. The adaptability of their industrial policy, which can continuously adapt to new market conditions, and a competitive environment are the fundamental guarantees for latecomers' sustainable innovation and development. And the close cooperation between government and firms is the necessary condition to form effective industrial policy [57]. For latecomers' catching-up, the essence is that they cooperate with the government to form a joint force to step forward with the minimum coordination costs and trial-and-error costs.

2.5. Analysis Framework

Existing research explains the contributing factors by which many latecomers can achieve technological improvement within a limited period. To explain how to achieve sustainable growth in a longer time, we aim to set up a framework to deconstruct the causes of latecomers' strategic path transformation in the catch-up cycle (Figure 2). SM, TIC, and industrial policy are incorporated into the actual process of the latecomer's catch-up. We consider the changes and interactions of these variables to explain the way out of the dilemma of circular backwardness for latecomers in emerging economies.
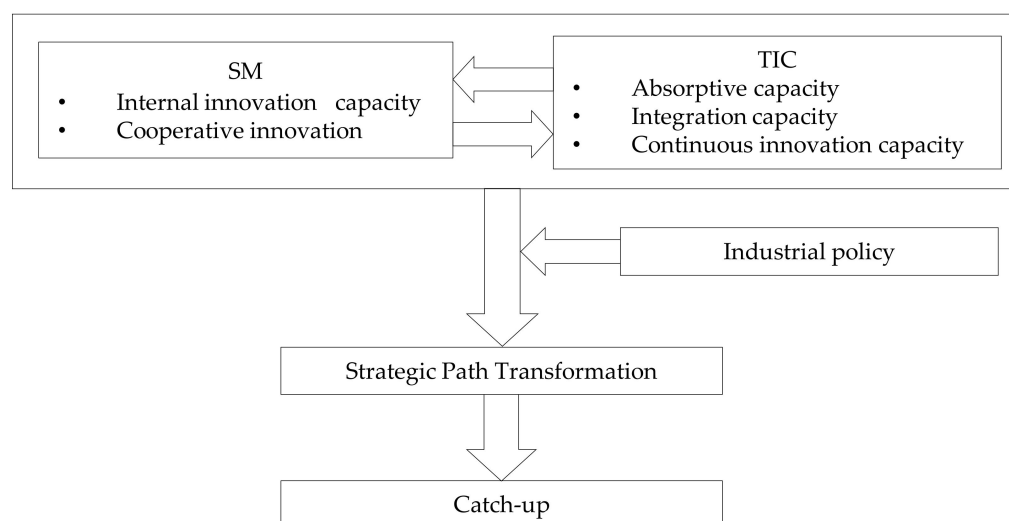
Figure 2. Theoretical framework.

Stable SM is formed based on resources and routines [58]. However, catching-up changes the basis of competition for latecomers [59]. The original effective SM will not adapt to the new competitive environment when the gap between the latecomers and incumbents shrinks. The inefficient SM hinders the latecomers from catching up [60] and even causes a survival crisis [61]. Therefore, latecomers need to break the original SM and form a new path matching with the new competitive environment, that is, to realize the transformation of the strategic path.

In this paper, SM includes internal innovation and cooperative innovation. Internal innovation refers to the pattern that latecomers develop the core technology of the main products by owned resources. Cooperative innovation includes strategic technology alliances, network organization, and short-term cooperation for specific projects, such as R&D contracts and licensing agreements. Both internal innovation and cooperative innovation can coexist within a certain period, but one becomes the dominant form.

TIC is an endogenous combination of new technology stock. Latecomers search, identify, acquire new external technologies, or discover new varieties and new applications of existing technologies by TIC. In this paper, TIC includes three sub-capabilities: absorption capacity, integration capacity, and continuous innovation capacity. Absorptive capacity is the capability to identify and acquire external technology in latecomers. Integration capacity is the capability to internalize technical knowledge from different sources. Con-

tinuous innovation capacity refers to the ability to create new technological knowledge independently in latecomers continuously.

We adopt the industrial policy as a method by which government promotes resource allocation. The government launches industrial policies to improve the software and hardware infrastructure, such as the formulation of mandatory and guiding plans, adjustment plans, support plans, financial policies, project approvals, etc. In the catch-up cycle, industrial policy's primary purpose is to diversify the economy into new areas of comparative advantage.

The salient feature of strategic management research is the emphasis on the competitive environment. To survive and succeed, latecomers must match the requirements of the competitive environment with its internal characteristics. Thus, SM and TIC link within technology innovation activities. It corresponds to Ammon Salter's view that strategic matching and resource-based capability view are complementary in explaining firm performance [62]. Unlike earlier studies that focused on the mediate effects [63], the characteristics of a capability (i.e., promotion, improvement, and innovation) can enhance the positive impact of strategies on firm performance. In contrast, strategy features (i.e., adaptation and deployment) can also improve the promoting effect of capabilities on a firm's performance. Further, we focus on how SM and TIC's interaction pushes the strategic path's change under the industrial policy.

3. Method

3.1. Case Selection

We propose a new theoretical analysis framework for latecomers' sustainable growth based on an in-depth analysis of the typical case. Thus, we adopt the exploratory embedded single-case study. An embedded case study is a method that involves multiple analysis units such as the main analysis unit and secondary embedded analysis unit [64]. The secondary embedded analysis unit is extracted from the main analysis. It should be heterogeneous and have a significant impact on the main analysis unit. We choose China Railway Rolling Stock Corporation (referred to as "CRRC") as the main analysis unit and its catch-up process of Electric Multiple Units (EMUs) as the secondary embedded analysis unit. An EMU is a group of vehicles with power, usually a bullet train and a trailer. Powered vehicles are bullet trains, and unpowered vehicles are trailers. We follow the typicality principle of case selection from the following three aspects.

- Representativeness. A powered car train set can be divided into Diesel Multiple Unit (DMU) and Electric Multiple Unit (EMU) according to the type of power. CRRC's products were mainly DMU in the early stage and then gradually replaced by EMU. CRRC has now become the world's largest and technologically advanced railway vehicle manufacturer by catching-up, and the most prominent international competitor.
- Integrity. The development of CRRC started from imitating the units of the former Soviet Union, benefiting from the continuous development of a high-speed network under the background of China's transitional economy [65]. It has now developed into a world-leading manufacturer in production scale, product level, and R&D and test capabilities. This process fully interprets the strategic path's transformation process in manufacturers' catch-up cycle in emerging economies.
- Correlation. CRRC has experienced the whole process of strategic path transformation; SM changes between internal innovation and cooperative innovation; TIC has improved in various periods of technological development. A large number of supportive policies targeted at competitive industrial advantages have operated successively. These are closely related to the research theme.

3.2. Data Collection

The research data were "triangulated" through a variety of data sources. The primary data sources are as follows. (a) On-site interviews: we conducted several semi-structured interviews with managers and technical experts of CRRC (the semi-structured interview

list is shown in Appendix B). The interviewees' selection was made with the following considerations: more than five years of work experience; positions included middle and senior managers and technical experts; and a rich experience and extensive participation in technological innovation practices. We interviewed seven employees. Each round of interviews lasted 20 to 45 min. (b) Public information, such as websites, reports and bulletin, news reports, publications, etc. (Table 1 shows Evidence sources and coding).

Table 1. Evidence sources and coding.

Source Code	Type	Source	Content
E_1	Interviews	Managers and technical experts of CRRC	Interview records and documents provided by the interviewees.
E_2	Reports and bulletin	CRRC/National Railway Administration website	Annual reports and interim reports; Railway Statistics Bulletin.
E_3	National experimental platforms	China State Railway	Information about national key scientific research projects and national key Laboratories.
E_4	Policy documents and industry reports	National Railway Administration	Policy documents and industry reports including national strategies, industrial policies, science and technology innovation policies, foreign policies, plans, industry standards, regulations, etc.
E_5	Publications	China national knowledge infrastructure; National Press and Publication Administration	Papers, dissertations, and monographs about CRRC and China high-speed railway.
E_6	Videos	China Central Television	Documentaries, news reports, and interpretation about history and construction outline of China high-speed railway.

