Shandong Peninsula National Independent Innovation Demonstration Zone Innovation Capability Evaluation System Construction

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Abstract. Based on the strategic positioning and regional characteristics of the Shandong Peninsula National Independent Innovation Demonstration Zone, this paper use descriptive statistics from SPSS to conduct a comparative analysis of overall scientific and technological innovation strength, innovation environment, service capabilities, innovation input, innovation output, agglomeration level, radiating driving force, and internationalization across the six cities within the Shandong Peninsula National Independent Innovation Demonstration Zone. Subsequently, corresponding strategic recommendations are proposed based on the analysis results.

Keywords: National Independent Innovation Demonstration Zone, Innovation Capability; Shandong Peninsula, Evaluation Indicators

1 Introduction

The National Independent Innovation Demonstration Zone serves as a significant platform for the implementation of China's science and technology innovation-driven development strategy in the new era, accelerating the construction of an innovative country[1]. The Shandong Peninsula National Independent Innovation Demonstration Zone, approved by the State Council in 2016 as the 13th national demonstration zone, has actively reformed since its approval. Through measures such as overcoming institutional obstacles and creating an innovative environment, the Shandong Peninsula National Independent Innovation Demonstration Zone has achieved remarkable success in areas such as technological innovation, industrial upgrading, and talent cultivation. The development of the demonstration zone has not only stimulated local economic prosperity but has also provided valuable experience for enhancing China's independent innovation capabilities. The successful practice of the Shandong Peninsula National Independent Innovation Demonstration Zone offers instructive lessons for the development of other demonstration zones. This success is of great significance for the construction of China's innovation system and the promotion of the

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PMBDA 2023, December 15-17, Nanjing, People's Republic of China

DOI 10.4108/eai.15-12-2023.2345388

integrated development of science, technology and industry[2].This article will construct a scientific and reasonable innovation capability evaluation system to evaluate the Shandong Peninsula Independent Innovation Demonstration Zone from the aspects of scientific and technological innovation environment, service capability, innovation input, innovation output, etc., in order to better promote the development of the Shandong Peninsula National Independent Innovation Demonstration Zone and provide reference for the construction of other independent innovation capability evaluation systems.

Innovation capability assessment, as a significant tool in the management of science and technology and policy formulation, has garnered widespread attention from scholars both domestically and internationally. The European Commission, for instance, evaluates innovation levels across multiple domains at the national, regional, and corporate levels to identify new developmental opportunities[3]. This assessment serves as the basis for innovation policy formulation at various levels within the European Union and relevant countries and regions. The innovation level measurement tools employed include the National Innovation Index at the national level, the Regional Innovation Index at the regional level, and the Innovation Barometer at the corporate level. The Regional Innovation Index, building upon the National Innovation Index, assesses regional innovation levels from three dimensions: innovation drive, innovation activities, and innovation output. Based on regional performance, it categorizes regions into innovation leaders, strong innovators, moderate innovators, and slow innovators[4].

In China, the design of indicators for autonomous innovation can be broadly categorized into two main types: one focuses on the innovation actors as the starting point, measuring the innovation levels of these actors. Qi Jingjing [5][6] assesses the input and output of research institutions and enterprises in knowledge creation, technological innovation, technology diffusion, and collaborative innovation between industry, academia, and research. The emphasis is placed on improving the innovation input-output ratio, highlighting internal collaboration and rational resource utilization within the innovation entities, and addressing the industrialization capability of innovation outcomes. Chen Lei center their approach on the interactive relationships among elements, constructing four subsystems—technology innovation, knowledge innovation, innovation diffusion, and innovation support environment—to measure the overall level of autonomous innovation and the interaction among innovation entities. The second type begins with analyzing the driving forces of autonomous innovation, delving into the internal structure of the innovation system and evaluating the configuration of elements within the autonomous innovation system. Zhou Hongyu [7] selects 22 indicators from five perspectives—innovation input, innovation talents, innovation output, innovation entities, and innovation environment—to construct a research platform for evaluating the innovation capability of the national autonomous innovation demonstration zone. Xiong Xi [8] based on the dimensions of input elements, structural level, and functional performance, utilize relative quantity indicators to assess the rationality of input elements, optimize industrial structure, and evaluate the level of functional effects. Hu Shuhua building on the regional innovation system input-output model, construct an autonomous innovation evaluation model with innovation entities, innovation content, innovation input, and innovation output as the central components. Liu Zimei propose the Innovation Drive Four Forces Model, consisting of four aspects: innovation entity subsystem, innovation input subsystem, innovation output subsystem, and innovation environment. The model operates based on a mechanism where the market serves as a traction force, policies act as driving forces, and innovation and development interact, forming a virtuous cycle system.

