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Research on Improving the Transition Support System for Coal Resource-Based Cities from the Perspective of Industrial Life Cycle: A Case Study of Jining City

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ABSTRACT
As a typical coal resource-based city, the difficulties faced in its transition, the characteristics of its industrial structure, its locational conditions, and its ecological environmental problems are highly representative among coal cities nationwide. Based on the actual situation of Jining City, this paper designs an implementable, assessable, and replicable support system. This can directly provide reference for local government decision-making, helping Jining City balance energy security, industrial upgrading, ecological protection, and livelihood improvement. At the same time, the research conclusions can provide experience and reference for similar cities in major coal-producing regions such as Shanxi, Shaanxi, Inner Mongolia, Anhui, and Henan, promoting the continuous improvement of the overall transition quality and efficiency of China's coal resource-based cities.

KEYWORDS
Urban transition; Industrial life cycle; Coal resources

1 Introduction

Coal resource-based cities are crucial for China's energy security and economy but have developed a rigid resource-dependent model. Their fate is tied to the coal industry's life cycle, leading to the "prosper and trouble because of coal" dilemma. Jining City, a key coal base in East China, is now at a critical stage from maturity to decline, making building a comprehensive transition support system urgent for its sustainable development.

2 Theoretical Foundation of Industrial Life Cycle and Transition of Coal Resource-Based Cities

2.1 Core Connotation of Industrial Life Cycle Theory

The industrial life cycle theory indicates that any industry goes through four development stages: introduction, growth, maturity, and decline [1]. Different stages exhibit regular changes in industrial scale, technological level, economic benefits, market competition, and market demand. As a typical resource-based industry, the life cycle of coal is influenced by multiple factors such as resource reserves, mining costs, market demand, policy regulation, and technological progress, making its cyclical fluctuation characteristics more pronounced.

2.2 The Logic of Cycle-Adaptation for Coal Resource-Based City Transition

Urban transition is a dynamic process synchronized with the industrial life cycle, requiring support systems tailored to each stage's needs. The growth stage requires expansion support (infrastructure, safety). The maturity stage needs quality improvement support (industrial chain extension, clean production). The decline stage necessitates safety-net support (worker resettlement, ecological restoration). The regeneration stage relies on innovation support (new industries, talent). The core is to avoid a one-size-fits-all approach and achieve sustainable transition while safeguarding energy security.

2.3 Determination of the Coal Industry Life Cycle Stage in Jining City

Judging comprehensively based on indicators such as resource reserves, production capacity scale, mine service life, industrial structure, and ecological conditions, Jining's coal industry is in a transition stage from maturity to decline overall, exhibiting the "three haves and three lacks" characteristics: possessing a certain production capacity foundation, but a declining trend is gradually emerging; possessing a preliminary industrial chain, but the level of high-end development is insufficient; having initiated ecological governance actions, but historical legacy problems remain prominent. Simultaneously, problems such as insufficient transition funds, lack of new growth drivers, and inadequate systemic support exist.

This stage is a strategic window period for Jining City to promote transition development, and it is also a period prone

to frequent occurrence of various risks. Accelerating the construction of a comprehensive transition support system is urgent and necessary.

3 The Realistic Dilemmas of Coal Resource-Based City Transition in Jining

3.1 Rigid Industrial Structure and High Cyclical Risk

Jining's economy is dominated by traditional coal-related industries (mining, power, chemicals), making it highly vulnerable to coal market fluctuations [2]. The coal industry chain is short with low added value, while emerging industries like new energy and digital economy remain too small to effectively replace the traditional pillars [3].

3.2 Many Historical Ecological Environmental Liabilities, Heavy Comprehensive Governance Tasks

Long-term, large-scale coal mining has led to large areas, wide distribution, and high difficulty in treating coal mining subsidence areas in Jining City. Subsidence areas cause a series of problems such as land damage, housing cracking, farmland waterlogging, water system destruction, and geological safety hazards. The ecological functions of some areas have significantly degraded. The discharge and stockpiling of waste such as coal gangue, fly ash, and mine water cause combined pollution of soil, water bodies, and the atmosphere. Ecological restoration work is characterized by high investment, long cycles, and high technical requirements [4].

