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Application and Performance Evaluation of Industrial Internet Platform in Power Generation Equipment Industry

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Abstract: The development and application of the industrial Internet platform (IIP) has brought enterprises huge benefits, such as improving the efficiency of resource management and equipment maintenance, achieving the precipitation and reuse of industrial knowledge, and enhancing the development ability of industrial APPs, etc. Therefore, in order to accelerate the application of the IIP, promote the digital transformation of enterprises, and enhance the application effect of the IIP, it is necessary to evaluate the application level and performance of the enterprise IIP. In this paper, taking the IIP in the power generation equipment industry as the research object, the background, architecture, and implementation process of the platform is described, and an evaluation method is proposed. First, a third-level evaluation index system is proposed via reference analysis and the Delphi method from four dimensions—platform basic condition, platform technology capability, platform application service capability, and platform input–output capability—and a total of sixty-five bottom indexes are designed in particular. Then, the fuzzy analytic hierarchy process (FAHP) and particle swarm optimization (PSO) algorithm are used to determine the weights of indexes, where FAHP is used to construct a fuzzy judgment matrix and PSO is adopted to adjust the consistency of the fuzzy judgment matrix in the FAHP. Finally, through the weights of indexes and questionnaire scores, the evaluation results are obtained, and the application level and performance of the IIP in the power generation equipment industry is analyzed. Through analysis, the important indexes that have a significant influence on the evaluation are determined, and the weaknesses that need to be enhanced are also pointed out, which can guide enterprises to make targeted improvements on the IIP in the power generation equipment industry so as to ensure the sustainable development of the power generation equipment industry.

Keywords: industrial Internet platform; power generation equipment; evaluation index system; FAHP; PSO

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1. Introduction

In recent years, with the generation of new information technologies and industrial technologies, such as the Internet, big data, cloud computing, the Internet of Things (IoT), and artificial intelligence, a new round of technological revolution and industrial transformation has developed rapidly. The Internet has rapidly extended from the consumption field to the production field, and the industrial economy has expanded deeply from digitization to networking and intelligence [1]. The historical intersection between the innovative development of the Internet and the new industrial revolution has given birth to the industrial Internet [2].

The industrial Internet is acknowledged to be a requisite promoter for the transformation and upgrading of traditional industries. The industrial Internet promotes the evolution of design, production, management, and services from single-point digitization to comprehensive integration, accelerating the profound revolution of innovative methods, production modes, organizational forms, and business paradigms, and giving birth to many new modes, formats, and industries such as platform-based design, intelligent manufacturing, networked collaboration, personalized customization, service-oriented extension, and digital management [3–7]. Under the functions of the industrial Internet, through comprehensive interconnectivity across devices, systems, factories, and regions, various production and service resources can be optimized and allocated on a larger scale with greater efficiency and precision, achieving quality improvement, cost reduction, efficiency enhancement, and green and safe development, and significantly improving the quality and efficiency of industrial economic development [8–11]. So, the industrial Internet has played an important role and covered a wide range of applications, such as smart manufacturing, intelligent transportation, medical health, commercial aviation, power production, environment monitoring, agriculture, and construction [1,12,13].

The industrial Internet includes three systems: network, platform, and security [13,14]. The network is the foundation, the platform is the core, and security is the guarantee [14]. The company, General Electric (GE), put forward the concept of the industrial Internet platform (IIP) for the first time in 2012 [11], and released the world's first IIP called Predix, which is similar to Google's Android system and Apple's ios operating system; it has a set of software services that help developers quickly build APPs for the industrial Internet. The Alliance of Industrial Internet (AII) in China inherits the idea of the GE Predix, and regards industrial Internet platforms as industrial cloud platforms that orient to the digitalization, networking, and intelligence needs of the manufacturing industry, and which can support the ubiquitous connectivity, flexible supply, and efficient configuration of manufacturing resources [14]. The industrial Internet platforms bring information flow, capital flow, talent creativity, manufacturing tools, and manufacturing capabilities together on the cloud; gather industrial enterprises, information and communication enterprises, Internet enterprises, third-party developers, and other entities on the cloud; and integrate data science, industrial science, management science, information science, and computer science on the cloud to promote the aggregation and sharing of resources, entities, and knowledge, and ultimately to construct a socialized collaborative production mode and organizational model. The essence of industrial Internet platforms is to build an accurate, real-time, and efficient data collection and interconnection system, to establish a development environment for industrial big data storage, integration, access, analysis, and management, to achieve the modeling, standardization, software, and reuse of industrial technology, experience, and knowledge, to continuously optimize resource allocation efficiency such as research and development design, production manufacturing, and operation management, and, eventually, to form a new ecology of manufacturing industry that has resource enrichment, multi-party participation, win–win cooperation, and collaborative evolution [13,14].

1.1. Related Work to Industrial Internet Platform

Considering these benefits, leading enterprises in different industries around the world have built industrial Internet platforms with different aspects and levels based on their own advantages and resources, such as GE Predix, ABB Ability, Siemens MindSphere, Haier COSMOPlat, PTC ThingWorx, and Ali SupET [2,15,16]. These industrial Internet platforms can be divided into two main types: one type is ICT (information and communication technology) enterprises that provide computer, communication, and software services, such as PTC ThingWorx, Ali SupET, Amazon AWS, Huawei FusionPlant, etc.; the other type is leading manufacturing enterprises with equipment automation conditions, such as GE Predix, ABB Ability, Siemens MindSphere, Haier COSMOPlat, XCMG Hanyun, Dongzhi Tongchuang Co-plat, etc. The industrial Internet platforms of ICT enterprises have similar characteristics that mainly provide IaaS (infrastructure as a service) services such as computing, storage, and networking, as well as SaaS (software as a service) services such as public software and industrial software. The industrial Internet platforms of manufacturing enterprises have obvious industry characteristics that accumulate domain knowledge of their respective industries; for example, GE Predix focuses on the predictive maintenance of rotating machinery equipment, Haier COSMOPlat leans towards mass customization, and XCMG Hanyun mainly considers the predictive maintenance and industry–finance economic mode of construction machinery.