Based on a comprehensive review of domestic and international research, it is evident that the study of innovation capability evaluation has developed a relatively mature theoretical and methodological framework. However, in specific regions and under particular contexts, the evaluation of innovation capabilities still encounters numerous challenges, such as the selection of indicator systems and the innovation of evaluation methods. Therefore, this paper, after synthesizing and filtering existing evaluation systems, addresses the geographical and industrial characteristics of the Shandong Peninsula and aligns with the development strategy of the Shandong Peninsula National Autonomous Innovation Demonstration Zone. It constructs an indicator system from four dimensions. The objective is to objectively and accurately assess the innovation capabilities of six cities within the Shandong Peninsula National Autonomous Innovation Demonstration Zone. This endeavor aims to provide targeted policy recommendations for leveraging the regional advantages of the Shandong Peninsula and constructing the National Autonomous Innovation Demonstration Zone on the Shandong Peninsula.

2 Construction of Innovation Capability Evaluation System

2.1 Selection of Evaluation Indicators

The design of the innovation capability evaluation system for the Shandong Peninsula National Autonomous Innovation Demonstration Zone should be based on its strategic positioning and regional characteristics. The strategic positioning of the Shandong Peninsula National Autonomous Innovation Demonstration Zone is defined as follows: "Guided by the blue economy, aiming to promote economic transformation and upgrading, with the enhancement of autonomous innovation capability as the core, driven by deepening reforms and innovative mechanisms, following the path of regional coordinated development, emphasizing regional and industrial characteristics, actively integrating into the global innovation system, and becoming an internationally influential center for scientific and technological innovation and a competitive hub for innovative economic development." The construction of the innovation capability evaluation system for the Shandong Peninsula National Autonomous Innovation Demonstration Zone should reflect these characteristics.

This article employs various methods, including obtaining government statistical data, company and research institution reports, reports from specialized research institutions, social surveys, and interviews. Data is entered into the SPSS software, with each indicator treated as a variable, and each row representing a sample (year or region). Utilizing SPSS, descriptive statistics such as mean and standard deviation are generated for each indicator to understand the distribution of the data. Through SPSS descriptive statistics, the original data related to indicators within the Shandong Peninsula National Autonomous Innovation Demonstration Zone for the six cities in the region (Figure 1) undergo standardization. This process eliminates differences in magnitude and units, yielding standardized indicator values through Z-standardization. This approach contributes to the construction of a comprehensive and reliable innovation capability evaluation system.

INDEX	Jinan	Qingdao	Zibo	Weifang	Yantai	Weihai
X1	0.672 053	0.055 272	0.585 049	0.177 351	0.305 614	0.640 752
X2	15.052 521	60.611 238	6.534 286	7.915 213	19.567 347	24.348 130
X3	0.435 388	0.422 715	0.349 238	0.346 256	0.647 824	0.542 520
X4	0.030 213	0.145 849	0.047 165	0.016 358	0.044 002	0.019 231
X5	22.866 667	47.657 143	84.800 000	133.625 000	62.555 556	24.882 353
X6	0.038 632	0.100 950	0.033 156	0.052 153	0.442 550	0.042 242
X7	0.008 326	0.008 282	0.008 548	0.006 256	0.008 116	0.009 451
X8	0.869 562	0.324 929	0.587 663	0.397 967	0.078 885	0.500 212
X9	31.123 441	50.445 484	28.373 270	33.611 832	45.328 462	29.979 072
X10	51.000 000	50.000 000	47.000 000	27.000 000	108.000 000	85.000 000
X11	0.011 319	0.005 527	0.002 167	0.001 081	0.002 856	0.007 119
X12	0.005 065	0.046 839	0.014 174	0.013 865	0.027 454	0.005 698
X13	1.024 886	5.398 324	1.151 271	1.314 068	1.679 579	0.094 551
X14	0.131 761	0.007 883	0.041 535	0.117 407	0.005 423	0.067 083
X15	3.410 666	0.078 084	1.252 717	2.251 178	0.012 254	1.588 056
X16	1.624 120	0.850 010	-0.698 220	-0.743 760	-0.333 930	-0.698 220
X17	0.196 803	0.259 014	0.399 394	0.433 847	0.229 302	0.114 762
X18	-0.839 609	-0.378 834	0.576 178	-0.132 381	1.710 576	-0.935 930
X19	0.076 667	0.085 667	0.131 000	0.091 333	0.081 667	0.0902 667
X20	0.097 105	0.146 266	0.067 811	0.080 549	0.101 000	0.046 954
X21	0.056 092	0.030 098	0.038 748	0.031 657	0.003 922	0.015 640
X22	1.376 550	1.716 637	0.911 316	1.438 316	2.723 538	3.784 451
X23	0.015 364	0.043 375	0.016 309	0.011 657	0.018 273	0.022 486
X24	0.002 445	0.013 709	0.005 132	0.003 116	0.010 530	0.001 246

