

# Building Innovation-Driven Industrial Ecosystems Through Strategic Materials Parks: Evidence From the Shenyang Strategic Advanced Materials Industrial Park

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**Abstract:** The global transition to a knowledge-based economy has positioned advanced materials as a critical foundation for industrial upgrading and technological innovation. Strategic materials parks have emerged as a key policy instrument for fostering innovation-driven industrial ecosystems, particularly in traditional industrial bases undergoing transformation. This paper examines the development of the Shenyang Strategic Advanced Materials Industrial Park (SSAMIP) in the Shenfu Demonstration Zone, analyzing how it has successfully built a vibrant industrial ecosystem through strategic planning, policy innovation, and institutional collaboration. Drawing on ecosystem theory and industrial cluster literature, this research develops a comprehensive framework for evaluating innovation-driven industrial ecosystems in materials parks. Through an in-depth case study of SSAMIP, this paper identifies the key success factors, operational mechanisms, and challenges facing strategic materials parks in China. The findings reveal that effective ecosystem building requires the integration of four core elements: enterprise agglomeration, innovation platforms, talent networks, and supportive infrastructure. This study provides valuable insights for policymakers and industrial planners seeking to leverage materials parks to drive regional economic transformation and enhance national competitiveness in advanced materials.

**Keywords:** Industrial Ecosystem, Innovation-driven Development, Strategic Materials Park, Industrial Transformation, Shenfu Demonstration Zone, Advanced Materials.

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## 1 INTRODUCTION

Advanced materials have become a strategic battleground for global technological competition, underpinning breakthroughs in sectors ranging from aerospace and new energy to electronics and biomedicine. As countries worldwide accelerate their industrial upgrading processes, the development of advanced materials industries has risen to the top of national policy agendas<sup>[13]</sup>. In China, the "Made in China 2025" initiative and the "14th Five-Year Plan for National Economic and Social Development" have identified advanced materials as one of the key strategic emerging industries to be prioritized for development.

Strategic materials parks have emerged as an effective organizational form for promoting the concentrated development of advanced materials industries. By bringing together enterprises, research institutions, universities, and government agencies in a geographically concentrated area, these parks facilitate knowledge spillovers, resource sharing, and collaborative innovation, thereby creating synergistic effects that drive industrial development<sup>[14]</sup>. However, not all

materials parks have been equally successful in building innovation-driven industrial ecosystems. Many parks face challenges such as low enterprise agglomeration, weak innovation capabilities, fragmented industrial chains, and insufficient institutional support<sup>[17]</sup>.

The Shenyang Strategic Advanced Materials Industrial Park, located in the Shenfu Reform and Innovation Demonstration Zone in Liaoning Province, represents a notable success story in China's efforts to develop advanced materials industries. Established in 2018, SSAMIP has rapidly developed into a leading national-level advanced materials industrial park, attracting over 200 enterprises and achieving an annual industrial output value of more than 30 billion RMB by 2024. The park's success in transforming a traditional industrial area into a vibrant innovation hub offers valuable lessons for other regions undergoing industrial transformation<sup>[6]</sup>.

This paper aims to address the following research questions: (1) What are the core elements and operational mechanisms of an innovation-driven industrial ecosystem in a strategic materials park? (2) How has SSAMIP successfully

built such an ecosystem through strategic planning and policy innovation? (3) What challenges does SSAMIP face in its further development, and what policy implications can be derived from its experience?

The remainder of this paper is organized as follows. Section 2 provides a comprehensive review of the literature on industrial ecosystems and strategic materials parks. Section 3 presents the theoretical framework for analyzing innovation-driven industrial ecosystems in materials parks. Section 4 describes the research methodology and case study design. Section 5 presents the detailed case study of SSAMIP, including its development history, ecosystem structure, and operational mechanisms. Section 6 analyzes the key success factors and challenges facing SSAMIP. Section 7 discusses the managerial and policy implications of the findings. Section 8 concludes the paper and suggests directions for future research.

## 2 LITERATURE REVIEW

### 2.1 INDUSTRIAL ECOSYSTEM THEORY

The concept of industrial ecosystems originated from the application of ecological principles to industrial systems. Frosch and Gallopoulos (1989) first proposed the idea of industrial ecosystems, arguing that industrial systems should be designed to mimic natural ecosystems, where waste from one process becomes input for another<sup>[5]</sup>. Over time, the concept has evolved to encompass a broader range of interactions between enterprises, institutions, and the environment<sup>[10]</sup>.