To meet the quality criterium of construct validity concerning the semi-structured interview list (Appendix B), we covered two steps. First, we selected specific factors (SM, TIC, industrial policy, and catch-up) of strategic path transformation that is to be studied based on literature and related them to the study's original objective. Second, we ensured that selected measures (Table 2) based on literature and experts consulting reflected the specific factors that have been set. We followed the same principles for every interviewee. Simultaneously, the later interview questions were different from the earlier questions because various interviewees provided new research data, which directly applied in the following talks. Finally, we formed the case description based on interviews and other sources for further analysis.

3.3. Data Analysis Method

We analyzed the data obtained from the interviews using coding technology. First, we initially coded and categorized the case information obtained through various sources and explored the possibility of extracting different data theories. Subsequently, we coded emphatically and derived relevant data and information about catch-up, strategic paths, SM, and TIC from other codes. The interview time of various interviewees was inconsistent. Thus, new content could be added to the data information acquired earlier. We returned to the previous data information and then confirmed again to determine the similarity of the concepts. Once no new ideas or expressions appeared, and no important subcategories or conceptual dimensions appeared, the theoretical saturation point was reached.

Table 2. Measures of constructs and keywords.

Constructs	Measures Variable	Keywords
SM	Internal innovation Cooperative innovation	High proportion of R&D expenses in sales; high proportion of R&D staff;
		Cooperate in R&D, purchase of technology, technology licensing, technology authorization, technology consulting, innovation investment;
TIC	Absorption capacity Integration capacity Continuous innovation capacity	Fast mastering of the production process, Well utilize technical knowledge;
		Strong product system integration, prescriptive technical integration process;
		Adequate technicians, advanced product, internal R&D as a main technology source
Industrial policy	Target Methods	Capacity expansion, speed up, independent R&D, independent brand, leapfrog development
Catch-up	Catch-up performance	Technical level, the proportion of new product, market share of core products, number of Patents

4. Findings

We combed the development history of CRRC's powered car train sets (Figure 3). To explore the strategic path transition process, we divide CRRC's EMU technology development into three stages: exploration stage, localization stage, and standardization stage based on a technology development curve and characteristics, and combined with suggestions of managers and technicians (Table 3).
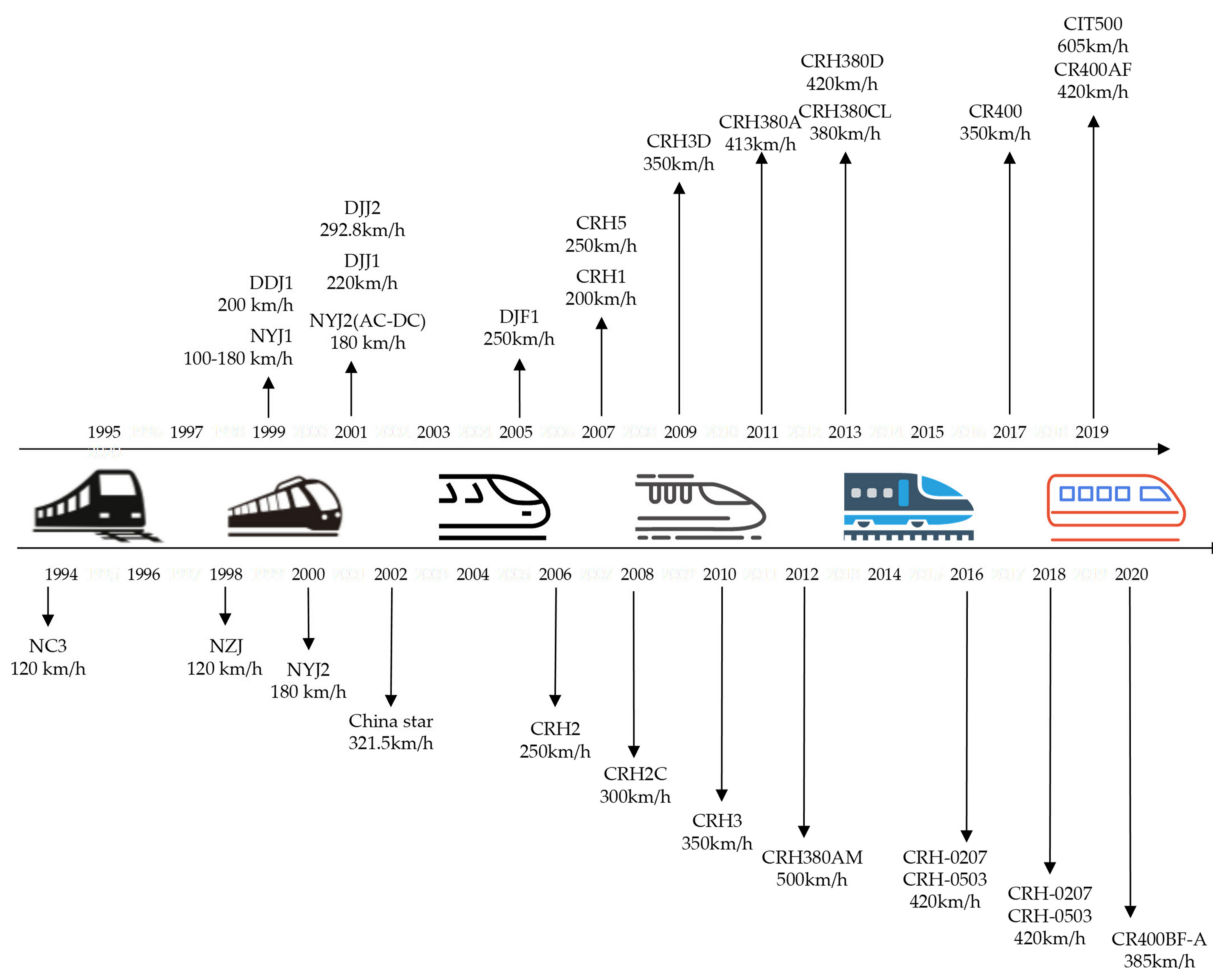
Figure 3. Development history of CRRC's EMU. Data Source: The authors compiled from the CRRC website and published publications.

Table 3. Catch-up stages of CRRC's EMU (data source: the authors compiled from the CRRC website and published publications).

Time	Stages	Content
1994–2003	Exploration stage	Independent development of main models; Exploration of valuable experience for EMU manufacturing.
2004–2014	Localization stage	Cooperation with Japan, Canada, France, and Germany, and began to produce CRH series EMU.
2015–present	Standardization stage	Distinctive and comprehensive Chinese standard system. Higher than European and Japanese standards in function and construction.

4.1. Original Strategic Path

In the exploration stage, SM was based on internal innovation, supplemented by cooperative introduction. As a latecomer in EMU, it was inevitable to imitate existing EMU products of leading countries due to the weak technical base for CRRC. Some critical systems and components had to be purchased from abroad. During this period, most EMU products designed and developed by CRRC were internal combustion EMUs with speeds below 200 km per hour. There were mainly two import EMUs. One NC3 diesel EMU was imported from Hungary and operated between Beijing and Tianjin in 1962. And an X2000 EMU from Sweden served in August 1998.

