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# ACHIEVING EFFECTIVE CROSS-BOUNDARY INNOVATION IN TECHNOLOGY-ORIENTED ENTERPRISES: A COMPARATIVE CASE STUDY

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**Abstract:** Digital transformation and intensified industrial competition have made cross-boundary innovation an important route for technology-oriented enterprises seeking growth and value upgrading. This study applies complex adaptive system theory to compare Sixth Mirror, a little-giant small and medium-sized enterprise, with Meiya Optoelectronic, a listed single-champion enterprise. The analysis identifies three innovation dimensions: factor innovation, value-factor dual innovation, and value innovation. Cross-boundary innovation follows a stimulus-individual-response process in which an enterprise senses internal or external drivers, managers select an innovation direction according to organizational resources and the external environment, and the enterprise produces an innovation outcome through its response mechanism and effectors. Sixth Mirror's two attempts show how strong market sensitivity can be undermined by resource imbalance and managerial short-termism, while university-industry-research cooperation can improve the second attempt. Meiya Optoelectronic demonstrates how technological accumulation, endogenous value orientation, and mature decision-making support high-dimensional innovation. The comparison indicates that SMEs should consolidate technological advantages, strengthen value orientation, improve resource allocation, and introduce higher-quality decision support before entering new industries.
**Keywords:** Cross-boundary innovation; Complex adaptive system; Value orientation; Single-champion enterprise; Small and medium-sized enterprise

## 1 INTRODUCTION

Cross-boundary innovation has become a central route through which technology-oriented enterprises respond to digital transformation, industrial convergence, and intensified market competition. For firms whose competitive advantage depends on a specific core technology, sustainable growth increasingly depends on whether that technology can be transferred to another application field and converted into new value. This issue is especially significant in the Chinese manufacturing context, where enterprises are expected not only to expand business boundaries but also to overcome technological bottlenecks and support high-quality industrial upgrading. The experience of Meiya Optoelectronic shows that a single-champion enterprise can use key core technologies to enter new industries, reconstruct value, and form a more stable innovation trajectory [1].

However, the mechanism of effective cross-boundary innovation is not identical across enterprise types. Little-giant SMEs such as Sixth Mirror may possess early algorithmic or technological advantages, but they usually face constraints in capital, managerial experience, market recognition, and resource coordination when entering unfamiliar industries. Listed single-champion enterprises such as Meiya Optoelectronic often have stronger R&D accumulation, financing capacity, and ecological coordination ability. Therefore, the successful experience of a mature single champion cannot be copied mechanically by an SME. A comparative perspective is needed to explain why similar technology-oriented enterprises may choose different innovation dimensions and produce different outcomes under different resource endowments and decision-making conditions.

The objective of this study is to clarify the dimensions, operating mechanism, and influencing factors of cross-boundary innovation in technology-oriented enterprises. Based on complex adaptive system theory, this paper compares Sixth Mirror and Meiya Optoelectronic and interprets their cross-boundary innovation processes through a stimulus-individual-response framework. The analysis focuses on how enterprises sense external and internal drivers, how managers select innovation directions according to organizational resources and environmental conditions, and how effectors such as technological development, cooperation networks, and market actions transform decisions into innovation outcomes. Through this framework, cross-boundary innovation is examined as a dynamic adaptation process rather than a simple diversification decision.

The innovation of this paper lies in three aspects. First, it distinguishes three progressive innovation dimensions: factor innovation, value-factor dual innovation, and value innovation. Second, it links these dimensions with exogenous driving and endogenous dominance, explaining how enterprise scale, managerial cognition, technical accumulation, and cooperation resources shape innovation selection. Third, it derives practical implications for SMEs by comparing unsuccessful and successful paths. The study is meaningful because it helps technology-oriented SMEs reduce blind market chasing, strengthen value orientation, improve resource allocation, and build more reliable decision support before entering new industries.

## 2 LITERATURE REVIEW

### 2.1 Chinese Research

Chinese research has developed along a sequence of conceptual definition, driving mechanisms, implementation paths, and differentiated enterprise practices. A dynamic framework based on goal, scope, and depth shows that cross-boundary objectives may evolve from business growth to the reconstruction of competitive advantage, the scope may expand from intersecting industries to an industrial ecosystem, and the depth may move from technology application to digital co-creation [2]. This framework is especially relevant to manufacturing SMEs because their innovation level changes as organizational resources and external relationships accumulate.