Energy is the lifeblood of national economic development, and electric energy is one of the most widely used energy sources. In the context of the "dual carbon" strategy, the power generation equipment industry is facing many changes and challenges such as industrial structure adjustment, green and low-carbon transformation, etc. The industrial Internet has become the main measure with which to deal with these challenges, and researchers as well as enterprises have begun to study the construction of industrial Internet platforms in the power generation equipment industry [17,18]. Many power generation equipment enterprises have successively built industrial Internet platforms to serve the internal and external of group company, such as GE Predix, Dongzhi Tongchuang Co-plat, and Shanghai Electric SEunicloud. This type of industrial Internet platform in the power generation equipment industry is called the power generation equipment IIP, which is different from platforms of companies such as Amazon, PTC, Alibaba, Haier, XCMG, etc. The power generation equipment IIP is mainly focusing on the field of "green and low-carbon", including green manufacturing process, green supply chain management, clean energy equipment PHM (prognostics and health management), and the multi-energy complementary comprehensive smart energy solution, etc. The aim of the power generation equipment IIP is to integrate digital technology, power electronics technology, and advanced manufacturing technology, to develop clean energy and energy digitization, to promote energy revolution, and to jointly build a green and beautiful future.

So, construction and application of the IIP can accelerate the transformation of the industrial development mode, promote the integration of various enterprises, and establish the modern economic system. At present, the academic and industrial research on the IIP mainly focuses on the technology, functions, elements, and applications based on the industrial Internet [19–22]. However, after the IIP officially empowers regions, industries, and enterprises, how to ensure that the huge investment in platform construction achieves the expected results, how to assess the construction and operation of the platform, how to guide the stable development of the platform, and how to ensure the benefits of the platform are problems that need to be considered [23,24]. Therefore, carrying out the evaluation for the application and performance of the IIP is very important, it can guide the IIP construction enterprises through evaluation, diagnosis, and benchmarking analysis, identifying the weak points, development paths, and optimization directions.

Currently, a few studies have focused on the evaluation of industrial Internet, which can provide some reference information. Menon et al. [25] developed a maturity model framework of the industrial Internet to achieve a coordinated, systematic, and stepwise adoption of the industrial Internet, thus enabling the industrial Internet to be used to its full potential in manufacturing enterprises. Afterwards, Menon et al. [26] focused on various dimensions of IIP openness to help end-users to select a platform based on their needs, while keeping in mind the long-term and short-term benefits as well as the risks. German proposed the "Industry 4.0 maturity index" to assess the current capabilities of German Industry 4.0 from resources, information systems, organizational structure, culture aspects [27]. An evaluation model for the security system of IoT is proposed by Industrial Internet Consortium of United States, and it can provide some references for enterprises to evaluate their own security status in management and operation and help them establish a comprehensive security defense mechanism [28].

In China, the management and guidance for the IIP are steadily advancing. In 2017, the Alliance of Industrial Internet proposed the industrial Internet maturity model, including three core elements: interconnection, comprehensive integration, and data analysis and utilization [29]. In 2018, the Ministry of Industry and Information Technology issued the "Evaluation Method for Industrial Internet Platform" [30], providing a basis for the preparation of specific evaluation indexes and standards. The evaluation contents include platform equipment access, software deployment, user services, etc. In 2022, the government proposed the National Standard "Industrial Internet Platform-Assessment on application level and performance of enterprises" [31]. This standard specifies the guidance and principles, evaluation framework, and evaluation content for the application and performance evaluation of IIP enterprises. In 2023, the National Standard "Selection requirements of industrial Internet platform" was officially released [32], which specifies the key points of evaluation on technical capabilities, business support capabilities, deployment and implementation capabilities, and security protection capabilities of IIP.

Based on these guidelines, Li et al. [23] put forward the assessment index system for the construction and application of the IIP in 2018. The evaluation framework is constructed of three dimensions, including platform basic guarantee, key ability, and benefit, and nine aspects in particular. Subsequently, in 2021, Li et al. [24] proposed an index system with which to evaluate the effectiveness of the IIP application. The evaluation framework is constructed of five dimensions: strategy and organization, basic conditions, platform application, business innovation, as well as efficiency and benefit; and twenty aspects in particular. Zhang and Ming [33] studied the evaluation index system for the performance of the IIP in a pharmaceutical manufacturing industry enterprise via three dimensions, including resource management capability, platform application capability, and industrial service capability, with ten aspects in particular. Heng et al. [34] assessed the industrial Internet maturity of building materials industry from three primary, six secondary, and twenty-one tertiary indexes. A co-author of this paper, Han et al. [35] published a patent for an evaluation system regarding the capability of power generation equipment IIP with respect to technology capability, implementation capability, and profitability.

Multiple countries and studies have proposed evaluation indexes and models related to industrial Internet maturity, security, application level and performance, etc., but there is still a lack of evaluation index systems for industrial Internet platforms based on the industry characteristics. In the literature, there are some evaluation systems for the IIP in certain industries, such as the pharmaceutical manufacturing industry [33] and the building materials industry [34], but for the power generation equipment industry, due to its specific characteristics, such as the diversity of power generation equipment types and the differences in industrial APPs, etc., the existing evaluation systems cannot be used directly. Although Han et al. [35] have studied the evaluation index system for the capability of power generation equipment IIP, the patent only establishes an evaluation index system, i.e., without conducting application analysis. In addition, the evaluation index system is not comprehensive enough; some key indexes have not been considered, such as the system security, industrial data management ability, platform competitiveness, etc.

In addition, these above studies and standards mainly propose evaluation indexes [23–35], with a little attention paid to the evaluation methods for the IIP [23,24,33–35]. The evaluation methods mainly involve determining the weights of indexes. In [33,35], the index weight is directly given via subjective judgment. In [23], the index weight is determined via a hierarchical analysis process (AHP). AHP is one of the subjective weighting methods and has wide applicability in multiple criteria decision-making problems because of its simplicity, ease of use, and great flexibility [36]. However, the uncertainty, vagueness, and ambiguity of human thinking cannot be expressed using AHP [37]. So, in [24,34], the indexes weights are determined via interval hesitant fuzzy entropy and the entropy weight method to weaken the uncertainty of experts in subjective evaluation.

1.2. Research Gap and Contribution

From the above description, the research gaps can be described as follows:

(1) There are various industrial Internet platforms, but the construction of industrial Internet platforms in different industries should have obvious specific industry characteristics, such as accumulating domain knowledge of their respective industries and

building industrial mechanism models with industry characteristics, etc. So, the IIP in the power generation equipment industry should be unique.
(2) The evaluation index system for the application and performance of the IIP in the power generation equipment industry should be more comprehensive, and the practical application effects on the power generation equipment IIP need to be evaluated.
(3) When determining the weights of evaluation indexes, the uncertainty and vagueness of humans in subjective evaluation should be taken into consideration.