Fig.1. Raw Data of Relevant Indicators for Shandong Peninsula National Independent Innovation Demonstration Zone

Based on the standardized indicator values and their corresponding weights, the overall strength of technological innovation in the high-tech zones of Jinan, Qingdao, Zibo, Weifang, Yantai, and Weihai within the Shandong Peninsula National Autonomous Innovation Demonstration Zone can be determined. This assessment encompasses their performance across seven dimensions: technological innovation environment, service capability, innovation input, innovation output, aggregation level, radiation drive, and internationalization (Figures 2, 3, and 4). Through horizontal comparative analysis, this study explores the developmental levels and industrial characteristics of the Shandong Peninsula National Autonomous Innovation Demonstration Zone.

INDEX	Jinan	Qingdao	Zibo	Weifang	Yantai	Weihai
Technological Innovation Level	0.165 92	0.209 37	-0.012 62	0.120 48	-0.111 16	-0.371 99
Technological Innovation Environment	0.035 83	-0.026 95	0.004 72	-0.062 91	-0.000 53	0.049 84
Service Capability	-0.182 36	0.049 69	0.084 24	0.243 54	-0.008 15	-0.186 96
Innovation Investment	0.116 38	0.030 38	-0.040 25	-0.099 51	-0.019 86	0.012 88
Innovation Output	0.254 87	0.104 62	-0.108 81	0.036 47	-0.157 36	-0.129 78
Agglomeration Level	-0.068 05	-0.026 15	0.082 86	0.027 22	0.063 99	-0.079 87
Radiation Driven Level	0.025 51	0.060 83	-0.017 45	-0.008 54	-0.005 13	-0.055 22
Internationalization	-0.016 26	0.016 98	-0.017 93	-0.051 79	0.015 88	0.017 12

Fig.2. Evaluation results of high-tech zones in various regions within the Shandong Peninsula National Independent Innovation Demonstration Zone

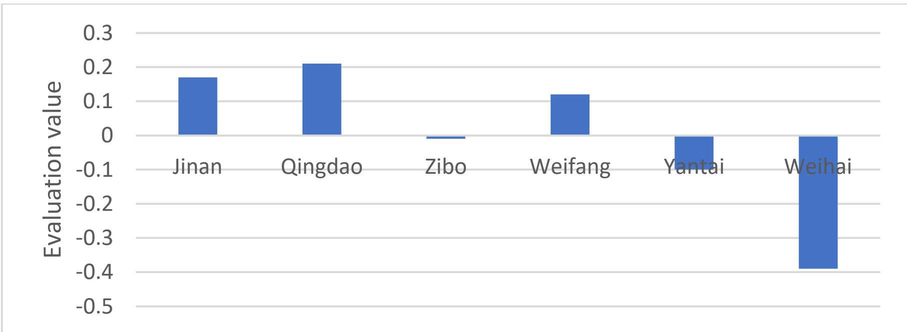

Fig.3. The level of scientific and technological innovation in various high-tech zones within the Shandong Peninsula National Independent Innovation Demonstration Zone