Research on drivers emphasizes policy, market, and technology. Single-champion cultivation and domestic substitution policies provide institutional support for manufacturing enterprises, while the configuration between digital innovation strategy and organizational conditions affects whether an enterprise can turn policy opportunity into innovation output [3]. Market saturation and unmet demand create a push-pull mechanism for industrial diversification [4]. The transferability of a core technology, including photoelectric identification and computer vision, determines whether an enterprise can adapt its existing capability to another industrial setting [5].

Implementation research includes optimal distinctiveness and resource integration. Compensation orchestration combines technological differentiation with market-recognition consistency when entering a mature industry. Integration orchestration combines technological and market differentiation when entering an emerging field. A longitudinal study of latecomer firms shows that effective transcendence is a dynamic process rather than a single decision [6]. These findings imply that cross-boundary innovation should be evaluated by the depth of technological reconstruction and the logic of value creation, not merely by whether a company enters another market.

### 2.2 International and Comparative Research

International research emphasizes dynamic organizational boundaries, global resource integration, and technological coordination. Research on emerging-market enterprises proposes a staged path from local breakthroughs to ecological expansion and treats international springboarding as an entrepreneurial act [7]. Recent evidence on micro-, small-, and medium-sized enterprises further shows that firm size, specialist shortages, security constraints, and the ability to manage transformation independently shape the innovation path and the barriers encountered by smaller firms [8].

Digitalization changes the cost and scope of boundary crossing. A recent synthesis of business and management research shows that digital transformation reshapes organizational adaptation, management processes, and the relationship between technology and value creation [9]. Research on digital technology and business model innovation further indicates that digital technologies support the reconfiguration of value propositions, organizational arrangements, and ecosystem relationships [10]. Chinese and international research therefore share a technology-market-resource logic. Chinese studies focus more heavily on policy support and differences among enterprises, while international studies emphasize organizational adaptation, capability reconfiguration, and ecological coordination. The two perspectives together suggest that enterprise scale, technological transferability, managerial cognition, and network resources should be analyzed within one adaptive framework.

## 3 THEORETICAL FRAMEWORK

### 3.1 Cross-Boundary Innovation Dimensions

Cross-boundary innovation is defined here as the process through which an enterprise crosses an industrial boundary, combines value points from different fields, and creates a new technological or market outcome. It is not simply diversification. Its depth depends on whether the enterprise merely transfers existing factors, integrates technology and market value, or reconstructs technology to overcome a critical bottleneck. The three dimensions form a gradient from factor innovation to value-factor dual innovation and value innovation.

Factor innovation is market-oriented. It extends an existing technology into an intersecting value chain to satisfy consumption or functional demand. Because it relies on the existing technical advantage and remains constrained by market preferences, it is a low-dimensional form and is vulnerable to homogeneous competition. Value-factor dual innovation combines market adaptation with a degree of technological integration but does not complete technological reconstruction. It is a medium-dimensional form with greater adjustment and breakthrough capacity. Value innovation is technology-oriented and aims to overcome a critical technological bottleneck, reorganize technical elements, and apply the reconstructed technology across fields. Its challenge, breakthrough potential, and irreplaceability make it the highest-dimensional form.

### 3.2 Complex Adaptive System Mechanism

Complex adaptive system theory regards an organization as a system of interacting agents whose adaptation generates complexity. Enterprises learn, accumulate capabilities, modify organizational arrangements, and interact with the environment. Their behavior can be described through the stimulus-individual-response model. The receptor senses environmental or internal stimuli and processes information. The response mechanism represents the managerial rules

and decisions used after information is recognized. The effector transforms the selected direction into technological development, resource coordination, cooperation, and market action.

In cross-boundary innovation, an enterprise first perceives a stimulus such as market saturation, competitive pressure, functional demand, managerial aspiration, or entrepreneurial values. Managers then interpret the stimulus according to organizational resources and environmental conditions and determine a direction and objective. The enterprise implements the plan through its effectors, creating either a successful new state or an unsuccessful response. Drivers may be exogenous, including operating pressure, competition, and functional demand, or endogenous, including value realization, managerial emotional needs, and entrepreneurship.