Therefore, this paper studies the application and performance evaluation of the IIP in the power generation equipment industry, and its contributions are as follows:

(1) The IIP architecture of power generation equipment is constructed, and the industry characteristics of the platform are pointed out.
(2) Combining the IIP evaluation indexes in references with the characteristics of the power generation equipment industry, a more comprehensive evaluation index system for the application and performance of the power generation equipment IIP is proposed.
(3) Based on the evaluation index system, an effective evaluation method is studied in consideration of the uncertainty and vagueness of subjective evaluation.

2. Power Generation Equipment IIP

2.1. Background of Power Generation Equipment IIP

Electric power equipment is the basis for achieving energy security and stable supply and the sustained and healthy development of the national economy, including wind power, photovoltaic, hydropower, nuclear power, gas, and thermal power equipment. However, in the power generation equipment industry, there are pain point issues, as follows:

(1) The data standards and data protocols are not uniform, and it is difficult to realize the sharing and reuse of manufacturing data.
(2) The digital island phenomenon is serious, and the global coordination ability is insufficient. The information of research and development, production, supply, operation and maintenance, management, and other links are separated.
(3) There is a lack of knowledge and experience precipitation, and it is difficult to achieve reuse and empowerment.
(4) The software system is difficult to control independently, and the cost of operation and maintenance is high.

Therefore, power generation equipment manufacturing enterprises have adopted the industrial Internet platforms to deal with the problems; for example, GE Predix platform, SEunicloud IIP, Dongzhi Tongchuang Co-Plat IIP.

2.2. Architecture of Power Generation Equipment IIP

The research object in this paper is a large power generation equipment manufacturing enterprise, which belongs to Sichuan Province, China. In order to deal with the above pain points, this enterprise has built a power generation equipment IIP which is independent and controllable for enterprises. The platform has realized informatization, intelligence, networking, and collaboration across all aspects, from product to supply chain, through the Internet of things, cloud computing, big data, and other technologies to improve production efficiency, reduce cost, optimize resource allocation, and innovate business mode, etc. The power generation equipment IIP is an industrial cloud platform, and the architecture of the platform is shown in Figure 1.

In Figure 1, the power generation equipment IIP mainly consists of four core layers: the edge layer, IaaS layer, PaaS (platform as a service) layer, and SaaS layer. The PaaS layer includes basic PaaS and industrial PaaS. The SaaS layer includes entrance and industrial APP. Among them, IaaS and basic PaaS have similar functions to other industrial Internet platforms, which are mainly supported by ICT enterprises. The features of the power generation equipment IIP are the edge layer, industrial PaaS layer, and industrial APP layer.

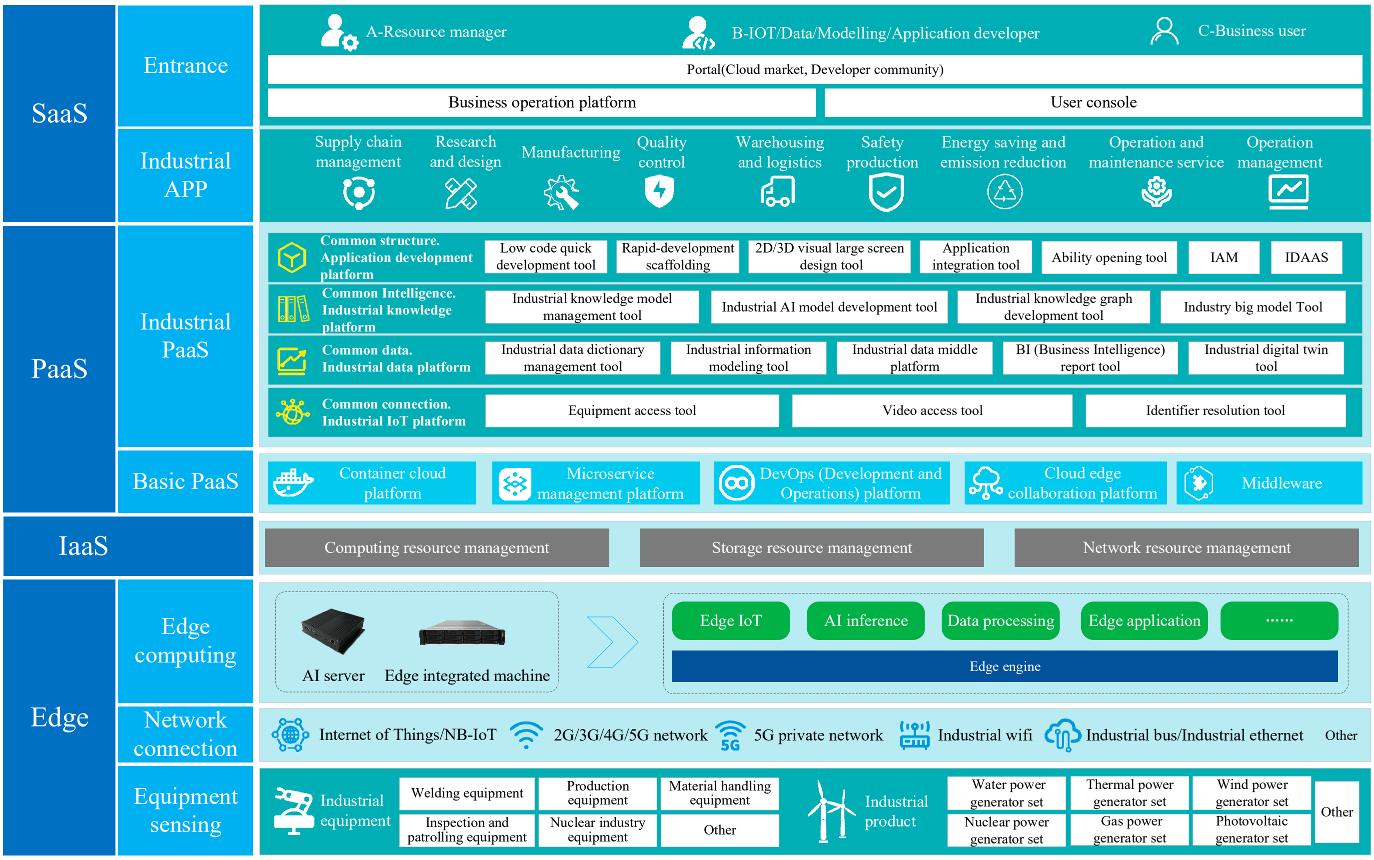

Figure 1. The architecture of power generation equipment IIP.

At the edge layer, it provides the industrial communication protocols that adapt to power generation equipment to support the rapid cloud deployment of equipment, such as wind power, photovoltaic, nuclear power, water power, gas power, thermal power, and other equipment.