Although Jining has implemented several ecological governance projects, governance funds heavily rely on higher-level transfer payments. A market-oriented, diversified investment mechanism has not been truly established. The pace of governance still lags behind the needs of transition development.

3.3 Talent Skill Mismatch and Weak Innovation Capacity

The workforce is concentrated in traditional coal mining jobs, lacking skills for emerging industries. There is also an overall shortage of high-end innovative and R&D talents, with weak capacity to attract and retain such talent [3].

3.4 Insufficient Transition Fund Supply, Imperfect Market-Based Financing Mechanisms

Transition funds in Jining have long relied on central transfer payments, provincial special bonds, and municipal fiscal input. The scale of social capital participation is small, channels are narrow, and enthusiasm is not high.

Most transition projects have characteristics such as large investment scale, long payback periods, and strong public welfare attributes, leading to low willingness of financial institutions to participate. The application of market-based financing tools such as green credit, transition bonds, PPP models, and industrial funds is insufficient, and risk-sharing and compensation mechanisms are lacking [5].

3.5 Insufficient Policy Coordination, Low Efficiency in Cross-Departmental Coordination

Urban transition work involves multiple departments such as development and reform, energy, finance, human resources and social security, ecology and environment, natural resources, state-owned assets, and emergency management. Problems such as policy fragmentation, overlapping functions, and inadequate implementation are prominent.

The industrial cycle monitoring and early warning mechanism is not sufficiently sound. There is a lack of real-time tracking and prediction regarding coal price fluctuations, capacity adjustments, employment changes, and ecological risks. Policy adjustments lag behind actual changes. The precision, timeliness, and effectiveness of policies need further improvement [6].

3.6 Continuous Increase in Livelihood Security Pressure, Social Stability Risks Cannot Be Ignored

Adjustments in the coal industry directly lead to problems such as worker resettlement, job contraction, and declining income levels, significantly increasing the living pressure on some mining area families. Livelihood projects such as relocation and resettlement in coal mining subsidence areas, shantytown renovation, and public service facility provision are heavy tasks. The layout of public service resources such as education, healthcare, elderly care, and transportation is not balanced enough, and the sense of gain and satisfaction among the people needs improvement. If the transition support system is not robust enough, problems in employment, social security, housing, ecology, and other areas can easily trigger social conflicts, affecting the stability of the overall urban transition [7].

4 Construction of Jining's Transition Support System from the Perspective of Industrial Life Cycle

This paper constructs a six-in-one transition support system encompassing policy and institutional support, capital investment support, talent and skill support, technological innovation support, livelihood and well-being support, and ecological security support, aiming to achieve full-cycle support, all-factor empowerment, and full-chain safety nets.

4.1 Policy and Institutional Support: Strengthen Top-Level Design and Coordinated Advancement

Improve municipal-level top-level planning and design. Formulate medium- and long-term plans for the green and low-carbon transition of Jining as a coal resource-based city, and plans for coal industry cycle response and orderly regulation. Clarify overall goals, phased tasks, key areas, and responsibility assignments, achieving "one county, one policy; one mine, one policy; one industry, one policy." Improve the cross-departmental coordination mechanism. Establish a municipal-level transition leading group, and implement systems such as joint meetings, project task forces, and supervision and assessment, forming a work pattern of municipal coordination, district/county implementation, departmental collaboration, and enterprise initiative. Build an industrial cycle monitoring and early warning system, establishing six monitoring modules for coal production capacity, prices, employment, fiscal revenue, ecology, and safety. Strengthen upward policy alignment. Proactively connect with national support policies such as transfer payments for resource-depleted cities, coal mining subsidence area governance, independent mining area renovation, and green and low-carbon pilot zones, maximizing the efforts to secure policy and funding support from national and provincial levels [1].

4.2 Capital Investment Support: Broaden Financing Channels and Optimize Capital Allocation

Capital investment is the core support for transition development. It is essential to build a diversified investment pattern guided by fiscal policies, supported by finance, with social participation, and led by enterprises.