4.1.1. Industrial Policy Fosters Absorption Capacity of TIC

Since the mid-1980s, china's railway transportation has suffered from short supply. For example, the world's railway operating mileage was approximately 1.2 million kilometers in 2002, of which China's railways accounted for 72,000 km, accounting for about 6%, which translates to about 24% of the workload (Figure 4). It meant that the transportation efficiency of CRRC was rare globally, but it also meant that it had been seriously overloaded. From the 1990s, the State Council issued four programmatic documents to enhance the transport capacity of CRRC as the overall goal of future development in the railway transportation industry. Then, the ministries formulated technology R&D programs, refined technical standards and defined implementation procedures.
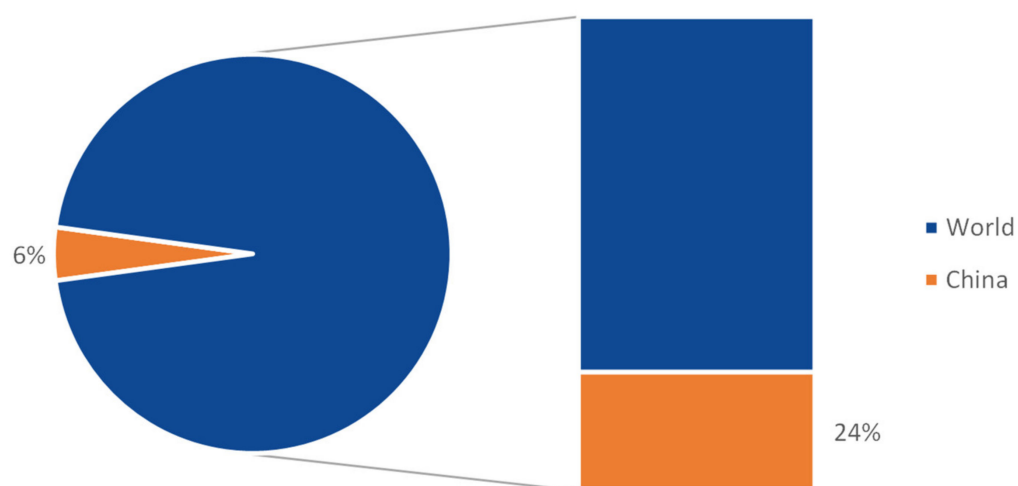
Figure 4. The proportion of CRRC's operating mileage (**left**) and workload (**right**) in 2002. Data source: Railway Statistics Bulletin 2002.

These industrial policies changed the technological selection criteria of CRRC by organizing research projects and procurement authority devolution, promoting it to focus on improving absorptive capacity. Some big tasks, such as selecting high-speed railway lines and the construction of trains, were assigned in the form of research projects. These research projects provided CRRC with opportunities for EMU R&D with low technical difficulty and different application conditions. With the gradual change in CRRC's product sequence,

the depth and breadth of EMU technical knowledge expanded, enabling the absorption of cross-domain expertise. Furthermore, these research projects prevented CRRC from falling into low-level EMU R&D. The ministries created market expectations as users. They transformed the technical standards of the research projects into the technical selection standards of CRRC. CRRC was encouraged to absorb and acquire knowledge according to these new standards. Attracted by these research projects and orders, CRRC subsidiaries have set up EMU R&D departments to focus on developing EMUs and strengthening the response to customized projects.

4.1.2. Interaction between SM (Internal Innovation) and TIC (Absorption Capacity)

CRRC innovated internally in central aspects of EMU, including theory construction, simulation test, design, and manufacturing. "China Star" and "Blue arrow" were representative products in the exploration stage. These primary EMUs concentrated the core strengths of vehicle manufacturing and R&D, including four key firms and four scientific research institutions, and two universities. The talents of various departments involved almost became the technical leaders afterward. In this period, the level of TIC was mainly concentrated on absorption capacity in manufacturing processes and stimulation tests. Simulation tests primarily focused on vehicle performance testing and parameter determination of critical components. Through internal innovation, CRRC began to form its technology development foundation, built a high-speed railway technology platform, cultivated a team of talents, and possessed specific R&D and design capabilities. It provided the basis and bargaining chips for the following importations.

4.1.3. Interaction between SM (Cooperative Innovation) and TIC (Absorption Capacity)

CRRC learned and imitated foreign EMUs. Two trains from abroad (Hungary and Sweden) were references to the development of power concentrated EMU and tilting EMU. Besides, degrees of autonomy in key technologies were different in various products. Systems or parts were imported and purchased from abroad. For example, CRRC purchased the traction system and control system of the "Changbai Mountain" from Bombardier. The development system was from Knorr-Bremse, and the auxiliary power supply was from a domestic joint venture with Bombardier, Canada. Some key components, including high-speed pantograph vacuum circuit breakers, GTO devices, high-speed bearings, and screw air compressors, were also important. Table 4 shows the core construct and evidence in the original strategic path.

4.2. First Transformation of Strategic Path: Mismatch between SM and TIC

The exploration broke the matching balance between SM and TIC of experience in independently developing EMUs. The sharp contradiction between supply and demand caused by passengers and freights' collinear limitation, the small scale of the railway network, and insufficient transportation capacity. The elements that constituted TIC changed. CRRC had accumulated knowledge in required technical fields such as aluminum alloy car body, traction drive, and braking and network control. It also cultivated a group of innovative talents and initially established a technology development foundation and a high-speed train technology platform. The SM that focused on internal innovation and supplemented by cooperation innovation no longer matched TIC. To alleviate the difficulties, CRRC expanded the new SM by increasing the import of EMUs and cooperative design and production.

4.2.1. Improvement of TIC

TIC of CRRC was at the level of exploration and absorption in critical technologies and system integration. It was reflected in the independent development of product platforms, and more than 20 EMU models developed and produced, mostly internal combustion with speeds below 200 km per hour. There are also five types of electric EMUs above 200 km per hour ("Pioneer", "Changbai Mountain", "Great White Shark", "Blue Arrow", and

"China Star"). CRRC could integrate autonomous systems on both power-concentrated and power-distributed high-speed EMUs. After in-depth research and repeated trials, the AC power transmission system's technical innovation level, train network control system, high-speed bogies, aluminum alloy car body, compound braking, train reliability, and comfort were comprehensively improved.

Table 4. Core construct and evidence in the original strategic path.

Theoretical Dimension	Secondary Construct	Evidence	Code Source
SM	Internal innovation	• Breakthroughs in core technological fields: AC drive system, high-speed braking system, high-speed bogies, networked control system • Total integration: CRRC's subsidiaries (Below 200 km/h);	E_1, E_5, E_6
	Cooperative innovation	• Resource: European, Japan, and German IEC3; • Traction system: from Mitsubishi Electric and Bombardier; • Procurement of critical components: high-speed pantograph, vacuum circuit breaker, GTO device, etc.	E_1, E_5, E_6
TIC	Absorption capacity	• Initially created EMU's system integration platform; • Internal design: AC drive, high-speed braking, high-speed bogie, network control, aerodynamics; • The core technology: not fully mastered. • Mass production: difficult.	E_1, E_2, E_3
Industrial policy	Promote absorption capacity	• Mainly administrative orders; • Clarify the development of electric vehicles as EMU; • Multi-ministerial cooperation in planning high-speed rail lines; • Set up 27 research projects on the Qin-Shen unique line, with a total investment of 15 billion yuan; • Procurement authority devolution; • Subsidiaries compete for orders from various railway bureaus	E_1, E_4, E_6
Catch-up	Catch-up performance	• Power—concentrated electric EMU is the most important type of EMU • Internal combustion ("Jiujiang," "Beiya," Halo," Jinlong," Beihai," etc.); • Electric power ("Blue arrow", "China star", "chuncheng", "xianfeng", etc.). • The speed is 160 km per hour; • Speed above 200 km per hour is still experimental; • Key technical links have not been fully mastered; • The material and craft level need to be improved; • It is difficult to achieve mass production because of poor stability and many faults in train operation.	E_2, E_5, E_6

4.2.2. Mismatch between Improved TIC and Original SM

CRRC's technical level was improved, but it did not match the original SM. First, the SM, based on internal innovation, enabled CRRC to build strong construction capabilities and operational experience in the general-speed field without a venture into high-speed railway practice. However, the Qin-Shen Passenger Dedicated Line's upcoming application had broken through the traditional concept of ordinary speed trains. Second, although it was possible to design and manufacture locomotives and equipment with the internal innovation SM, the technology and modernization were still decades behind the advanced level.