At the industrial PaaS layer, it establishes the industrial mechanism models with the characteristics of power generation equipment in research and development design, production manufacturing, operation, and maintenance services, such as gas turbine welding process optimization models, intelligent detection models for welding quality defects of small diameter pipes in power plant boilers, product carbon footprint accounting models, and fault warning models of wind power generation set.

At the industrial APP layer, it achieves the modularization and software package of industrial knowledge to create a “killer” industrial APP with power generation equipment characteristics; for example, smart wind power APP, quality defect intelligent detection and tracing APP, product carbon footprint assessment APP, remote diagnosis APP for waterpower units, etc. These industrial APPs will fully unlock the value of industrial data to help power generation equipment enterprises achieve quality improvement, efficiency enhancement, cost reduction, and green and safe development.

2.3. Implementation Process of Power Generation Equipment IIP

The industrial Internet platform is essentially an industrial operating system that provides a development environment for industrial APP creation, testing, and deployment in a building block manner, and it is similar to Microsoft’s Windows, Google’s Android system, and Apple’s ios system. The process of developing an industrial APP based on the power generation equipment IIP is shown in Figure 2, including industrial data acquisition, massive big data analysis, industry knowledge precipitation, and industrial APP development.

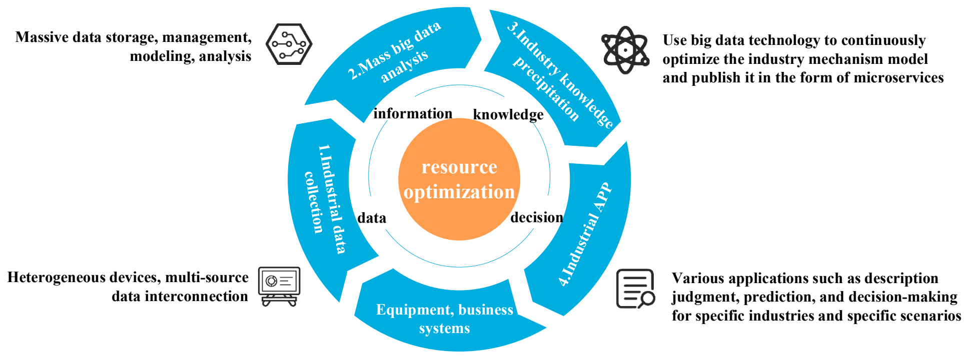

Figure 2. The process of developing an industrial APP.

According to Figure 2, taking the smart wind power industry APP as an example, the development process includes four steps as follows:

(1) Industrial data acquisition: The sensor data of the wind turbine are collected by the hard gateway or the soft gateway, including active power, reactive power, wind wheel speed, generator speed, generator voltage, generator current, bearing temperature, etc.;
(2) Massive big data analysis: Through the data lake technology, the time series data of the collected wind turbines are stored and managed uniformly, and the data are processed by secondary calculation such as unit conversion;
(3) Industry knowledge precipitation: Based on expert experience, the fault alarm rules of unit equipment are constructed, such as bearing temperature alarm rules; based on historical data, the early warning model of unit equipment is constructed by using artificial intelligence technology, such as the bearing fault early warning model, blade fault early warning model, and so on.
(4) Industrial APP development: Relying on the unified industrial information and industrial knowledge of wind turbines carried by the platform, the rapid development of smart wind power APP is realized by using low code development, DevOps, and other technologies. It has the functions of unit condition monitoring, fault alarm and fault warning to improve the operation and maintenance efficiency of wind turbines and reduce the operation and maintenance cost.

In summary, the core of the IIP is to accumulate the industrial knowledge model of the enterprise, fully release the data dividend, and realize value creation.

3. Application and Performance Evaluation of Power Generation Equipment IIP

The evaluation process of application and performance for power generation equipment IIP mainly includes two parts, as shown in Figure 3, and the description is as follows.

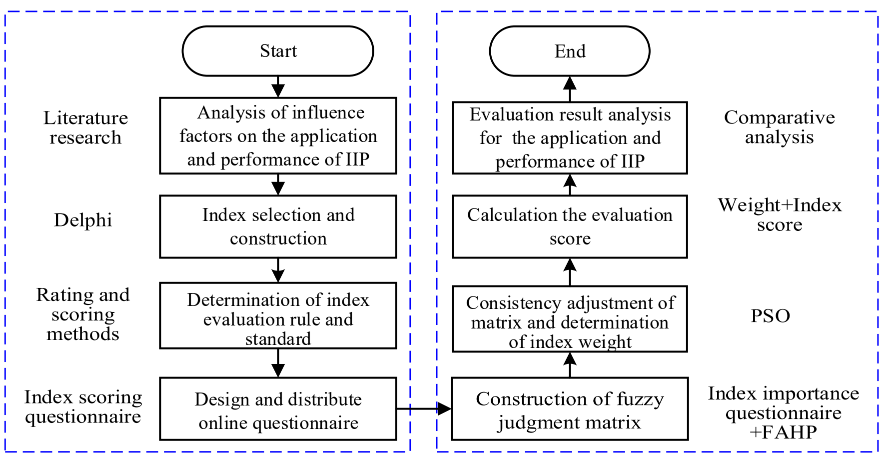

Figure 3. Evaluation process of application and performance for power generation equipment IIP.

(1) Construction of evaluation index system

In order to determine the application and performance evaluation indexes of power generation equipment IIP, this paper has reviewed the relevant references [23,24,30,31,33,35] to determine the key factors that need to be evaluated, and Table 1 presents a comparative analysis of existing relevant evaluation index systems with respect to evaluation level, method, and applied industry. From Table 1, it can be seen that the evaluation index systems in references [23,24,30,31] belong to the common evaluation index systems, facing to all manufacturing industries; while the evaluation index systems in references [33,35] are specific evaluation index systems, targeting the pharmaceutical and power generation equipment manufacturing industries separately; in addition, all the evaluation methods in these references tend to be subjective methods, such as the AHP, Delphi method, expert rating and scoring method. So, in this paper, based on the common evaluation indexes and specific industry evaluation indexes, the Delphi method is used to select and design the corresponding indexes, considering the characteristics of the power generation equipment manufacturing industry, to form a more targeted and practical evaluation system. In addition, in order to enable respondents to understand the evaluation content clearly and make evaluation easily, rating and scoring methods are adopted because of their simplicity and ease of use to determine the evaluation criteria and scoring rule of the indexes. In addition, the corresponding index scoring questionnaire is designed and distributed online.

Table 1. Current research on evaluation index system.