Actively strive for special fund support from higher levels, focusing on applying for fund projects such as coal mining subsidence area governance, mine ecological restoration, transition and upgrading demonstration zones, and special bonds. Establish a project reserve pool to improve the quality and success rate of project applications. Establish a municipal-level coal transition development fund, led by the government, spearheaded by state-owned enterprises, with participation from social capital. Focus investment on areas such as clean coal chemical industry, port and shipping logistics, new energy, equipment manufacturing, ecological restoration, and worker resettlement training. Innovate green financial products and service models. Promote tools such as green credit, carbon-neutral bonds, transition finance, PPP models, and infrastructure REITs. Encourage financial institutions to develop exclusive products suitable for transition projects. Establish a transition project risk compensation pool to reduce credit risks for financial institutions. Strengthen capital performance management. Implement whole-process supervision, evaluation, and comprehensive auditing to ensure funds are used for dedicated purposes, efficiently, transparently, and openly [5].

4.3 Talent and Skill Support: Adhere to Both Introduction and Cultivation with Precise Empowerment

Talent is the primary resource for transition development. It is essential to build a full-chain talent work mechanism encompassing training and empowerment, talent introduction, local cultivation, and incentive safeguards.

Implement a precise training plan for the resettlement and re-employment of coal mine workers. Establish employee information records and carry out order-based, position-specific, and targeted training, focusing on improving workers' skill levels in areas such as smart mining, logistics operation and maintenance, new energy, community services, and ecological management. Increase efforts to introduce high-level transition talents. Focus on key areas such as high-end chemicals, new materials, new energy, ecological governance, and the digital economy. Implement special talent introduction plans, providing supporting measures such as housing security, children's education, and research funding. Deepen the reform of local talent cultivation models. Support local universities and vocational colleges in optimizing their specialty offerings, opening urgently needed specialties for the transition. Promote school-enterprise cooperation, industry-education integration, and joint construction of training bases to achieve precise alignment between talent supply and industrial demand. Improve talent evaluation and incentive mechanisms. Establish a talent evaluation system oriented by innovation value, industrial contribution, and practical performance to stimulate the enthusiasm and initiative of talents participating in transition development [3].

4.4 Technological Innovation Support: Promote Green Transition and Industrial Upgrading

Technological innovation is the core driving force for transition development. It is essential to adhere to the dual-drive strategy of greening traditional industries and scaling up emerging industries.

Promote the intelligent and green transformation and upgrading of the coal industry. Promote technologies such as

intelligent mining, backfill mining, water-preserving mining, and clean and efficient utilization. Improve resource recovery rates, reduce ecological damage intensity, and extend mine service life. Strengthen the comprehensive resource utilization of industrial solid waste. Promote centralized utilization of coal gangue, fly ash, and mine water, vigorously develop industries such as new building materials, waste heat utilization, and circular agriculture, achieving thorough utilization and recycling of waste. Build industry-university-research-application collaborative innovation platforms. Jointly establish key laboratories, engineering research centers, and technological innovation centers with universities, research institutions, and leading enterprises to collectively achieve breakthroughs in a number of key core technologies. Accelerate the commercialization and application of scientific and technological achievements. Build technology trading markets, pilot test bases, and technology business incubators to promote the local commercialization and nearby industrialization of innovation achievements [7].

4.5 Livelihood and Well-being Support: Adhere to Employment Priority and Bottom-Line Thinking

Livelihood security is the bottom-line project of transition development. It is essential to firmly hold the three bottom lines of social stability, production safety, and basic security.

Adhere to the employment priority development strategy. Follow the approach of "resettling a batch, training a batch, encouraging entrepreneurship for a batch, and providing a safety net for a batch" to broaden employment channels, develop public welfare positions, and increase support for self-employment. Improve the multi-level social security system. Achieve full coverage of social insurance where it should be covered, smooth transfer of relationships, and steady improvement of benefits. Improve systems such as assistance for the needy, medical assistance, and temporary assistance. Accelerate the construction of key livelihood projects. Implement projects for relocation and resettlement in coal mining subsidence areas, shantytown renovation, and old residential area renovation. Improve public service facilities such as education, healthcare, elderly care, culture, and transportation. Improve the social risk prevention and control mechanism. Establish a regularized mechanism for the investigation, early warning, and resolution of conflicts and disputes. Unblock channels for the expression of public demands, creating a stable and orderly environment for transition development [2].