4.2.3. Adjustment of Industrial Policy

With the improvement of TIC and mismatch between TIC and SM in CRRC, the State Council issued "Medium- and long-term railway network planning" in 2004, proposing to build a 12,000-km network of "four vertical and four horizontal" passenger dedicated lines with speeds of 200 km per hour or above. In April of 2004, the State Council clarified the basic principles of "importing advanced technology, joint design and production, and

establishing a Chinese brand". It determined the project operation mode of purchasing some original EMUs, assembling and producing domestically. In June of the same year, the Ministry of Railways issued the "Bid Invitation Letter for Railway EMU Project with Speed of 200 km/h". Table 5 shows the core construct and evidence in the first transformation of the strategic path.

Table 5. Core construct and evidence in the first transformation of the strategic path.

Theoretical Dimension	Secondary Construct	Evidence	Code Source
TIC	Improvement	• Integrate autonomous systems on both power-concentrated and power-distributed high-speed EMUs; • Comprehensively improvement after in-depth research and repeated trials: AC power transmission system's technical innovation level, train network control system, high-speed bogie, aluminum alloy car body, compound braking, train reliability, and comfort.	E_1, E_2, E_3,
Interaction between SM and TIC	Mismatch	• Qin-Shen Passenger Dedicated Line's upcoming application had broken through the traditional concept of ordinary speed trains; • Possible to design and manufacture locomotives and equipment.	E_5, E_5,
Industrial policy	Adjustment	• The State Council issued "Medium- and long-term railway network planning" in 2004; • Build a 12,000-km network of "four vertical and four horizontal" passenger dedicated lines with speeds of 200 km per hour or above; • Basic principles of "importing advanced technology, joint design and production, and establishing a Chinese brand; • Ministry of Railways issued the "Bid Invitation Letter for Railway EMU Project with Speed of 200 km/h".	E_2, E_4, E_6

4.3. New Strategic Path

4.3.1. Industrial Policy Enhances Integration Capacity of TIC

Industrial policies promoted the integration capacity by changing the development direction of TIC, clarifying selection criteria, and supplying orders. First, the choice of technical routes and partners shaped the evolutionary direction and diversity of TIC. Before 2004, EMUs of CRRC were scattered in more than a dozen models with various technical routes and lower speed levels, without continuous product sequence. In June of 2004, the Ministry of Railways issued the "Bid Invitation Letter for Railway EMU Project with Speed of 200 km/h". The domestic transferees of EMU key technologies were designated, including Qingdao Sifang, Changke, and Tangke. The technical route focused on power-distributed electric vehicles and included three differentiated products and platforms. Therefore, CRRC's subsidiaries successively upgraded their technological systems and organizational systems, continuously improved products, technologies, and organizational elements around the platform, and enhanced their integration capabilities.

Second, the set procurement requirements and operating conditions prompted CRRC to strengthen project integration in accordance with the standards. Regardless of the joint design or evolved design, the commercial application is set as a guide when the project is initiated. The product is required to meet the commercial requirements of reliability and safety. Moreover, the Ministry clearly expressed the need for higher speed EMU. Therefore, it required CRRC not to stop learning and absorbing the manufacturing process of the joint design models but to master the design principles and architecture knowledge and the management methods that supported the advanced design process.

Third, the industrial policies expanded the batch of purchases and increased the frequency of purchases, encouraging CRRC to make dedicated investments for market prospects and practical value. Therefore, CRRC needed to explore EMU's parameter pedigree and design model under various conditions (such as alpine, windy sand, smog, etc.) and integrate them into the product development platform. The integration capac-

ity of TIC was rapidly enhanced by combining the imported technology and previous technology accumulation.

4.3.2. Interaction between SM (Cooperative Innovation) and TIC (Integration Capacity)

Cooperative innovation at the localization stage significantly promoted TIC. The project between CRRC and foreign companies in EMU production gradually increase the independence of CRRC. The manufacturing technology and critical components, as well as related processes and management technologies, were imported. The content transferred by foreign firms included: the manufacturing drawings (key elements were not provided), collaborative design of adaptive improvement according to CRRC's operating environment, manufacturing processes, and on-site guidance and training. Advice and training benefitted the most in subsequent sections for CRRC. In the joint design and manufacturing process, technicians of CRRC observed how foreign staff operated, and then they worked with the observations and guidance of collaborators. Finally, they ran it independently and consulted foreign experts if there was a problem. CRRC's subsidiaries practiced the working ideas of "rigidity, solidification, and optimization." "Rigidity" refers to strictly following the foreign drawings, not seeking innovation but just copying. "Solidification" refers to the standardization and stabilization of operations through hundreds of exercises. "Optimization" is the complete internalization of the work process and integrate it into daily works. Simultaneously, by training their own employees with foreign support and guidance, CRRC's technicians and managers could "do while learning and learn by doing." The transfer of manufacturing technology from partners to CRRC was realized, and more importantly, the internalization of related technologies, processes, and management processes.

4.3.3. Interaction between SM (Internal Innovation) and TIC (Integration Capacity)

The integration capability of TIC has been significantly enhanced from the handling and resolution of various faults. The level of faults can be simple or complex. The answer changed from dumb at the beginning to more advanced. The technical route became increasingly mature. OEMs, suppliers, universities, and research institutes made progress together and gradually established their design systems. It is worth pointing out that the exploration of technology in the previous stage also played an important role. Subsidiaries of CRRC had innovated many models internally before cooperative innovation. Technicians had concepts about how to design. Therefore, they could quickly digest foreign design principles and improve their capabilities through evolving model design. For example, 16-section sleeper compartments were developed based on 8-section. In this process, technical issues such as whether the power was sufficient, how to configure, the continuation of communication, and braking configurations were involved. A series of drawing expansion, braking and traction adjustment, formula correction, and test verification was required based on previous exploration and understanding of importation to overcome these technical problems. Table 6 shows the core construct and evidence in the new strategic path.

4.4. Second Transformation of Strategic Path: Re-Mismatch between SM and TIC

4.4.1. Further Improvement of TIC (Continuous Innovation Capacity)

In the localization stage, the TIC of CRRC had significantly been improved through a series of technology importations. CRRC carried out industrial upgrading, including the expanding of production sites, equipment, importing of a SAP (System Applications and Products) information platform that realized the integrated management of design, manufacturing, pre-production preparation, logistics, and distribution. A suitable quality management system was also formed, which greatly accelerated the manufacturing process level. Adaptability improvements of imported models and evolving models enabled the design and testing capabilities to reach a higher platform. A product and technology R&D system with 11 national institutions and 19 firm technology centers covering mainframe

manufacturers as the main body was established (High-speed train system integration National Engineering Laboratory, EMU and Locomotive Traction and Control State Key Laboratory, National Railway System Integration Engineering Technology Research Center, etc.). Simultaneously, the building up of overseas R&D centers and institutions ensured the continuity and advancement of CRRC's core products and technologies. The scope of R&D covered the entire production chain of embedded low-level software technology to application-level control software technology, from basic research to core product technology and from chip to board. Continuous innovation capacity was gradually formed in design analysis, simulation, experimental verification, testing, staff experience, and management processes.