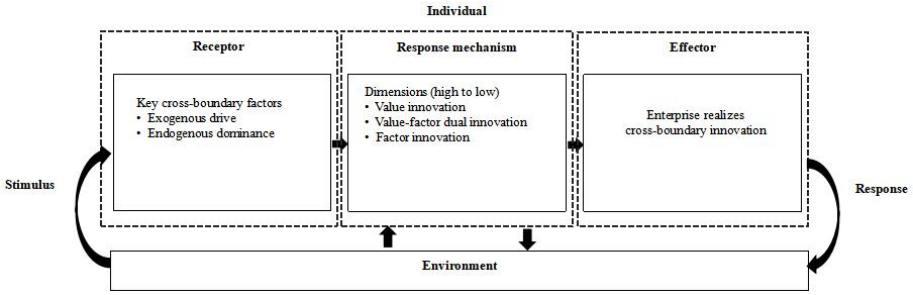


**Figure 1** Theoretical Model of Cross-boundary Innovation

Figure 1 directly connects the three innovation dimensions with exogenous and endogenous drivers and the receptor-response-effector mechanism. The framework also distinguishes cognitive adaptation from behavioral reconstruction. Cognitively, the enterprise identifies its strategic position by interpreting internal strengths and external conditions. Behaviorally, it rebuilds capabilities and coordinates them with the environment. Innovation succeeds when sensing, managerial response, and effectors remain aligned with the selected innovation dimension.

## 4 RESEARCH DESIGN

### 4.1 Method and Case Selection

The study combines case analysis with comparative analysis. Sixth Mirror is examined because its cross-boundary process includes unreasonable technology-resource allocation and an industrial AI project that occupied profit space. A single case can reveal its mechanism and problems, but comparison with Meiya Optoelectronic improves the general relevance of the conclusions and helps identify the mechanisms associated with successful outcomes.

The cases satisfy typicality, comparability, and thematic fit. Both are technology-oriented manufacturing enterprises and have conducted more than one cross-boundary initiative. Meiya Optoelectronic is a listed single champion that moved from color sorters to industrial inspection and oral healthcare. Sixth Mirror is a little-giant enterprise centered on computer vision and has explored urban AI, intelligent connected vehicles, and industrial AI. Their similar technical orientation provides a common comparison basis, while differences in scale, resources, cooperation, management, and outcomes reveal the effect of organizational heterogeneity.

## 5 CASE ANALYSIS

### 5.1 Sixth Mirror

Sixth Mirror originated from a university student team and built a high technological barrier through carefully developed algorithms. It focused on urban AI and applied facial recognition to daily-life scenarios. Demand increased during the Winter Olympics and the pandemic, helping the company become a little-giant enterprise in facial recognition. Its university background also supported a university-industry-research cooperation model. Market saturation in urban AI later threatened its market position, prompting two cross-boundary attempts.

The first attempt entered intelligent connected vehicles. The enterprise was sensitive to the decline of its original market but lacked sufficient capital and could not achieve the required technological breakthrough quickly. Management concentrated on collecting and analyzing demand and allowed market preference to replace its technological advantage. The attempt was therefore factor innovation: the company tried to use existing computer-vision capability in another market without establishing an irreplaceable technical position. Resource pressure and the absence of a strong response mechanism led to failure.

The second attempt focused on industrial AI. Potential industrial customers and production processes requiring optimization created a new opportunity. Critical industrial AI technologies remained difficult, and Sixth Mirror had to compete with technologically mature large enterprises. This time, the company relied more deliberately on its technical strengths and its university-industry-research network. Support from universities and research institutes strengthened technological adaptation and helped the company obtain financing. The attempt achieved initial success, but it did not generate explosive revenue growth or complete technological reconstruction, so it represents value-factor dual innovation rather than high-dimensional value innovation.

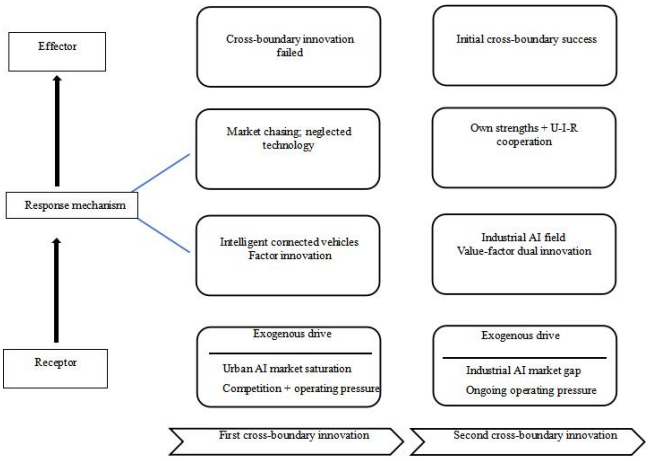


**Figure 2** Cross-boundary Innovation Mechanism of Sixth Mirror

Figure 2 shows that both attempts were strongly influenced by exogenous stimuli. Market saturation, competitive pressure, and operating pressure activated a sensitive receptor. The difference lay in the response mechanism. The first response blindly followed the market and neglected the firm's technical advantage; the effector failed to produce an effective outcome. The second combined external opportunity with entrepreneurship and university-industry-research cooperation, improving resource access and technological adaptation. Sixth Mirror learned from failure and raised the dimensional level of its second initiative, but its response mechanism and resource allocation still constrained value creation.