4.6 Ecological Security Support: Promote Systematic Governance and Value Realization

The ecological environment is the important backdrop for transition development. It is essential to adhere to the development path of ecological industrialization that follows "governance - utilization - value addition."

Implement comprehensive governance projects for coal mining subsidence areas. Coordinate and promote land reclamation, vegetation restoration, water system connectivity, and geological hazard management to systematically enhance regional ecological functions. Promote the "ecological restoration + integrated development" model. Focus on developing new formats such as "photovoltaics + agriculture," "photovoltaics + fisheries," "ecological tourism + health and wellness," and "wetland parks + cultural creativity," achieving organic unity of ecological, economic, and social benefits. Strictly enforce ecological and environmental supervision and law enforcement. Strengthen whole-process pollution prevention and control measures. Implement the ecological and environmental protection responsibility system. Strictly control the blind development of high-energy-consumption and high-emission projects. Promote green and low-carbon transition. Improve ecological compensation and ecological product value realization mechanisms. Explore models combining carbon sink trading, ecological product value accounting, and government and market compensation to form a long-term investment mechanism for ecological protection.

5 Characteristic Pathways for Implementing Jining's Transition Support System

5.1 Building a Modern Logistics Hub Economy

Leverage multimodal transport advantages (Grand Canal, railways). Strengthen core ports (Liangshan, Jining, Weishan) to build regional distribution centers and modern logistics parks. Develop supply chain finance and smart logistics, transforming coal corridors into economic development corridors [2].

5.2 Relying on Leading Energy Enterprises to Strengthen the High-End Equipment Manufacturing Industry

Relying on large energy enterprises such as Shandong Energy and Jining Energy, focus on developing high-end equipment industries such as intelligent mining equipment, coal chemical equipment, port machinery, and new energy equipment. Cultivate industrial chain leaders and specialized, sophisticated, distinctive, and innovative enterprises. Build a high-end equipment manufacturing industrial cluster in southern Shandong. Promote the upgrading of the equipment

manufacturing industry towards intelligence, greening, and servitization. Build a new regional manufacturing hub, realizing the industrial shift from primarily coal mining to primarily "equipment manufacturing + technical services" [7].

5.3 Leveraging Resources in Subsidence Areas to Develop New Energy and Ecological Industries

Deploy large-scale photovoltaic power generation projects in coal mining subsidence areas in Zoucheng, Yanzhou, Weishan, Liangshan, and other locations. Simultaneously develop modern agriculture, ecological fisheries, wetland tourism, health and wellness leisure industries, creating a national model for the integrated development of comprehensive coal mining subsidence area governance and ecological industries. Promote the deep integration of ecological governance and new energy development, forming a sustainable development model of "governing one area, utilizing one area, adding value to one area," transforming ecological and environmental shortcomings into advantages for transition development [4].

5.4 Leveraging Cultural Resource Endowments to Cultivate New Cultural Tourism and Health and Wellness Formats

Deeply explore characteristic resources such as Confucian culture, canal culture, and coal mining industrial heritage. Vigorously develop industries such as industrial tourism, study tourism, ecological tourism, and health and wellness resorts, promoting cultural resources to empower urban transition [3]. Create a number of cultural tourism brand projects with regional recognition, enhancing the city's cultural soft power and attractiveness, and promoting the city's transformation from an industrial and mining service-oriented city to a cultural tourism and health and wellness destination.

6 Conclusion

The transition of coal resource-based cities is a long-term, arduous systematic project and a profound transformation concerning the future of cities. Under the dual background of industrial cycle fluctuations and energy structure transition, only with the support of a systematic support system, driven by reform and innovation, and with the goal of people's well-being, can the dilemma of resource dependence be truly broken and urban regeneration and development be achieved. The exploration and practice of Jining City are not only the transition attempt of a single city but also a vivid microcosm of China's coal resource-based cities moving towards high-quality development. As the support system continues to improve, policy effectiveness is continuously released, and market vitality is fully stimulated, coal resource-based cities are bound to usher in a new development situation characterized by prosperous industries, ecologically livable environments, and happy people.

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