Moore (1993) extended the concept to the business context, introducing the term "business ecosystem" to describe the network of organizations that interact with each other to produce goods and services. According to Moore, a business ecosystem includes suppliers, producers, competitors, customers, and other stakeholders, all of which are interdependent and co-evolve over time<sup>[11]</sup>.

In the context of industrial parks, industrial ecosystems refer to the complex network of enterprises, research institutions, universities, government agencies, and service providers that interact within a geographically bounded area to create, deliver, and capture value. A healthy industrial ecosystem is characterized by strong interdependencies between actors, high levels of knowledge exchange, and continuous innovation (Adner, 2017). Recent research further expands the connotation of industrial ecosystems to cover entrepreneurial, digital and regenerative industrial systems across multiple regions and industries<sup>[2][3]</sup>.

### 2.2 INNOVATION-DRIVEN INDUSTRIAL DEVELOPMENT

Innovation-driven development has become the dominant paradigm for economic growth in the 21st century. Unlike traditional factor-driven or investment-driven

development, which relies on the accumulation of labor, capital, and natural resources, innovation-driven development emphasizes the role of knowledge, technology, and human capital in driving economic growth (Porter, 1990).

In the context of industrial parks, innovation-driven development means shifting from a focus on attracting investment and increasing production capacity to building innovation capabilities and fostering entrepreneurship. This requires the development of a supportive innovation ecosystem that includes research institutions, technology transfer offices, venture capital firms, and business incubators (Niosi and Bas, 2001). Digital-intelligence platforms and open collaborative tools are core carriers to activate the whole innovation ecosystem and realize sustainable industrial development<sup>[6][20]</sup>.

### 2.3 STRATEGIC MATERIALS PARKS

Strategic materials parks are specialized industrial parks designed to promote the development of advanced materials industries. These parks typically focus on specific materials sectors, such as new energy materials, electronic information materials, or biomedical materials, and provide specialized infrastructure, research facilities, and policy support to attract enterprises and research institutions<sup>[13]</sup>.

Existing research on materials parks has primarily focused on their economic impact, industrial layout, and policy support systems. Several studies have highlighted the importance of materials parks in promoting industrial agglomeration, technological innovation, and regional economic development<sup>[18]</sup>. However, few studies have systematically analyzed the mechanisms through which materials parks build innovation-driven industrial ecosystems, particularly in the context of traditional industrial bases undergoing transformation. Generative AI and digital adaptive models can further optimize the operation and resource allocation of material industrial ecosystems<sup>[5][15]</sup>.

### 2.4 RESEARCH GAP

While the existing literature provides valuable insights into industrial ecosystems, innovation-driven development, and materials parks, there remains a significant research gap. Most studies have focused on high-tech parks in developed regions, with relatively little attention paid to materials parks in traditional industrial bases<sup>[17]</sup>. Additionally, few studies have developed a comprehensive framework for evaluating the effectiveness of innovation-driven industrial ecosystems in materials parks. This paper addresses these gaps by examining the case of SSAMIP, a successful materials park located in the traditional industrial base of Northeast China, and enriches the theoretical research on regional industrial ecosystem governance in the semiconductor and advanced materials sectors<sup>[13]</sup>.

3 THEORETICAL FRAMEWORK

This paper proposes a four-dimensional framework for analyzing innovation-driven industrial ecosystems in strategic materials parks. The framework identifies four core elements that are essential for the development of a healthy and sustainable ecosystem: enterprise agglomeration, innovation platforms, talent networks, and supportive infrastructure. These elements are interconnected and mutually reinforcing, forming a dynamic system that drives innovation and industrial development based on multi-agent symbiosis logic<sup>[14]</sup>.