### 5.2 Meiya Optoelectronic

Meiya Optoelectronic is a national high-technology enterprise specializing in intelligent photoelectric identification equipment. Its products include artificial-intelligence color sorters, X-ray foreign-object inspection machines, and oral CBCT systems for agricultural processing, industrial inspection, and healthcare. The company developed China's first color sorter in 1994, the first digital color sorter in 2000, and the first intelligent color sorter in 2003. This early accumulation established a single-champion position before the company entered other fields.

In 2004, Meiya began exploring X-ray inspection equipment and mastered critical X-ray imaging and detection technologies. This first initiative was high-dimensional value innovation because it broke a technological bottleneck, reconstructed the technical system, and converted the new capability into industrial inspection value. The successful technological transition supported capital accumulation, and the company was listed in 2012. In the same year, it entered oral healthcare and developed China's first three-dimensional digital oral CBCT. In 2023 it launched a digital cloud platform for oral health. Figure 3 records this development and cross-boundary innovation timeline.

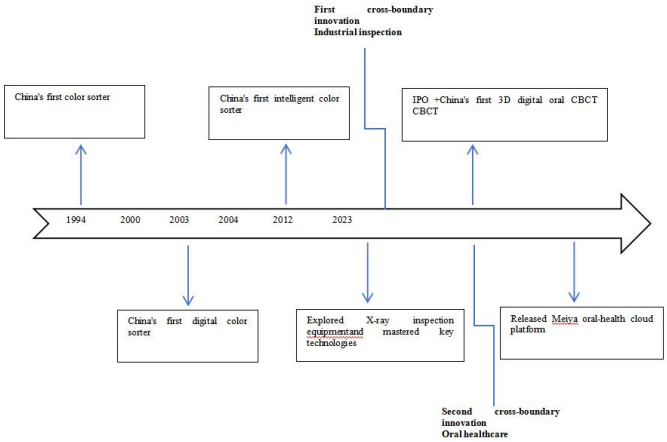


**Figure 3** Development and Cross-boundary Innovation Timeline of Meiya Optoelectronic

The second initiative integrated photoelectric identification and X-ray capability into oral healthcare. It expanded into an intersecting field and produced substantial technological integration without repeating the complete reconstruction achieved in the industrial-inspection initiative. It is therefore classified as value-factor dual innovation. Meiya's two initiatives were predominantly endogenous. The enterprise did not face the same operating and competitive pressure as Sixth Mirror; management sought to realize technological and corporate value. Strong technological accumulation, capital, R&D personnel, and decision-making transformed this internal orientation into successful outputs.

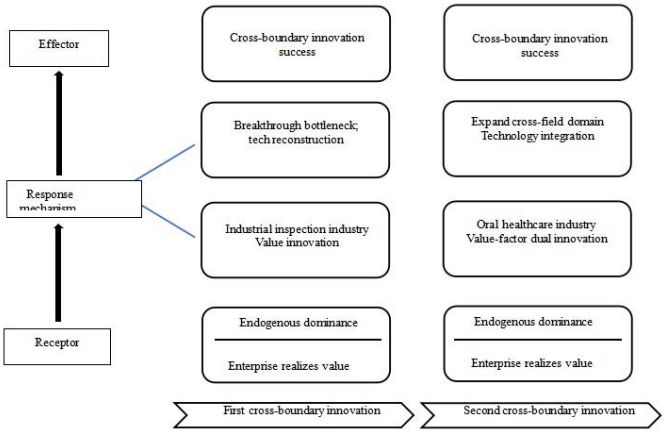


**Figure 4** Cross-boundary Innovation Mechanism of Meiya Optoelectronic

Figure 4 illustrates that Meiya's receptor did not require an intense external crisis. Its response mechanism emphasized technological bottleneck breakthroughs and technology reconstruction, while its effectors converted those choices into industrial products and new businesses. The first initiative began at a higher dimension and established the technology and capital base for the second. Its strong technical core also means that future cross-boundary projects can refine an already proven mechanism rather than reconstruct the entire organizational foundation.

## 6 COMPARATIVE FINDINGS

### 6.1 Scale, Drivers, and Innovation Dimensions

Enterprise scale creates a major difference between the two cases. Meiya's R&D team and listed-company financing channels provide stronger technical and financial support. Its successful initiatives are closely connected with mature decisions by core management. Sixth Mirror's founders are campus entrepreneurs with less experience in industry, market orientation, and resource allocation, increasing the possibility of managerial short-termism. Its cooperation with universities and research institutes partially compensates for limited internal R&D resources, and the financing it obtained can ease urgent constraints if allocated effectively.