Table 6. Core construct and evidence in the new strategic path.

Theoretical Dimension	Secondary Construct	Evidence	Code Source
SM	Internal innovation	• Adaptability improvements: • Train-body steel structure; Bogie; Traction motor; Network control system; Wheel set inner distance; Tread shape, bow-net flow; Winter-protection. • CRH2C: Original CRH2A • Power configuration; Total traction powerbase traction motor; Safety assessment; Middle body; Interior decoration.	E_1, E_5, E_6
	Cooperative innovation	• Two tenders organized by the Ministry of Railways on 200 km/h and 300 km/h; • Four imported EMUs: CRH1A: Bombardier(Canada); CRH2A: The coalition led by Kawasaki(Japan); CRH5A: Alston (France); CRH3C: Siemens (Germany).	E_1, E_5, E_6
TIC	Integration capacity	• Significant progress on manufacturing technology; • Improvements in design and testing; • Professional training; • Standardization and stabilization of operations; • Complete internalization of the work-flow; • Micro innovation and transformation.	E_1, E_2, E_3
Industrial policy	Enhance integration capacity	• Controversy over technology sources; • The Ministry of Railways issued the "Bid Invitation Letter for Railway EMU Project with Speed of 200 km/h; • Restrict four subsidiaries as recipients of technology introduction; • EMU need to meet the commercial requirements of reliability and safety; • Clearly expression of the need for higher speed EMU; • Market prospects: four vertical and four horizontal railway line planning;	E_1, E_4, E_6
Catch-up	Catch-up performance	• Establishment of product and technology R&D system: • National Research and Development Institution and National Enterprise Technology Center; • Relatively strong international market competitiveness; • Sustainability and advancement of core product R&D.	E_2, E_5, E_6

4.4.2. Mismatch between Further Improved TIC and SM

With the further improvement of TIC, it did not match the cooperative innovation SM again. First, compared with top firms of Japan, Germany, France, and other leading countries, CRRC has changed from cooperator to competitor by its large-scale construction, R&D, specification and standard preparation, modernization projects, and transportation management. The core technology was no longer imported, nor could it rely on importation. Second, a high-speed EMU system that could adapt to different climatic environments such as high temperature, freezing, high humidity, and the desert was constructed. The system covered public works, high-speed EMUs, train control, traction power supply, operation management, and risk prevention and control. Meanwhile, the operation of EMUs had a

huge driving effect on the social economy and civilization progress. Continued cooperative innovation could not grasp more development initiatives, eliminate regional barriers, and achieve any regional open pattern.

4.4.3. Adjustment of Industrial Policy

With the improvement of TIC in CRRC, China's railway operating mileage reached 139,000 km by the end of 2020, ranking second globally. High-speed railways accounted for 35,000 km, accounting for about 2/3 of the world's total high-speed railway mileage. From 2014–2020, China's railway investment in fixed assets reached over RMB 800 billion for seven consecutive years (Figure 5).
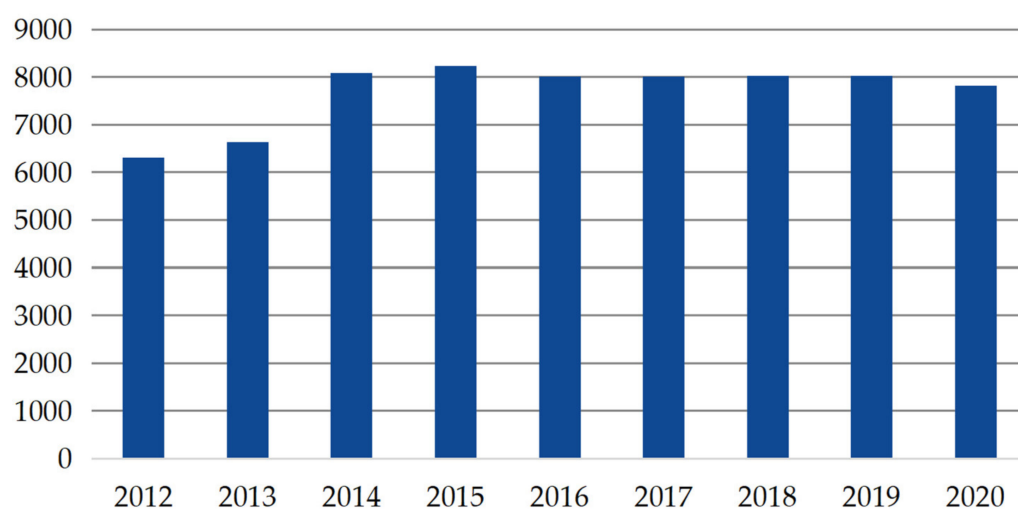
Figure 5. 2012–2020 China Railway Fixed Asset Investment (¥ Million). Data source: Railway Statistics Bulletin (2012–2019) and 2020 China Railway Conference.

The data shows that China has built and operates the most modern railway network and the most developed high-speed railway network globally. Railways have become an essential engine for economic development. In 2017, the "Thirteenth Five-Year Modern Comprehensive Transportation System Development Plan" was announced and implemented. For the first time, China proposed the concept of a "modern integrated transportation system" in this important document. By 2020, high-speed railways will cover more than 80% of cities with a permanent population of more than 1 million in this plan. Table 7 shows the core construct and evidence in the second transformation of the strategic path.

4.5. Recent Strategic Path

Continuous large-scale construction has triggered changes in the development prospects of the railway network. CRRC's products have been exported to nearly 100 countries and regions in six continents, and it is gradually transforming from product export to technology export, capital export, and global operation. CRRC has formed an absolute advantage in the competition of the rail transit equipment industry (Figure 6). China's future railway network will comprise a "high-speed railway network" at its core, with the "ordinary railway network" as complementary. The change represents that the entire railway network's primary technical performance is planned, constructed, and operated by high-speed EMU. Therefore, the prospect of China Railways replacing ordinary passenger trains with EMUs is predictable. Under this background, the strategic path of CRRC has shifted again to internal innovation based on previous cooperative innovation.

4.5.1. Industrial Policy Strengthens Continuous Innovation Capacity of TIC

Industrial policies have promoted continuous innovation capacity by raising the technical adaptability standards and maintaining purchasing expectations. Before 2013,

subsidiaries of CRRC only needed to realize the coupling of their own EMU system and the coupling between the EMU and the line, the bow network system, and the power supply system. There was no need to consider the coupling with other subsidiaries. The industrial policies brought the challenge of cross-subsidiary product coupling by the 350 km/h EMU interconnection. The product development platforms imported from French, Japanese, Canadian, and German companies are very different. Subsidiaries of CRRC first needed to understand the product concept and identify the key differences of each platform, that is, which differences must be eliminated and which differences can be retained, to highlight their own product design features while achieving cross-firm interoperability and interconnection. Standardization requirements made CRRC deeply understand EMU design logic. CRRC has no imitation objects. Exploratory product R&D based on new standards has expanded the scale of R&D projects and increased the difficulty of information exchange and control. The continuous innovation capacity of CRRC was exercised.

Table 7. Core construct and evidence in the second transformation of the strategic path.