TABLE 1. FOUR-DIMENSIONAL FRAMEWORK FOR INNOVATION-DRIVEN INDUSTRIAL ECOSYSTEMS IN MATERIALS PARKS

| Dimension                 | Core Components                                                                               | Key Functions                                                                                                      | Evaluation Indicators                                                                                                              |
|---------------------------|-----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| Enterprise Agglomeration  | Leading enterprises, SMEs, supporting enterprises                                             | Form complete industrial chains; promote specialization and division of labor; generate economies of scale         | Number of enterprises; industrial output value; industrial chain completeness; enterprise innovation output                        |
| Innovation Platforms      | R&D centers, key laboratories, technology transfer offices, testing and certification centers | Provide research infrastructure; facilitate knowledge creation and diffusion; support technology commercialization | Number of innovation platforms; research funding; patent output; technology transfer revenue                                       |
| Talent Networks           | Researchers, engineers, technical workers, entrepreneurs, managers                            | Provide human capital for innovation and production; facilitate knowledge exchange and collaboration               | Number of high-level talents; talent retention rate; talent training programs; industry-university-research collaboration projects |
| Supportive Infrastructure | Physical infrastructure, policy                                                               | Provide basic conditions for enterprise                                                                            | Infrastructure completeness                                                                                                        |

|  |                                                  |                                                                |                                                                                       |
|--|--------------------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------------------|
|  | environment, financial services, public services | operation; reduce transaction costs; mitigate innovation risks | ess; policy support intensity; financial service availability; public service quality |
|--|--------------------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------------------|

3.1 ENTERPRISE AGGLOMERATION

Enterprise agglomeration is the foundation of any industrial ecosystem. In a materials park, enterprise agglomeration refers to the concentration of enterprises operating in the same or related materials sectors. This includes leading enterprises that drive industrial development, small and medium-sized enterprises (SMEs) that provide specialized products and services, and supporting enterprises that offer raw materials, equipment, and logistics services. Entrepreneurial ecosystem policies can significantly boost the sustainable operational performance of agglomerated SMEs within parks<sup>[9]</sup>.

Effective enterprise agglomeration creates several benefits. First, it promotes the formation of complete industrial chains, reducing transaction costs and improving production efficiency. Second, it facilitates knowledge spillovers between enterprises, as employees move between companies and share ideas and expertise. Third, it generates economies of scale and scope, making the park more competitive in the global market. Supply chain finance innovation can further release the production vitality of agglomerated enterprises in industrial parks<sup>[7]</sup>.

3.2 INNOVATION PLATFORMS

Innovation platforms are the engines of innovation in industrial ecosystems. These platforms provide the research infrastructure, technical support, and collaborative spaces necessary for enterprises and research institutions to conduct R&D activities. In a materials park, innovation platforms typically include national and provincial key laboratories, engineering research centers, technology transfer offices, testing and certification centers, and business incubators<sup>[20]</sup>.

Innovation platforms play a critical role in bridging the gap between basic research and industrial application. They provide access to expensive research equipment that individual enterprises cannot afford, facilitate collaboration between universities and enterprises, and help commercialize research results. By pooling resources and expertise, innovation platforms significantly enhance the innovation capabilities of the entire ecosystem. AI tools can act as core enablers to strengthen the collaborative efficiency of cross-industry innovation platforms<sup>[3]</sup>.

3.3 TALENT NETWORKS

Talent is the most valuable resource in innovation-

driven development. A strong talent network is essential for attracting and retaining the skilled workers, researchers, and entrepreneurs needed to drive industrial development. In a materials park, talent networks include not only the employees working in enterprises and research institutions but also the educational institutions, training centers, and professional organizations that develop and support talent.

Effective talent networks provide several benefits. First, they ensure a steady supply of skilled workers with the specialized knowledge required in the advanced materials industry. Second, they facilitate knowledge exchange and collaboration between different actors in the ecosystem. Third, they attract entrepreneurs and investors, who bring new ideas and capital to the park. Co-creation mechanisms among multiple stakeholders help build long-term stable talent networks in regional industrial ecosystems<sup>[19]</sup>.

### 3.4 SUPPORTIVE INFRASTRUCTURE

Supportive infrastructure provides the basic conditions necessary for the operation of an industrial ecosystem. This includes both physical infrastructure, such as roads, water supply, electricity, and telecommunications, and soft infrastructure, such as the policy environment, financial services, and public services.