Both companies are technology-oriented, but Sixth Mirror's initiatives are more market-oriented and seek revenue through the integration of existing technology with new scenarios. Meiya emphasizes corporate value realization and the solution of critical technological problems. Scale also changes the weight of drivers. Sixth Mirror has lower resistance to market risk and is more easily affected by saturation and loss of market share; its innovation is consequently dominated by external pressure. Meiya has stronger risk resistance, making internal technological ambition and managerial value orientation the principal drivers.

The mechanism comparison is equally important. SMEs may have highly sensitive receptors because survival requires close attention to competition and demand, but sensitivity does not ensure success. Weak managerial rules, inadequate capital, and imbalanced allocation may prevent the response mechanism and effectors from producing useful output. A single champion may face weaker external stimuli but can rely on stronger managerial cognition, technological resources, and implementation capability. The comparison therefore supports a sequence of sensing, interpretation, strategic selection, capability reconstruction, and output rather than a direct transition from market signal to expansion.

**Table 1** Comparison of Sixth Mirror and Meiya Optoelectronic

| Dimension | Sixth Mirror | Meiya Optoelectronic |
|---|---|---|
| Enterprise scale | Little-giant SME | Listed single-champion enterprise |
| Enterprise type | Technology-oriented enterprise | Technology-oriented manufacturing enterprise |
| Management capability | Medium to relatively low | High |
| Innovation dimension | Low + medium: factor innovation + value-factor dual innovation | Medium + high: value innovation + value-factor dual innovation |
| Key driver | Exogenous driving | Endogenous dominance |
| Mechanism | Sensitive receptor; weak response mechanism and effector | Strong response mechanism and effective output |
| Organizational response | Market chasing; university-industry-research cooperation | Technological bottleneck breakthrough; technology reconstruction |
| Risk resistance | Low | High |
| Innovation outcome | First attempt failed; second achieved initial success | Both attempts succeeded |

Table 1 summarizes the original comparative dimensions. Sixth Mirror displays low and medium innovation dimensions,

exogenous driving, and mixed outcomes. Meiya displays medium and high dimensions, endogenous dominance, and two successful outcomes. The distinction does not mean that SMEs cannot achieve value innovation. It indicates that the selected innovation dimension must match available resources and that SMEs need compensating mechanisms before attempting a high-dimensional transition.

## 7 CONCLUSIONS AND RECOMMENDATIONS

### 7.1 Conclusions

Cross-boundary innovation has three gradient dimensions whose central difference lies in the degree of technological breakthrough and the logic of value creation. Factor innovation transfers existing advantages into an intersecting value chain and is easily constrained by demand and homogeneous competition. Value-factor dual innovation combines demand adaptation and technological integration without complete reconstruction. Value innovation overcomes a critical bottleneck and reorganizes technology, making it the most challenging and irreplaceable form. Meiya's first initiative reached value innovation, whereas Sixth Mirror's two attempts remained at low and medium levels.

The mechanism follows the complex adaptive system logic of stimulus, individual interpretation, and response. An enterprise senses internal and external signals, management selects a direction according to resources and capabilities, and effectors implement technological development and coordination. Sixth Mirror's receptor was sensitive, but resource imbalance and short-term decisions limited output. Meiya's strong response mechanism and effectors supported high-dimensional results even without intense external pressure.

Exogenous and endogenous factors change with scale and industry position. SMEs are more strongly influenced by operating pressure, competition, and functional demand. A single champion can be driven primarily by technological value, managerial aspiration, and entrepreneurship. Enterprise scale, R&D strength, managerial experience, financing, and cooperation amplify the difference between innovation selection and implementation efficiency.

The study is limited by its two-case design and qualitative evidence; future research can test the framework with broader samples, longitudinal data, patent and financial indicators, interviews, and ecosystem variables such as policy change, supply-chain cooperation, and digital platforms.

### 7.2 Recommendations for Sixth Mirror

Sixth Mirror should deepen university-industry-research cooperation and focus resources on industrial-AI projects where its computer-vision capability can form a defensible technical base before entering new fields. Joint laboratories, collaborative research projects, and targeted commercialization work can improve the probability of mastering key technologies in the target field.

The company should place technological and corporate value ahead of blind market pursuit, reject opportunities beyond its resources or without technical barriers, and strengthen decision quality by engaging external advisers in industry research, technology commercialization, and resource allocation. This support should help align financing, R&D, and market development and guide the firm from factor innovation toward stable dual innovation and future value innovation.

## COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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