Evaluation Index System	Evaluation Level	Evaluation Method	Applied-Industry
Assessment index system for construction and application of IIP [23]	3 first-level indexes: platform basic guarantee, key ability, and benefit; 9 second-level indexes; 24 third-level indexes; and 144 data collection items under the third-level indexes.	AHP and Delphi method	All manufacturing industries
Evaluation system of IIP application for manufacturing enterprises [24,31]	5 first-level indexes: strategy and organization, basic conditions, platform application, business innovation, as well as efficiency and benefit; 20 second-level indexes; 34 third-level indexes; and 51 data collection items under the third-level indexes.	Expert scoring and interval hesitant fuzzy entropy	All manufacturing industries
Evaluation method for industrial Internet platform [30]	Documentation guidelines provide a basis for the preparation of specific evaluation indexes and standards and include five parts: platform basic common capability requirements, industry specific platform capability requirements, domain specific platform capability requirements, regional specific platform capability requirements, and cross industry and cross domain platform capability requirements; for example, the basic common capability requirements of IIP includes 4 first-level indexes: platform resource management capability, platform application services capability, basic technical capabilities, as well as platform input–output capability; and 15 second-level indexes.	Not mentioned	All industries
Service evaluation index system for the IIP comprehensive performance [33]	3 first-level indexes: resource management capability, platform application capability as well as industrial service capability; 10 second-level indexes; and 23 third-level indexes.	Subjective weight and quantitative calculation method	Pharmaceutical manufacturing industry
Evaluation index system for the capability of power generation equipment IIP [35]	3 first-level indexes: technology capability, implementation capability, and profitability; 8 second-level indexes; 22 third-level indexes; and 41 data collection items under the third-level indexes.	Subjective weight and expert rating and scoring method	Power generation equipment manufacturing industry

(2) Determining the weight of index

After determining the evaluation index system of the IIP's application and performance, the next step is to select corresponding weighting method to determine the weight of each index. In this paper, the index weight is determined via the subjective weight method, and the fuzzy analytic hierarchy process (FAHP) is used to calculate the index weight. The FAHP is an extension of the combination of AHP and fuzzy sets and is a widely used approach for decision making problems with uncertainty and vagueness [38,39]. The analysis steps of the FAHP and AHP are basically the same, but some shortcomings of traditional AHP are improved by FAHP, and the main differences between FAHP and AHP include the establishment of a consistent judgment matrix and the determination of weight for each element in the matrix [40]. In FAHP, the fuzzy judgment matrix is established, and when the consistency of the fuzzy judgment matrix does not meet the requirement, it needs to be adjusted.

At present, the adjustment methods mainly include the following three types [41]: (1) finding the element with the largest deviation in the judgement matrix and adjusting it step by step, such as through the use of the geometric mean-induced bias matrix (GMIBM) method [42]; (2) the proportion correction method, such as that based on the transitivity preferences [43]; and (3) the construction planning model method, i.e., transforming the consistency adjustment into a programming problem with constraints. The third type not only solves the matrix consistency problem but also retains the original subjective intention of the decision makers to the greatest extent [41], and it is more suitable to adopt a meta-heuristic algorithm, such as the genetic algorithm and the differential evolution algorithm [41,44], to adjust the consistency of the judgement matrix. Therefore, as one of the meta-heuristic algorithms, the particle swarm optimization (PSO) algorithm, because of its simple, fast search speed and high efficiency, is adopted to adjust the consistency of the fuzzy judgment matrix in the FAHP and thus to obtain the weights of the evaluation indexes for the power generation equipment IIP. Although the weight calculation method is a general method, it is still suitable for the research object in this paper, which is evaluated via the Delphi method and an index scoring questionnaire. Until now, the FAHP combined with PSO for the determination of the weight of index has not been used for the evaluation of the IIP.

Finally, the IIP evaluation score is calculated based on the index scoring values obtained from the questionnaire and the weight obtained via the FAHP combined with PSO, and the evaluation result is analyzed and compared to guide the improvement and development of the power generation equipment IIP.

3.1. Construction of Evaluation Index System

First, in considering of the common evaluation indexes, the evaluation index system of application and performance for power generation equipment IIP mainly analyzes the influence factors via four dimensions: platform basic condition, platform technology capability, platform application service capability, and platform input–output capability. Furthermore, in combination with the characteristics of the power generation equipment industry, using of Delphi method to design the evaluation index system with 19 aspects, a total of 65 bottom indexes are identified in particular. The evaluation index system for the application and performance for the IIP in the power generation equipment industry is proposed as shown in Table 2, along with the relevant references. From Table 2, it can be seen that based on the evaluation index system in the reference [35] for the capability of power generation equipment IIP, some key common indexes are added from the related references [23,24,30,31,33], such as B5 (Edge computing ability) and B6 (Industrial data management ability), and a few indexes are expanded to consider the features of the power generation equipment industry, such as the C6 (Connection number of photovoltaic generator set) and C8 (Connection number of gas power generator set).

Table 2. Evaluation index system for the application and performance for the power generation equipment IIP.

First Level Index	Second Level Index	Third Level Index	References
A1: Platform basic condition	B1: Industrial equipment connection ability	C1: Connection number of processing equipment; C2: Connection number of logistics equipment; C3: Connection number of quality inspection equipment; C4: Connection number of other equipment;	[35] [35] [35] [35]
	B2: Industrial product connection ability	C5: Connection number of wind power generator set; C6: Connection number of photovoltaic generator set; C7: Connection number of thermal power generator set; C8: Connection number of gas power generator set; C9: Connection number of water power generator set; C10: Connection number of nuclear power generator set; C11: Connection number of other units;	[35] New index [35] New index [35] [35] [35]
	B3: Network connection ability	C12: New generation information communication technology; C13: Number of compatible adaptations for industrial protocol; C14: Platform gateway adaptation capability;	[24,31,33] [35] [23,24,31]
A2: Platform technology capability	B4: Construction and operation of platform	C15: Platform infrastructure construction mode; C16: Platform operation mode; C17: Platform intellectual property rights;	[35] [35] [30]
	B5: Edge computing ability	C18: Edge data processing capability; C19: Edge data response delay;	[23,24,31] [23]
	B6: Industrial data management ability	C20: Data management measure; C21: Data management scope; C22: Heterogeneous data conversion; C23: Big data application ability;	[23,24,31] [24,31] [23] [24,31]
	B7: Industrial knowledge precipitation and reuse ability	C24: Number of business process models; C25: Number of industry mechanism models; C26: Number of data algorithm models; C27: Number of other models;	[35] [35] [35] [35]
	B8: Industrial microservice ability	C28: Number of general microservice components; C29: Number of dedicated microservice components; C30: Microservice development environment and tools;	[35] [35] [23]
	B9: Industrial APP service ability	C31: Industrial APP types; C32: Number of industrial APPs; C33: Number of industrial APP subscriptions; C34: Industrial APP users; C35: Industrial APP operation management;	[23,24,31] [35] [35] [23] [30]
	B10: User management ability	C36: Number of registered users; C37: Number of paid users; C38: Registered user management;	[35] [35] [30]
	B11: Developer management ability	C39: Number of third-party developers; C40: Number of third-party active developers; C41: Developer operation management;	[35] [35] [23]
A3: Platform application service capability	B12: Storage computing service	C42: Computing capability; C43: Storage capability;	[35] [35]
	B13: Application development service	C44: Supportable application development languages; C45: Supportable application management links; C46: Supportable application development measures;	[23] [23] [23]
	B14: Inter-platform invocation service	C47: Number of cross-platform invocation models; C48: Number of cross-platform invocation microservices; C49: Number of cross-platform invocation APPs;	[35] [35] [30,33]
	B15: Security protection service	C50: Platform information security system; C51: Platform data security technology; C52: Platform network security protection technology;	[23,24,31] [23] [23,33]