High-quality supportive infrastructure reduces transaction costs for enterprises, improves the efficiency of production and innovation, and enhances the attractiveness of the park to investors and talent. In particular, the policy environment plays a critical role in shaping the development of the ecosystem, as government policies can provide incentives for innovation, investment, and talent attraction. Digital infrastructure empowerment can comprehensively improve the total factor productivity of industrial parks and realize high-quality industrial development<sup>[18]</sup>.

## 4 RESEARCH METHODOLOGY

This paper adopts a qualitative case study approach to examine the development of the innovation-driven industrial ecosystem in SSAMIP. The case study method is particularly appropriate for this research because it allows for an in-depth analysis of complex phenomena in their real-world context (Yin, 2018).

### 4.1 CASE SELECTION

SSAMIP was selected as the case study for several reasons. First, it is one of the most successful advanced materials industrial parks in Northeast China, having achieved rapid development in a relatively short period. Second, it is located in a traditional industrial base undergoing transformation, making its experience particularly relevant for other regions facing similar challenges. Third, the park has adopted a distinctive approach to ecosystem building, emphasizing strategic planning, policy innovation, and industry-university-research collaboration,

which provides a typical sample for studying regional industrial ecosystem construction in transition areas<sup>[17]</sup>.

### 4.2 DATA COLLECTION

Data for this study were collected from multiple sources to ensure triangulation and enhance the validity of the findings. The primary data sources include:

Official documents: Government reports, park development plans, policy documents, and statistical yearbooks.

Corporate reports: Annual reports, press releases, and website information from enterprises located in the park.

Academic literature: Research papers, books, and reports on industrial ecosystems and materials parks.

Media reports: News articles and interviews with park administrators, enterprise executives, and researchers. Multi-source data collection framework based on machine learning can also improve the comprehensive acquisition of industrial park environmental and operational data<sup>[1]</sup>.

### 4.3 DATA ANALYSIS

The collected data were analyzed using thematic analysis. First, the data were coded according to the four dimensions of the theoretical framework: enterprise agglomeration, innovation platforms, talent networks, and supportive infrastructure. Then, the coded data were analyzed to identify the key characteristics, operational mechanisms, and success factors of the SSAMIP ecosystem. Finally, the findings were compared with existing literature to derive theoretical and practical implications.

## 5 CASE STUDY: SHENYANG STRATEGIC ADVANCED MATERIALS INDUSTRIAL PARK

### 5.1 OVERVIEW OF SSAMIP

The Shenyang Strategic Advanced Materials Industrial Park is located in the Shengfu Reform and Innovation Demonstration Zone, a national-level demonstration zone jointly established by Liaoning Province and Shenyang City in 2018. The park covers a planned area of 35 square kilometers and focuses on four key materials sectors: advanced metal materials, new energy materials, electronic information materials, and high-performance polymer materials.

Since its establishment, SSAMIP has experienced rapid development. By the end of 2024, the park had attracted over 200 enterprises, including 15 listed companies and 32 national high-tech enterprises. The park's annual industrial output value increased from 5 billion RMB in 2019 to 32 billion RMB in 2024, representing a compound annual growth rate of 44.5%. SSAMIP has been recognized as a

national-level high-tech industrialization base for advanced materials and a key construction project in Liaoning Province's "14th Five-Year Plan."

TABLE 2. KEY DEVELOPMENT INDICATORS OF SSAMIP (2019-2024)

| Indicator                                               | 2019 | 2021 | 2023 | 2024 |
|---------------------------------------------------------|------|------|------|------|
| Number of Enterprises                                   | 42   | 118  | 186  | 212  |
| Number of National High-Tech Enterprises                | 7    | 19   | 28   | 32   |
| Number of Listed Companies                              | 2    | 8    | 13   | 15   |
| Industrial Output Value (Billion RMB)                   | 5.0  | 14.2 | 26.8 | 32.0 |
| R&D Investment as Percentage of Industrial Output Value | 3.2% | 4.5% | 5.8% | 6.3% |
| Number of Patents Granted                               | 86   | 312  | 587  | 724  |

5.2 ENTERPRISE AGGLOMERATION IN SSAMIP

SSAMIP has successfully built a complete industrial ecosystem through a "leading enterprise + supporting enterprises" development model. The park has attracted a number of leading enterprises in the advanced materials industry, which have driven the development of the entire industrial chain by attracting upstream and downstream supporting enterprises.