Theoretical Dimension	Secondary Construct	Evidence	Code Source
TIC	Further improvement	• Significant improvement: Expansion of production sites, equipment, import of SAP information platform that realizes the integrated management of design, manufacturing, pre-production preparation, logistics, and distribution; • Establishment of the quality management system; • Continuous innovation capacity has been gradually formed in design analysis, simulation, experimental verification, testing, staff experience, and management processes.	E_1, E_2, E_3
Interaction between SM and TIC	Mismatch	• Change from cooperator to competitor: compared with top firms of Japan, Germany, France, and other leading countries; • The core technology is no longer imported, nor can it rely on importation; • Continued cooperative innovation cannot grasp more development initiatives, eliminate regional barriers, and achieve any regional open pattern.	E_1, E_6
Industrial policy	Adjustment	• China's railway investment in fixed assets reached over RMB 800 billion for seven consecutive years; • The "Thirteenth Five-Year Modern Comprehensive Transportation System Development Plan" was announced and implemented; • The first proposed the concept of a "modern integrated transportation system": by 2020, high-speed railways will cover more than 80% of cities with a permanent population of more than 1 million.	E_2, E_4, E_6

Industrial policies maintained or even expanded EMU procurement expectations, encouraging CRRC's product development to become an independent standard. In 2016, the revised "Medium and Long-term Railway Planning" expanded the high-speed rail line into a pattern of eight verticals and eight horizontals. 350 km/h Chinese standard EMU and subsequent series products created credible market demand prospects. Therefore, CRRC will actively transform the product development platform to implement cross-subsidiary product coupling and independent standards. The continuous innovation capacity of CRRC has, therefore, been strengthened.

4.5.2. Interaction between SM (Internal Innovation) and TIC (Continuous Innovation Capacity)

Based on exploration and localization, the continuous independent innovation capability of CRRC's TIC was formed in the standardization stage. In terms of R&D design, EMUs with different speed grades and additional operating requirements can be designed independently. As the "heart" and "brain" of high-speed EMU, the traction drive system and

network control system's independent design have also been realized. In manufacturing, the world's largest high-speed railway network and mass production system have been built. CRRC Changchun Railway Vehicles has an annual production capacity of 1000 EMUs; CRRC Sifang has a yearly production capacity of 1600 EMUs, and CRRC Tangshan has an annual production capacity of 800 EMUs. In terms of human capital, the structure has continued to improve. The proportion of technicians has increased significantly. With the establishment of the national key laboratory, with the active cooperation of industry–academia–research, the number of technicians in simulation experiments has increased significantly and rapidly. Sixty-three academicians, more than 500 professors, more than 200 researchers, and tens of thousands of engineers formed the CRH380A R&D team. They undertook nine key technologies (system integration, body, bogie, traction transformer, main converter, traction motor, traction drive control system, train control network system, braking system) and ten supporting technologies (air-conditioning system, stool collection device, doors, and windows, etc.) for the CRH380A high-speed EMU.
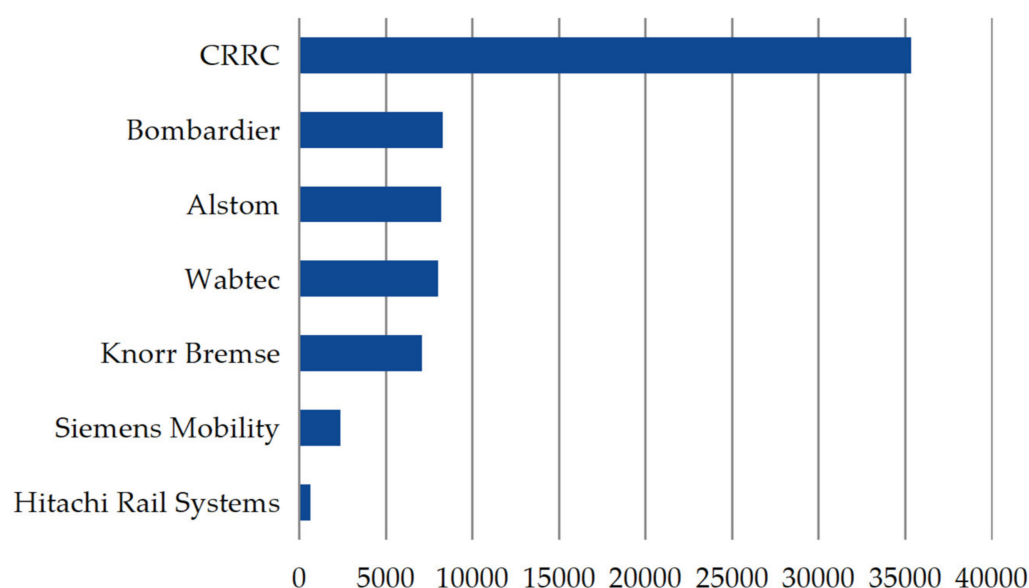
Figure 6. 2019 Revenue of top global rail equipment suppliers ($ Million). Data source: each company's annual financial report.

4.5.3. Interaction between SM (Cooperative Innovation) and TIC (Continuous Innovation Capacity)

In the standardization stage, cooperative innovation served as an adjunct to independent innovation. It is unavoidable to develop the necessary components cooperatively to raise the efficiency of the overall system. For instance, with the increased speed and operation of large trains of 10,000 tons, the impact of rolling on the steel rail has been prominent. It is not only the geometric shape of the track that will be changed, but also defects such as wavy wear and enlarged sides of the track surface will appear. A profiling milling cutter will mill and reshape the contour of the rail and eliminate various hidden dangers. After milling, the track life will increase by about 30%, and the track replacement rate will be significantly reduced. At present, only Germany and Austria have advanced technology for manufacturing cutter heads and blades of profiling milling cutters. Most of their milling cutters are used for maintenance work on European railways. CRRC has imported several rail grinders and milling cutters. Currently, the Chengdu Tool Research Institute, a partner of CRRC, is exploring a feasible plan and has conducted theoretical calculations, where it is estimated that milling cutters developed in the future can be increased by 30%, and the cost will be reduced by half. Table 8 shows the core construct and evidence in the recent strategic path.

Table 8. Core construct and evidence in the recent strategic path.

Theoretical Dimension	Secondary Construct	Evidence	Code Source
SM	Internal innovation	• System integration: CR200J, CR300AF, etc.; • Plenty of national and industrial standards; • Good compatibility; • Serialization of products: EMUs with different speed; Intercity EMUs and frigid EMUs;	E_1, E_5, E_6
	Cooperative innovation	• 15 international R&D centers: the United States; Germany; Britain; The Swedish; Czech; Israel; Russia; Turkey; Italy; South Africa; Italy; • Parts procurement: brake pads; large precision CNC; machine tools; special insulation paper; hydraulic; pump; hydraulic control valve.	E_1, E_5, E_6
TIC	Continuous innovation capacity	• Complete and competitive technology innovation system: 11 national R&D institutions; 19 national product and technology R&D systems; 50 provincial and ministerial R&D institutions. • Product technology standard systems: drafting or revising international standards; Drafting industry and national standards; mutual recognition with firms in Europe and the USA; • Product technology platform: rail transit equipment, important systems, and core components; • Sustainable growth on patents, R&D spending, and technical input ratio.	E_1, E_2, E_3
Industrial policy	Strengthen continuous innovationca-pacity	• Cross-subsidiary product coupling by the 350 km/h EMU inter-connection; • Develop a new generation of 350 km/h EMU; • The Ministry of Science and Technology approved 10 major projects and allocated RMB one billion yuan; • Raise market expectations: eight vertical and eight horizontal railway line planning; • Exploratory EMU R&D based on new standards expanded the R&D scale and increased the difficulty of information exchange and control.	E_1, E_4, E_6
Catch-up	Catch-up performance	• Products have been exported to nearly 100 countries and regions in six continents; • Continuous breakthroughs on basic technologies, core technologies and generic technologies; • World-leading manufacturer in production scale, product level, and R&D and test capabilities	E_2, E_5, E_6

5. Discussion

Through the analysis of CRRC, we find that strategic path transformation is an evolutionary process from mismatch to rematch of SM and TIC. Both SM and TIC change during the catch-up cycle (Figure 7). This paper analyzes the actual process to identify the key variables that determine the strategic path transformation and sets up a framework to explain how the key variables act in the catch-up cycle.