Table 2. *Cont.*

First Level Index	Second Level Index	Third Level Index	References
A4: Platform input-output capability	B16: Platform research and development investment	C53: Number of salespersons; C54: Number of development persons; C55: Number of maintenance persons; C56: Cumulative investment amount of the platform;	[35] [35] [35] [35]
	B17: Platform output benefit	C57: Number of platform solutions; C58: Number of industries covered by the platform;	[35] [35]
	B18: Platform application effect	C59: Cumulative revenue amount of the platform; C60: Return on investment of the platform;	[35] [35]
	B19: Platform competitiveness	C61: Research and development capability; C62: Equipment efficiency; C63: Product quality; C64: Service level; C65: Emergency response.	[24,31] [23,24,31] [24,31] [24,31] [24,31]

The evaluation index system for the power generation equipment IIP in Table 2 contains three levels, and the main content includes four dimensions, as follows.

(1) Platform basic condition

The platform basic condition (A1) is evaluated via three aspects: industrial equipment connectivity ability (B1), industrial product connectivity ability (B2), and network connectivity ability (B3), with a total of 14 bottom indexes (C1–C14). The descriptions for the bottom indexes are as follows:

C1: Connection number of processing equipment: this means the power generation equipment for the production, such as machine tools, welding equipment, etc.;

C2: Connection number of logistics equipment: this means the equipment for handling inside and outside the factory, such as AGV, logistics vehicles, etc.;

C3: Connection number of quality inspection equipment: this means the equipment used to detect the quality of parts of power generation equipment, such as welding defect detection equipment, etc.;

C4: Connection number of other equipment: this means the equipment other than the above three types of equipment;

C5: Connection number of wind power generator set: this means the power generation equipment that converts wind energy into electrical energy, including wind turbines for onshore and offshore wind farms;

C6: Connection number of photovoltaic generator set: this means the power generation equipment that converts solar energy into electrical energy, including photovoltaic and photothermal power generation equipment;

C7: Connection number of thermal power generator set: this means the power generation equipment using coal as a power source, including boilers, steam turbines, generators, and other equipment in thermal power plants;

C8: Connection number of gas power generator set: this means the power generation equipment using natural gas as power source, including gas turbines, generators, etc.;

C9: Connection number of water power generator set: this means the power generation equipment using water as power source, including hydraulic turbines, generators, etc.;

C10: Connection number of nuclear power generator set: this means the nuclear power generation equipment, including nuclear reactors, steam generators, steam turbine generators, etc.;

C11: Connection number of other units, except the above six types of generator equipment sets, such as hydrogen energy equipment, etc.;

C12: New generation information communication technology, such as the usage of 5G, WIFI6, TSN, etc.;

C13: Number of compatible adaptations for industrial protocol: this means the communication protocols compatible with mainstream devices, such as ModBus, OPC-UA, CAN, Profibus, etc.;

C14: Platform gateway adaptation capability: this means that the gateway has a mainstream protocol conversion plug-in and supports customized development of personalized protocols.

(2) Platform technology capability

The platform technology capability (A2) is analyzed via eight aspects, including the platform construction and operation (B4), edge computing ability (B5), industrial data management ability (B6), industrial knowledge precipitation and reuse ability (B7), industrial microservice ability (B8), industrial APP service ability (B9), user management ability (B10), and developer management ability (B11), along with twenty-seven bottom indexes in total (C15–C41). The descriptions for the bottom indexes are as follows:

C15: Platform infrastructure construction mode: this means that the Cloud platform is self-built or rent a third party, such as Alibaba Cloud, Amazon Cloud, etc.;

C16: Platform operation mode: this means that the platform is operated independently or entrusted to a third party;

C17: Platform intellectual property rights: this means that the platform has independent intellectual property rights, shared intellectual property rights or no intellectual property rights;

C18: Edge data processing capability: this means the ability to process data at the edge site, including data acquisition, storage, transmission, and intelligent analysis;

C19: Edge data response delay, such as less than 50 milliseconds;

C20: Data management measure, such as metadata management, data classification and grading, etc.;

C21: Data management scope, such as design, manufacturing, operation and maintenance, management data;

C22: Heterogeneous data conversion, such as structured, semi-structured, unstructured data;

C23: Big data application ability, such as data storage, modeling, analysis, and sharing services;

C24: Number of business process models, such as purchase process;

C25: Number of industry mechanism models, such as wind turbine load calculation formula;

C26: Number of data algorithm models, such as the AI detection model of welding defects;

C27: Number of other models, except the above three types of models; e.g., other models such as geometric models, etc.;

C28: Number of general microservice components, such as user authentication, and unified message microservices;

C29: Number of dedicated microservice components, such as planning and scheduling microservices;

C30: Microservice development environment and tools, such as Spring Cloud, Istio, etc.;

C31: Industrial APP types, such as design, manufacturing, safety production and other industrial APPs;

C32: Number of industrial APPs, such as the platform has 100 industrial APPs;

C33: Number of industrial APP subscriptions, such as the number of industrial APP subscriptions on the platform being 10,000;

C34: Industrial APP users: this means that the industrial APP is the industry general or customized industrial APP according to the customer needs;

C35: Industrial APP operation management, such as search, transaction, running, maintenance, etc.;

C36: Number of registered users, such as the platform registered users being 10,000;

C37: Number of paid users, such as the platform paid users being 1000;

C38: Registered user management, such as rights management, transaction management, etc.;

C39: Number of third-party developers; for example, there are 10,000 developers working on the platform.