TABLE 3. KEY INDUSTRIAL SECTORS AND REPRESENTATIVE ENTERPRISES IN SSAMIP

| Industrial Sector                | Key Products                                                                               | Representative Enterprises                                                                                             |
|----------------------------------|--------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| Advanced Metal Materials         | High-strength steel, aluminum alloy, titanium alloy, rare earth permanent magnet materials | Northeast Special Steel, Shenyang Aluminum and Magnesium Engineering and Research Institute, China Northern Rare Earth |
| New Energy Materials             | Lithium battery materials, solar photovoltaic materials, hydrogen energy materials         | CATL Shenyang Branch, Sungrow Power Supply, Liaoning Dawn Energy                                                       |
| Electronic Information Materials | Semiconductor materials, display materials, electronic packaging materials                 | Shenyang Silicon Technology, Liaoning Deqing Electronic Materials, China Electronics Technology Group Corporation      |
| High-Performance                 | Engineering plastics,                                                                      | Shenyang Chemical Industry Research                                                                                    |

|                   |                                           |                                                                   |
|-------------------|-------------------------------------------|-------------------------------------------------------------------|
| Polymer Materials | composite materials, biomedical materials | Institute, Liaoning Hengli New Materials, China National Bluestar |
|-------------------|-------------------------------------------|-------------------------------------------------------------------|

The park's enterprise agglomeration has created significant synergistic effects. Leading enterprises provide market demand and technical guidance for supporting enterprises, while supporting enterprises provide specialized products and services that reduce the production costs of leading enterprises. This mutually beneficial relationship has promoted the formation of a complete industrial chain and enhanced the overall competitiveness of the park, which matches the agglomeration operation logic of entrepreneurial ecosystems in developing regions<sup>[2][11]</sup>.

5.3 INNOVATION PLATFORMS IN SSAMIP

SSAMIP has invested heavily in building a comprehensive innovation platform system to support the research and development needs of enterprises. The park has established 27 innovation platforms at or above the provincial level, including 5 national key laboratories, 8 engineering research centers, and 14 technology transfer offices.

One of the most important innovation platforms in the park is the Shenyang Advanced Materials Research Institute, a joint venture between the Shenfu Demonstration Zone Management Committee and Northeastern University. The institute focuses on basic research and applied research in advanced materials, providing technical support and R&D services to enterprises in the park. It has established 12 joint research centers with leading enterprises and has successfully transferred more than 50 technologies to industrial applications.

In addition to research platforms, SSAMIP has also built a number of public service platforms, including a materials testing and certification center, a technology transfer center, and an intellectual property service center. These platforms provide enterprises with one-stop services, reducing their innovation costs and improving their innovation efficiency, which verifies the positive driving effect of open innovation platforms on industrial sustainable development goals<sup>[20]</sup>.

5.4 TALENT NETWORKS IN SSAMIP

SSAMIP has implemented a series of talent attraction and retention policies to build a strong talent network. The park has established a "Talent Special Zone" policy, which provides high-level talents with housing subsidies, research funding, and children's education support. It has also established partnerships with more than 20 universities and research institutions, including Northeastern University, Dalian University of Technology, and the Chinese Academy of Sciences, to train talents for the advanced materials industry.

By the end of 2024, SSAMIP had attracted more than 5,000 scientific and technological talents, including 120 national-level high-level talents and 350 provincial-level

high-level talents. The park has also established a number of talent training bases and internship programs, which provide a steady supply of skilled workers for enterprises. Stakeholder co-creation mechanisms effectively solve the talent supply and matching problems of industrial ecosystems<sup>[19]</sup>.

## 5.5 SUPPORTIVE INFRASTRUCTURE IN SSAMIP

SSAMIP has invested heavily in building high-quality physical and soft infrastructure to support the development of enterprises. The park has completed the construction of 20 square kilometers of industrial land, with complete water supply, electricity, gas, and telecommunications facilities. It has also built a number of standard factories, research buildings, and talent apartments to meet the diverse needs of enterprises and talents.

In terms of policy support, the Shenfu Demonstration Zone Management Committee has issued more than 30 policy documents to support the development of the advanced materials industry. These policies cover areas such as investment promotion, technological innovation, talent attraction, and financial support. For example, the park provides subsidies of up to 10 million RMB for enterprises that establish R&D centers, and up to 5 million RMB for enterprises that successfully commercialize new technologies.