5.1. Impetus: Interaction between SM and TIC

There are two types of SM in CRRC: cooperative innovation and internal innovation. TIC has also experienced a trend of evolution from low-level to high-level (absorption capacity, integration capacity, and continuous innovation capacity) in technological improvement.

In the exploration stage, SM drives TIC. Cooperative innovation and internal innovation had a different effect on the promotion of TIC. The exploration and practice of internal innovation significantly improved TIC in manufacturing, simulation, and human capital exploration. CRRC developed the first electric EMU in 1988. However, the transportation mode was considered to be unsuitable for the national conditions by the competent authorities at that time. Therefore, EMUs were not identified and promoted.
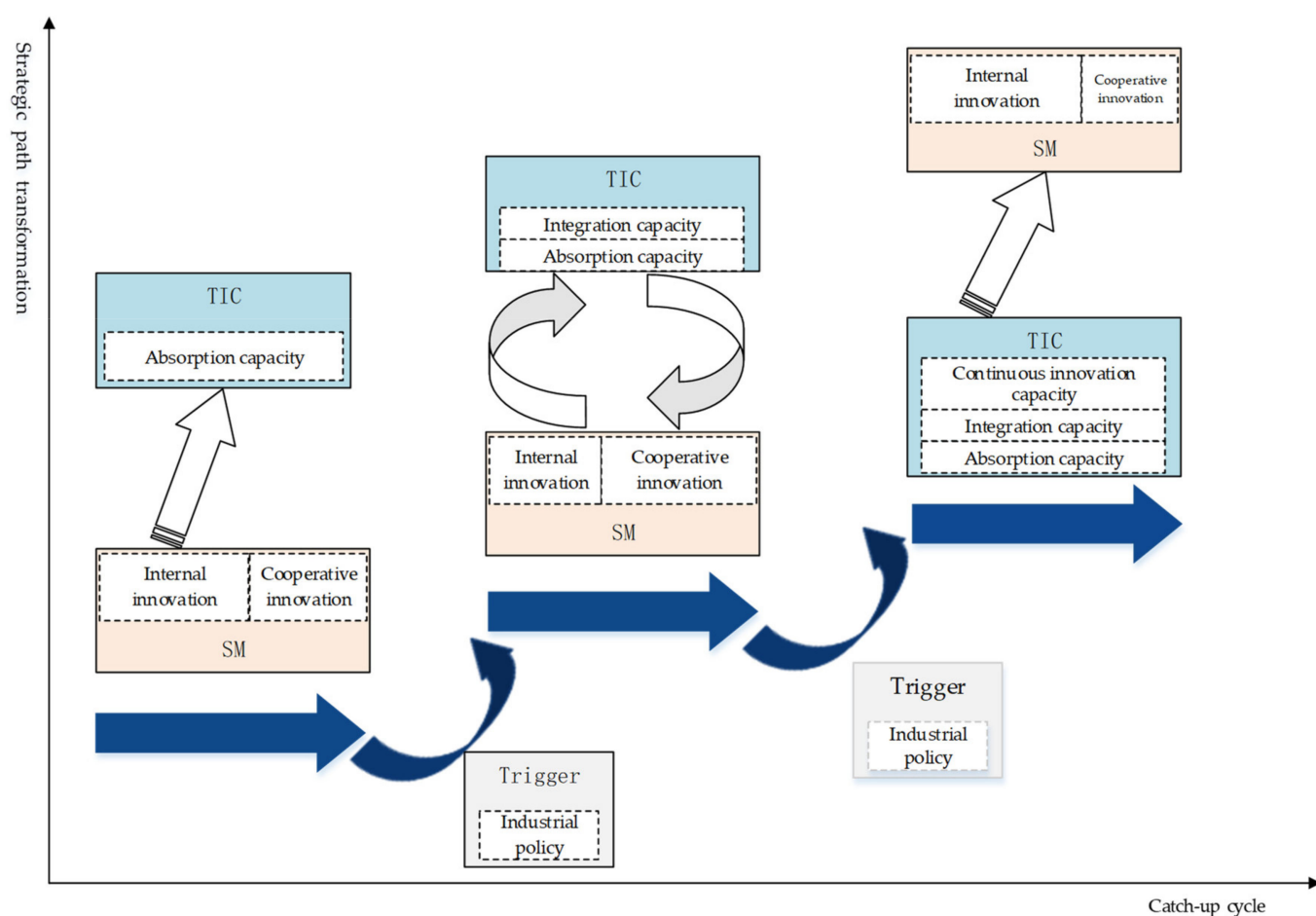
Figure 7. The framework of strategic path transformation for latecomers in catch-up cycle.

In contrast, the product sequence, professional R&D team, and technical support system had been accumulated. It enabled CRRC to understand the cause and effect behind the technical parameters of foreign EMUs and saved time by exploring all the unknowns to design a complete product. It is the reason for the formation of absorptive capacity in TIC. It also shows that CRRC had a strong TIC foundation before the large-scale cooperative innovation. It adjusts the claim that TIC is acquired after importation [66].

Theoretically, cooperative innovation is not enough to achieve technological progress [67]. All intellectual property rights still belong to the seller. The product design got by CRRC is only information, not knowledge, because products did not reflect the principles of design. If CRRC benefits from cooperative innovation, it must understand the technical information's causality and generate new knowledge. To do so, CRRC must have technical R&D activities and experience base—this involves absorptive capacity. In innovation literature, absorptive capacity refers to recognizing new external information, absorbing it, and applying it for business purposes [68]. It is a by-product of technology R&D [69] because the current technical level determines the ability to absorb and use exterior technical details effectively. Therefore, long-term internal innovation efforts can build up absorptive capacity. It is the benefit of CRRC in cooperative innovation in the exploration stage.

In the localization stage, SM and TIC drive each other. TIC comes from the practice accumulation of internal innovation and the digestion and absorption of cooperative innovation. The enhanced TIC increases the return of cooperative innovation and accelerates the intensity of internal innovation. By cooperation innovation, CRRC reduced knowledge stickiness, shortened the product development cycle. CRRC made adaptive improvements and evolved model designs. These improvements require parameters redesign, safety assessment, and adaptability enhancement. The interrelationship of these improvements

makes TIC enriched from single absorptive capacity to integration capacity. Integration capability enables firms to develop new products by integrating disparate technologies quickly [70]. Through collaborations with leading firms, universities, and research institutes, CRRC acquired external explicit and tacit technical knowledge, significantly affecting a firms' technological innovation [71].

Simultaneously, CRRC clarified design principles, which significantly increase tooling equipment, training, process documentation, engineering control, and joint production. The changes of local structure and parameters must also consider the coupling with other subsystems in such a complex system product. It prevented CRRC from getting stuck in a path dependence on knowledge and thus survived the capability adjustment. Integration capacity provides a new perspective and impetus for internal innovation. Technicians combined their technical foundation, from "learning by doing" to "thinking by doing" and "trying by doing, "and finally to "innovating by doing." CRRC generated new ideas, re-identified opportunities, and surveyed themselves and competitive prospects. Integration capability promoted the transformation from cooperative innovation to internal innovation.