C40: Number of third-party active developers; for example, there are 1000 active developers who log in every month;

C41: Developer operation management, such as program development, testing, release, etc.

(3) Platform application service capability

The platform application service capability (A3) is analyzed via four aspects, including storage computing service (B12), application development service (B13), inter-platform invocation service (B14), security protection service (B15), along with a total of eleven bottom indexes (C42–C52). The descriptions for the bottom indexes are as follows:

C42: Computing capability: this means the number of CPU resources, such as 1000 cores;

C43: Storage capability, such as 1PB;

C44: Supportable application development languages, such as Java, C++, C#, Python, etc.;

C45: Supportable application management links, such as development, testing, simulation, etc.;

C46: Supportable application development measures, such as low code development, source code development;

C47: Number of cross-platform invocation models, such as 100;

C48: Number of cross-platform invocation microservices, such as 50;

C49: Number of cross-platform invocation APPs, such as 10;

C50: Platform information security system: this means that the platform has an information security protection system, and no safety accidents have occurred in the past year;

C51: Platform data security technology, such as data encryption technology;

C52: Platform network security protection technology, such as firewall, honeypot, and other technologies.

(4) Platform input–output capability

The input–output capability (A4) is mainly analyzed from four perspectives, including platform research and development investment (B16), platform output benefit (B17), platform application effect (B18), and platform competitiveness (B19), as well as via thirteen bottom indexes in particular (C53–C65). The descriptions for the bottom indexes are as follows:

C53: Number of salespersons, such as 100 sales staff;

C54: Number of development persons, such as 500 development persons;

C55: Number of maintenance persons, such as 50 maintenance persons;

C56: Cumulative investment amount of the platform, such as 100 million RMB;

C57: Number of platform solutions, such as the platform has 20 intelligent manufacturing solutions;

C58: Number of industries covered by the platform; for example, the platform covers two industries, such as the machinery and electricity industries;

C59: Cumulative revenue amount of the platform, such as 20 million RMB;

C60: Return on investment of the platform, such as 10%;

C61: Research and development capability; for example, after applying the platform, the new product development cycle is shortened by 10%;

C62: Equipment efficiency; for example, after applying the platform, the average equipment utilization rate is increased by 10%;

C63: Product quality; for example, after applying the platform, the product quality is increased by 5%;

C64: Service level; for example, the on-time delivery rate of orders has increased by 5%;

C65: Emergency response: this means that if the enterprise can respond to emergencies in a timely manner after applying the platform.

3.2. Determination of Weight of Index

Due to the different roles played by different indexes in evaluation, it is necessary to consider the weights of different evaluation indexes. The FAHP combined with PSO method is adopted to determine the index weight, and the specific steps are as follows.

3.2.1. Construction of Fuzzy Judgment Matrix

First, evaluation indexes need to be compared in pairs. The 0.1~0.9 scale method adopted in [40] is used to determine the relative importance between two indexes. Multiple experts related to the power generation equipment IIP are invited to evaluate the relative importance of indexes separately through an index importance questionnaire. Then, we collect and process the questionnaire data, and the average value is used as the representative value of the importance of each index. Suppose there are n indexes at the same level with the same affiliation that need to be evaluated. After obtaining the importance score between indexes, a fuzzy judgment matrix R can be constructed as follows:

$$R = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{n1} & \cdots & r_{nn} \end{bmatrix}.$$

The fuzzy judgment matrix R has the following properties:

$$0 < r_{ij} < 1, r_{ij} + r_{ji} = 1, r_{ii} = 0.5, (i, j = 1, 2, \ldots, n). \quad (1)$$

In order to know whether the characteristic of fuzzy judgment matrix R is rational or not, the matrix consistency must be checked. The steps of consistency check are as follows:

(1) Calculate the sum of element values in each row of R by the following formula:

$$r_i = \sum_{j=1}^{n} r_{ij}, (i, j = 1, 2, \ldots, n). \quad (2)$$

(2) Calculate the weight of each index by the following formula [45]:

$$w_i = \frac{1}{n} - \frac{1}{2\alpha} + \frac{r_i}{n\alpha}, (i = 1, 2, \ldots, n), \quad (3)$$

where $w_i > 0$, $\sum_{i=1}^{n} w_i = 1$, α is a measure of the difference in importance between elements, and $\alpha \geq (n-1)/2$. The smaller the α shows that decision-makers place greater emphasis on the differences between elements. In this paper, $\alpha = (n-1)/2$.

(3) If fuzzy judgment matrix R is a fuzzy consistent matrix, then R meets the following requirement:

$$r_{ij} = \alpha(w_i - w_j) + 0.5, \sum_{i=1}^{n}\sum_{j=1}^{n} \left|\alpha(w_i - w_j) + 0.5 - r_{ij}\right| = 0. \quad (4)$$

Therefore, consistency adjustment can be considered as a constrained programming problem as follows:

$$\min CIF = \frac{1}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{n} \left|\alpha(w_i - w_j) + 0.5 - r_{ij}\right|. \quad (5)$$

CIF is the consistency index function. The smaller the *CIF* value is, the better the consistency is. Generally, when *CIF* < 0.1, consistency requirement is met. The fuzzy judgment matrices that do not meet the consistency requirement must be adjusted.

3.2.2. Consistency Adjustment of Fuzzy Judgment Matrix Based on PSO

In this paper, the consistency adjustment of the fuzzy judgment matrix is transformed into a programming problem with constraints and solved with PSO. Taking the minimum *CIF* value as the objective function, elements diagonally divided in the upper right corner of the original matrix are used as optimization variables. The number of variables is $n(n-1)/2$, and PSO is used to iteratively optimize these variables in order to obtain the minimum consistency index value.

(1) The basic principle of PSO

The basic principle of PSO is that, in a population of P particles, each particle is regarded as a point in N-dimensional space with its own position and velocity, where the position of the particle represents a candidate solution to the problem. Particles dynamically adjust their position and velocity through their own flight experience and the flight experience of their companions so as to find the optimal solution to the problem. The flight trajectory update of each particle includes velocity update and position update as follows:

$$V_i(t+1) = wV_i(t) + c_1 r_1 (L_i(t) - X_i(t)) + c_2 r_2 (G(t) - X_i(t)), \tag{6}$$

$$X_i(t+1) = V_i(t+1) + X_i(t), \tag{7}$$

where $i = 1, 2, \ldots, P$, P is the population size; $t = 1, 2, \ldots, K$, K is the number of iterations; $X_i(t) = [x_{i1}(t), x_{i2}(t), \ldots, x_{iN}(t)]$ is the position; $V_i(t) = [v_{i1}(t), v_{i2}(t), \ldots, v_{iN}(t)]$ is the velocity of particle i in N-dimensional space; $L_i(t) = [L_{i1}, L_{i2}, \ldots, L_{iN}]$ is the local optimal solution of particle i; $G(t) = [G_1, G_2, \ldots, G_N]$ is the global optimal solution obtained so far; c_1 and c_2 are learning factors; w is inertia factor; r_1 and r_2 are random numbers in the range of [0, 1]; $V_i(t) \in [-V_{\max}, V_{\max}]$, $V_{\max}$ is usually a user-defined constant; and $[-V_{\max}, V_{\max}] = [-X_{\max}, X_{\max}]$.