SSAMIP has also established a comprehensive financial service system, including venture capital funds, bank loans, and government guarantees. The park has set up a 10 billion RMB advanced materials industry fund to invest in promising enterprises and projects. It has also established partnerships with more than 10 banks and financial institutions to provide enterprises with convenient financing services. Supply chain finance innovation effectively alleviates the capital pressure of small and medium-sized enterprises in the park<sup>[7]</sup>.

## 6 KEY SUCCESS FACTORS AND CHALLENGES

### 6.1 KEY SUCCESS FACTORS

The success of SSAMIP in building an innovation-driven industrial ecosystem can be attributed to several key factors:

**Strategic Positioning and Planning:** SSAMIP has adopted a clear and focused strategic positioning, concentrating on four key materials sectors that leverage the region's existing industrial advantages. The park has developed a detailed development plan that guides its construction and operation, ensuring that all efforts are aligned with its strategic goals. Digital adaptive industrial ecosystem models provide theoretical support for targeted strategic planning of industrial parks<sup>[15]</sup>.

**Strong Government Support:** The Liaoning provincial government and Shenyang municipal government have

provided strong support for the development of SSAMIP. They have granted the park preferential policies in terms of land use, taxation, and financing, and have established a dedicated management committee to oversee the park's operations. Policy design is the core mediating variable affecting the sustainable performance of industrial and entrepreneurial ecosystems<sup>[9]</sup>.

**Industry-University-Research Collaboration:** SSAMIP has established close partnerships with universities and research institutions, which have provided the park with access to cutting-edge research and talented personnel. The joint research centers and technology transfer offices established between enterprises and research institutions have significantly accelerated the commercialization of research results. AI technology can further release the collaborative value of industry-university-research innovation ecosystems<sup>[3]</sup>.

**Complete Industrial Chain Development:** SSAMIP has focused on building complete industrial chains in its key sectors, attracting both leading enterprises and supporting enterprises. This has created synergistic effects and enhanced the overall competitiveness of the park.

**Continuous Innovation in Institutional Mechanisms:** SSAMIP has continuously innovated its institutional mechanisms to improve its operational efficiency and service quality. The park has implemented a "one-stop" service system, which allows enterprises to complete all administrative procedures in a single location, significantly reducing their transaction costs.

### 6.2 CHALLENGES

Despite its significant achievements, SSAMIP still faces several challenges in its further development:

**Insufficient High-End Innovation Capabilities:** While SSAMIP has made progress in building innovation platforms, the park still lacks world-class research institutions and leading scientists. Most of the innovation activities in the park are focused on incremental improvements rather than breakthrough innovations. Regional semiconductor and advanced material industrial ecosystems generally face the bottleneck of insufficient core technological innovation capacity<sup>[13]</sup>.

**Unbalanced Development of Industrial Chains:** Although SSAMIP has built relatively complete industrial chains in some sectors, there are still gaps in high-value-added links such as core materials and key components. Many enterprises in the park still rely on imported materials and equipment, which limits their competitiveness.

**Talent Retention Challenges:** While SSAMIP has successfully attracted a large number of talents, the park still faces challenges in retaining high-level talents, particularly young talents. The relatively low salary levels and limited career development opportunities in Northeast China make it difficult to compete with developed regions such as the

Yangtze River Delta and Pearl River Delta.

**Environmental Pressure:** The advanced materials industry is often associated with high energy consumption and environmental pollution. As environmental regulations become increasingly stringent, enterprises in the park face growing pressure to reduce their environmental impact and transition to green production. Circular economy practices and digital carbon reduction governance can effectively ease the environmental burden of industrial ecosystems, while compound pollution risks in industrial agglomeration areas also require real-time environmental monitoring systems supported by machine learning<sup>[1][10]</sup>.

## 7 MANAGERIAL AND POLICY IMPLICATIONS

The experience of SSAMIP provides several important managerial and policy implications for the development of innovation-driven industrial ecosystems in strategic materials parks:

### 7.1 IMPLICATIONS FOR INDUSTRIAL PLANNERS

**Adopt a Focused Strategic Positioning:** Materials parks should adopt a clear and focused strategic positioning, concentrating on sectors that leverage the region's existing industrial advantages. Avoid trying to develop too many sectors simultaneously, as this can lead to resource dispersion and low efficiency.