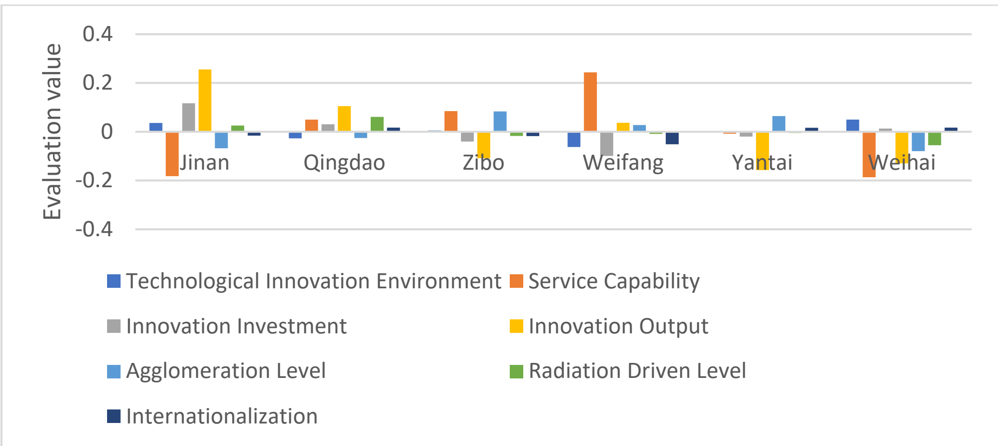

Fig.4. Target level indicators of high-tech zones in various regions within the Shandong Peninsula National Independent Innovation Demonstration Zone

2.2 Empirical Analysis of Enterprises

The innovation capability evaluation system for the Shandong Peninsula National Autonomous Innovation Demonstration Zone constructed in this paper holds significant practical application value. This evaluation system is not only an achievement of academic research but also serves as a practical guide for enterprises within the demonstration zone. It provides tangible and feasible guidance for government decision-making departments, offering a scientific basis for guiding enterprise innovation strategies and management decisions. Furthermore, it supports the formulation of innovation policies by the government, facilitates experiential exchange and collaboration among enterprises, and contributes to the sustainable innovation development of the demonstration zone. The system holds crucial significance and can serve as an exemplary experience for other regions.

When conducting case analysis, the selection of representative enterprises is of paramount importance. The choice of representative enterprises should consider factors such as their position within the demonstration zone, the breadth and depth of innovation activities, market influence, among others. Through in-depth studies of these enterprises, a more comprehensive understanding of the innovation ecosystem within the demonstration zone can be achieved, providing practical foundations for the construction of the innovation capability evaluation system. Based on the analysis of the selected representative enterprises, a set of indicators for evaluating innovation capability is constructed. This system should encompass various aspects, including technological innovation (such as the proportion of R&D investment, success rate of new product development, number of patent applications, etc.), market innovation (including market share growth rate, proportion of sales from new products, market expansion speed, etc.), organizational innovation (including the establishment of an innovative culture, internal innovation management mechanisms, construction of innovative teams, etc.), and talent innovation (including the proportion of high-level talents, investment in employee training, construction of research teams, etc.). These indicators aim to comprehensively and objectively assess the innovation capability of enterprises. In this paper, data from sources such as the "Shandong Statistical Yearbook" and the "Shandong Science and Technology Statistical Yearbook" are utilized. Enterprises A and B are selected for evaluating their autonomous innovation capabilities, as detailed below(Table 1):

Table 1. Comparative Analysis of Evaluation Indicators for Enterprise A and Enterprise B

Evaluation Indicators	Enterprise A	Enterprise B
R&D Expenditure Ratio (%)	8%	10%
Number of Patent Applications	50	70
Number of New Product Developments	10	15
Market Share Growth Rate (%)	5%	8%
Institutional Development and Management Innovation Score (1-10)	8	7
Proportion of Senior Talents (%)	20%	18%

After obtaining the data, a maximum-minimum normalization was applied to each indicator, transforming the data into relative values within the range of 0 to 1 to standardize the data(Table 2). Subsequently, scores for each enterprise in each innovation domain were calculated, followed by a weighted summation based on assigned weights to derive a comprehensive score.

Table 2. Comparative Analysis of Scores for Enterprise A and Enterprise B

Score Category	Enterprise A	Enterprise B
Technological Innovation Score	0.7 * 8% + 0.2 * 50 + 0.1 * 10 = 5.6	0.7 * 10% + 0.2 * 70 + 0.1 * 15 = 9
Market Innovation Score	0.5 * 5% + 0.3 * 8% + 0.2 * 70 + 0.1 * 15 = 7.65	0.5 * 8% + 0.3 * 8% + 0.2 * 70 + 0.1 * 15 = 8.15
Organizational Innovation Score	0.6 * 8 + 0.4 * 7 = 7.4	0.6 * 7 + 0.4 * 7 = 7
Talent Innovation Score	0.8 * 20% + 0.2 * 18% = 19.6	0.8 * 18% + 0.2 * 18% = 18
Comprehensive Score	Technological Innovation (0.3) + Market Innovation (0.3) + Organizational Innovation (0.2) + Talent Innovation (0.2) = 7.82	Technological Innovation (0.3) + Market Innovation (0.3) + Organizational Innovation (0.2) + Talent Innovation (0.2) = 8.33

Based on the comprehensive scores, Enterprise A's overall innovation capability score is 7.82, while Enterprise B's score is 8.33. Therefore, from the perspective of comprehensive innovation capability, Enterprise B demonstrates stronger competitiveness in the field of innovation compared to Enterprise A. However, it is important to note that specific weights and evaluation criteria may require adjustments based on real-world circumstances and expert opinions.