In the standardization stage, TIC drives SM. The operation of China standard EMUs ("Fuxing") standardizes the design process and reduces production and operating costs. CRRC has mastered the core technologies in essential running equipment, traction electrical, braking, air supply, train network standards, operation, and maintenance, etc. The test results of technical indicators such as noise, braking, dynamics, and traction have all shown stable and excellent performance. The innovation source of core technology is continually developing because transference, sharing, creation, and knowledge use are the key to successful innovation when new products are designed [72]. It has reconfigured TIC and developed new self-capabilities, that is, continuous innovation capacity. The new sub-capacity enables CRRC to innovate and contribute to service innovation, thereby continuously creating new value. The new technical knowledge created through internal accumulation is the most direct source required by firms. And the method by which latecomers acquire unique technical expertise through internal synergy is considered an effective way to catch up [73]. It promotes CRRC's market competition position, which has changed the cooperate willingness of the incumbents. Therefore, internal innovation in this stage comes naturally. However, the considerable improvement in a short period cannot achieve the complete mastery of all technology for CRRC. There is still cooperative innovation in the non-core technology area at the standardization stage. Cooperative innovation can complement and share innovation resources, save R&D costs and shorten the innovation cycle. However, the balance between the expenses incurred and the time cost and human capital needs further demonstration and analysis. It is consistent with Xie (2013) [74] that collaborative innovation and innovation growth are not merely linear positive or negative.

5.2. Trigger: Industrial Policy

Industrial policies trigger the strategic path transformation by promoting the evolution of TIC from absorption capacity to integration capacity and continuous innovation capacity. In the exploration stage, industrial policies foster the absorption capacity of TIC by organizing research projects and procurement authority devolution. In the localization stage, industrial policies promote the integration capacity by changing the development direction of TIC, clarifying selection criteria, and supplying orders. The choice of technical routes and partners shaped the evolutionary direction and diversity of TIC. The set procurement requirements and operating conditions prompted CRRC to strengthen project integration in accordance with the standards. The increase of purchase batch and frequency improved the enthusiasm of dedicated investment of CRRC. In the standardization stage, industrial policies promote continuous innovation capacity by raising the technical adaptability standards and maintaining purchasing expectations.

Due to technology-intensive and external characteristics, the rail transit industry is highly dependent on industrial policies [75]. In three periods of CRRC's development, with

the cooperation and promotion of competent industry departments represented by the Ministry of Railways (renamed China Railway Corporation in 2013) and relevant ministries and commissions, a highly cooperative operation mechanism of the whole system has been formed around EMU innovation. On behalf of the government, the State Council promulgated the National Development Plan Outline to establish the rail transit industry's future development goals. Under the guidance, the industry's competent authorities introduced more specific industrial policies to promote and guarantee the development goals. Catch-up by latecomers is a process of getting closer to the world's leading edge. The first strategic goal focuses on promoting the scale expansion of specific industries from scratch, while the final strategic plan focuses on the breakthrough of critical technologies. In the different catch-up stages, industrial policy needs to be duly adjusted to trigger strategic path transformation.

Meanwhile, it is worth noting that the effectiveness of government intervention in CRRC's strategic path transformation is achieved with complex conditions. For example, the EMU is a complex product with relatively mature technology, requiring the government's unified management and coordination. The railway market between countries is closed, which provides the space and possibility for technology import negotiation. Railways have public goods properties; they can be used to finance government credit guarantees, to provide the necessities of large-scale capital investment. The essence of industrial policy is to appropriately intervene in market structure and prices through structural or discriminatory measures to solve external problems, multi-agent coordination problems, and system failures that the market itself cannot effectively solve. The TICs of latecomers are developing rapidly. The government and firms should strategically consider the structure of the innovation system and the institutional requirements to ensure the dynamic adaptability of the strategic path to the competitive environment to achieve sustainable growth.

6. Conclusions

The current study on catch-up has focused on how the firms in emerging economies compete with forerunners. We deepen this theme and offer a firm-level analytical framework basis for theoretically discussing the reasons for this achievement by analyzing the latecomer's strategic path's actual transformation process. The starting point is to identify two key factors that CRRC can be recognized as successful catch-up: interaction between TIC and SM and the role of industrial policy. However, these two factors did not exist at the beginning of EMU construction in CRRC but only occurred and changed in the subsequent process. Based on the analysis of two factors' changes in three stages (exploration stage, localization stage, and standardization stage), this paper finds that the strategic path transformation is an evolutionary process from mismatch to rematch between SM and TIC. In this process, industrial policy inspires SM and TIC rematches based on native development and historical specificity. This paper reveals factors that have been widely overlooked in explaining the successful catch-up of CRRC: the impetus and trigger of strategic path transformation. These analyses provide clear prospects for sustainable growth for the latecomers in emerging economies and rectify the popular claim that "re-innovation based on the technology market" is the source of CRRC's successful catch-up.

The strategic path transformation framework may also provide practice implications. Latecomers should prioritize completing products that are easy to replicate or solidify a set of helpful methodology. Products and methods can accumulate technological stocks and obtain more market resources. It is the starting point of catching up, providing a sufficient technical foundation for the subsequent jump. A notable feature of strategic management and organization theory is the competitive corporate environment and the concept of "strategic fit" as the core of strategy formulation [76]. It helps to understand trade-offs and changes of factors permeating the firm's development to integrate the strategic evolution and capability evolution in a catch-up cycle into a unified analysis framework.

Due to CRRC's remarkable technological achievements, the conditions and behaviors that have promoted CRRC's success in catch-up in the past can be generalized into everyday experiences and even "models" that other latecomers should follow. However, with the profound changes in CRRC's TICs, government and corporate incentive structures, industrial organization, and market conditions, the economic effects of the former positive factors may be weakened or even have adverse effects. From this perspective, CRRC's most enormous enlightenment for other latecomers' catch-up is that industrial policies' effectiveness is always context-specific and stage-specific. The adaptability of industrial policies that can continuously adapt to new market conditions and competitive environments is the fundamental guarantee for latecomers' sustainable development.

The study can be improved in several ways, opening avenues for future research. While this study has focused on the strategic path transformation of manufacturing firms, future research may expand the selection of emerging industries such as information, new energy, new materials, etc. Similarly, continuous longitudinal tracking of CRRC can be considered to obtain relevant variable data in stages, thereby improving our conclusions' applicability and universality. Also, this study has integrated the market and government to explain the significance of national action, the content and critical information in policy can be incorporated to discuss the extent of the effect.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. List of nomenclature.

Nomenclature	Full Names	Note
CRRC	China Railway Rolling Stock Corporation	Analyses object of the case study.
EMU	Electric Multiple Unit	Specific analysis units of the case study.
SM	Strategic mode	The decisions of the corporate innovation asset portfolio. Including internal innovation and cooperative innovation.
TIC	Technological innovation capability	The capability of firms to improve technological innovation. Including absorption capacity, integration capacity, and continuous innovation capacity.

Appendix B

The outline of the interview
1. Brief Introduction
Self-introduction, academic purpose, corporate and interviewee privacy protection.
2. Basic situation of the interviewee and department
2.1. Please briefly introduce your department

2.2. Please briefly introduce the main work you are responsible for

3. The strategic path transformation process

Please introduce your company's innovation achievements, market share, and industry status, etc.

- Strategic mode (SM)

3.1. Please introduce whether your company has ever cooperated with other leading firms in technological development? Please illustrate the specific sources, types of technology, and what products are applied in your company.

3.2. Please introduce the main core technologies that your company has developed internally in technological development? Please illustrate the specific project leader and responsible department, as well as which products are used.

Technological innovation capability (TIC)

3.3. Please describe the speed of technological change and product iteration cycle in your industry.

3.4. Please introduce the technical development history of your company and the history of primary products. If possible, please clarify in stages and indicate the milestone events of each step.

- Catch-up cycle

3.5. Please introduce whether your company has made any breakthrough technological progress or the patent ownership of the core technology has changed.

3.6. Do the technical indicators developed by your company exceed the original standards? Or change the dominant technology paradigm?

3.7. Is your company involved in developing various standards, such as the industry, national or international level?

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