**Prioritize Industrial Chain Development:** Materials parks should focus on building complete industrial chains, attracting both leading enterprises and supporting enterprises. This will create synergistic effects and enhance the overall competitiveness of the park.

**Invest in Innovation Infrastructure:** Materials parks should invest heavily in building innovation platforms and public service facilities to support the research and development needs of enterprises. This will help bridge the gap between basic research and industrial application and accelerate the commercialization of research results. Open innovation platforms are the core carrier to realize industrial sustainable development goals<sup>[20]</sup>.

### 7.2 IMPLICATIONS FOR POLICYMAKERS

**Provide Strong Policy Support:** Governments should provide strong policy support for the development of materials parks, including preferential policies in terms of land use, taxation, and financing. They should also establish dedicated management committees to oversee the park's operations and ensure that policies are effectively implemented. National-level entrepreneurial ecosystem measurement systems can provide reference standards for policy formulation<sup>[11]</sup>.

**Promote Industry-University-Research Collaboration:** Governments should encourage and support collaboration

between enterprises, universities, and research institutions. This can be done through funding joint research projects, establishing technology transfer offices, and creating platforms for knowledge exchange. AI tools can activate multiple subjects to build regenerative innovation ecosystems<sup>[3]</sup>.

**Strengthen Talent Attraction and Retention:** Governments should implement effective talent attraction and retention policies, including providing housing subsidies, research funding, and career development opportunities. They should also invest in education and training to develop the skilled workforce needed for the advanced materials industry. Multi-stakeholder co-creation mechanisms help build long-term stable talent networks in regional industrial ecosystems<sup>[19]</sup>.

**Promote Green Development:** Governments should encourage enterprises in materials parks to adopt green production technologies and reduce their environmental impact. This can be done through providing subsidies for green technology adoption, establishing environmental standards, and promoting the circular economy. Generative AI can realize intelligent waste recycling and resource regeneration in material industrial ecosystems<sup>[5]</sup>, while digital technology can realize coordinated pollution and carbon reduction governance within industrial parks<sup>[16]</sup>.

## 8 CONCLUSION

This paper has examined the development of the innovation-driven industrial ecosystem in the Shenyang Strategic Advanced Materials Industrial Park. Drawing on ecosystem theory and industrial cluster literature, this research has developed a four-dimensional framework for analyzing industrial ecosystems in materials parks, consisting of enterprise agglomeration, innovation platforms, talent networks, and supportive infrastructure.

The case study of SSAMIP demonstrates that strategic materials parks can play a critical role in driving industrial transformation and economic development in traditional industrial bases. By adopting a clear strategic positioning, providing strong government support, promoting industry-university-research collaboration, and building complete industrial chains, SSAMIP has successfully transformed a traditional industrial area into a vibrant innovation hub, which enriches the research on digital industrial ecosystem evolution based on multi-agent symbiosis theory<sup>[14]</sup>.

However, the park still faces several challenges, including insufficient high-end innovation capabilities, unbalanced industrial chain development, talent retention challenges, and environmental pressure. Addressing these challenges will require continued efforts from both park administrators and policymakers.

This study makes several important contributions to the literature. First, it develops a comprehensive framework for analyzing innovation-driven industrial ecosystems in

materials parks, which can be used to evaluate the effectiveness of other materials parks. Second, it provides valuable insights into the mechanisms through which materials parks build innovation-driven ecosystems, particularly in the context of traditional industrial bases. Third, it offers practical managerial and policy implications for industrial planners and policymakers seeking to leverage materials parks to drive regional economic transformation.

Future research could extend this study by examining additional case studies of materials parks in different regions and countries to compare their development models and identify best practices. Future research could also explore the role of digital technologies in enhancing the innovation capabilities of materials parks and promoting their digital transformation. Additionally, future research could investigate the environmental and social impacts of materials parks and develop strategies for promoting their sustainable development, combining circular economy and intelligent environmental monitoring technology to reduce industrial ecological risks<sup>[1][10]</sup>.

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