3 Conclusion and Recommendations

In order to better promote the innovation development and enhance the innovation capability of the Shandong Peninsula National Autonomous Innovation Demonstration Zone, the following strategic recommendations are proposed:

3.1 Enhancing Strategic Layout and Positioning to Forge the Core Area for the Transformation of Old and New Drivers

Aligned with the overarching deployment of Shandong's major project for the transformation of old and new drivers, strengthening targeted guidance, reinforcing strategic positioning, and encouraging the high-tech zones in Jinan and Qingdao to strive for the status of "world-class high-tech parks" are recommended. This aims to create a globally influential hub for original emerging industries. Similarly, supporting the national high-tech zones in Zibo and Weifang to expedite the construction of "innovative science and technology parks" is advised, fostering the development of regional innovation centers with national influence. Additionally, guiding the high-tech zones in Yantai and Weihai to accelerate the establishment of "innovative characteristic parks" is suggested. This involves nurturing competitive clusters of innovative characteristic industries to enhance regional competitiveness.

3.2 Cultivating a Hub for Innovative Talent, Providing Intellectual Support for the Transformation of Old and New Drivers

Emphasizing the talent pool effect within the demonstration zone, implementing talent recruitment and training plans tailored to the industrial talent needs of the demonstration zone, and adhering to the principles of attracting, retaining, and effectively utilizing talents, are essential. This involves attracting a cohort of overseas high-level leading talents (teams) and high-caliber talents (teams) in innovation and entrepreneurship. Policy measures include the implementation of guidelines orienting distribution policies towards increasing knowledge value, supporting technology innovation leading talents to play a more effective role, and other relevant policies.

3.3 Optimize and Enhance the Industrial Ecosystem to Foster a Favorable Environment for the Transformation of Old and New Drivers

Companies such as Langchao, Weichai, and Weigao should fully leverage their leading roles and proactively establish open innovation and entrepreneurship platforms. These platforms aim to attract talents and teams, both internal and external, to engage in independent entrepreneurial endeavors, cultivate industry reserves, and create an ecological environment where large enterprises and small and micro-enterprises can mutually develop and interact for a win-win situation. The provincial science and technology supervisory department should establish a differentiated assessment mechanism guided by innovation. Each high-tech zone should focus on key areas such as electronic information, intelligent manufacturing, new materials, and life and health. The emphasis should be on developing 1-2 regional "signature industries" with a scale reaching hundreds of billions, leveraging their radiating and driving roles in the transformation of old and new drivers.

3.4 Promoting Leapfrog Development of High-Tech Zones to Establish a Core Area Supporting the Transition of Old and New Drivers

Guiding the advantageous industries in the demonstration zone to expand to other high-tech zones, reinforcing the radiation and driving force of the demonstration zone's innovative resources on other high-tech zones, and focusing on enhancing the leading role of high-tech zones in accelerating Shandong's transition of old and new drivers are key objectives. Leveraging the opening and sharing of technological resources in the demonstration zone as a breakthrough, we will gradually advance the joint construction and sharing of innovation service platforms across Shandong's high-tech zones. This includes jointly establishing key laboratories, industrial technology research institutes, and other technological innovation platforms. Exploring the formation of a high-tech zone development alliance, guiding and coordinating collaboration among high-tech zones in areas such as technological innovation, industrial integration, talent exchange, and management practices, will drive collaborative industrial development, resource integration, and linked growth among Shandong's high-tech zones, fostering comprehensive development. Adhering to the principle of "promoting development through enhancement," efforts will be made to expedite the elevation of provincial high-tech zones like Heze, Binzhou, Liaocheng, and Rizhao to the national level.

Acknowledgments. This work was supported by Shandong Province Key R&D Program (Soft Science Project) under Grant Number “2023RKY02009” and “2023RZB04036”.

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