(2) Particle expression of PSO

When using PSO to search for importance values between indexes, the particle expression is set as follows: the N-dimensional space is set as $N = n(n-1)/2$; and the position of particle i during the t-th iteration $X_i(t) = [x_{i1}(t), x_{i2}(t), \ldots, x_{iN}(t)]$ represents a candidate solution. The value of importance across indexes is a random number in the range of [0, 1], as shown in Figure 4.

particle i	j=1	2	3	4	5	N=6
$X_{ij}(t)$=importance value between two indexes	0.32	0.51	0.12	0.45	0.26	0.67

Figure 4. Particle expression.

In Figure 4, if there are $n = 4$ indexes, then there is $N = 6$ dimensional space. For particle i, the importance of index 1 relative to index 2 is 0.32; the importance of index 1 relative to index 3 is 0.51; the importance of index 1 relative to index 4 is 0.12; the importance of index 2 relative to index 3 is 0.45; the importance of index 2 relative to index 4 is 0.26; and the importance of index 3 relative to index 4 is 0.67.

During the initialization and update process of PSO, it should be ensured that the values corresponding to each dimension of the particle are within the interval [0, 1], and for values outside the interval, the following adjustment will be made:

If $x_{ij}(t) > X_{\max}$, then $x_{ij}(t) = X_{\max}$; or else, if $x_{ij}(t) < X_{\min}$, then $x_{ij}(t) = X_{\min} = -X_{\max}$.

In addition, the adjustment of particle velocity is as follows:

If $v_{ij}(t) > V_{\max}$, then $v_{ij}(t) = V_{\max}$; or else, if $v_{ij}(t) < V_{\min}$, then $v_{ij}(t) = V_{\min} = -V_{\max}$.

(3) The process of consistency adjustment using PSO

Taking Formula (5) as the objective function of PSO, the process of adjusting the consistency of the fuzzy judgment matrix using PSO is shown in Figure 5. First, the fuzzy judgment matrix is obtained via the FAHP; then, the consistency is judged, and the fuzzy judgment matrix that does not meet the consistency is adjusted using PSO. With the update of the particles, the optimal matrix can be obtained. Finally, according to the consistency adjustment process, all matrices that do not meet the consistency requirement can be adjusted, and the weights of all indexes at the same level with same affiliation can be obtained.

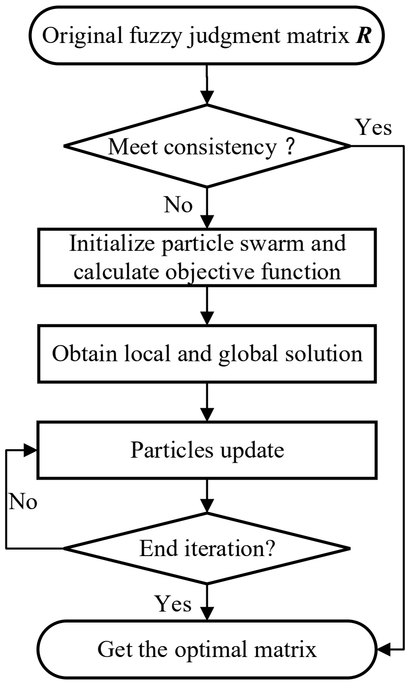

Figure 5. The process of consistency adjustment using PSO.

3.2.3. Determination of Global Weight of Index

With the weights of indexes obtained via the FAHP combined with PSO, the global weights of all indexes can be determined via the following formula:

$$w_j^{cg} = w_j^{cs} w_j^{pg}, j = 1, 2, \ldots, n, \quad (8)$$

where n is the number of indexes; w_j^{cg} is the global weight of child index j; w_j^{cs} is the weight of child index j at the same level with same affiliation; and w_j^{pg} is the global weight of parent index corresponding to child index j. Generally, the weight of the first level index is the global weight. So, when the weights of indexes at the same level have been obtained, the global weights of indexes are calculated from top to bottom based on the hierarchical structure of the evaluation system. By comparing the global weights of indexes, it is easy to identify the important indexes in evaluation.

3.3. Calculation of Evaluation Score

With the weights of indexes obtained, the evaluation score can be calculated by weighted summation, as shown below:

$$b = \sum c_j \times w_j^{cs}, j = 1, 2, \ldots, n, \quad (9)$$

where n is the number of indexes; b is the evaluation score of parent index; c_j is the score of child index j; and w_j^{cs} is the weight of child index j at the same level with same affiliation. The scores of bottom child indexes are obtained via the index scoring questionnaire in this paper; so, the index score is calculated from bottom to top based on the hierarchical structure of evaluation system.

After obtaining the evaluation score, benchmarking analysis is carried out. Referring to reference [24], the application level and performance of the enterprise IIP are divided into five levels from A to E, in which A level is 0~20 points, B level is 20~40 points, C level is 40~60 points, D level is 60~80 points, and E level is 80~100 points. The description for each level is as follows:

(1) A level shows that the application of enterprise IIP is still in its infancy, and the application effect has not been effectively obtained;
(2) B level shows that the enterprise has carried out the work related to the application of IIP in an orderly manner; has gradually consolidated the basic conditions; has initially carried out the work related to the equipment on cloud and the business on cloud; and has achieved initial results in terms of cost reduction and efficiency increase;
(3) C level shows that the enterprise has carried out a relatively perfect strategic formulation and organizational arrangement; the basic conditions are basically perfect; the key equipment and core business are realized on cloud; the competitiveness of the enterprise has been significantly improved; and obvious results have been achieved in terms of improving quality, reducing cost, and increasing efficiency;
(4) D level shows that the enterprise has basically completed the strategic formulation and organizational arrangement, as well as the basic conditions; the equipment and business on cloud are basically completed; the platform-based business model innovation has been carried out; the competitiveness has been greatly improved; and the economic and social benefits have been significantly improved;
(5) E level shows that the enterprise has perfect strategic formulation, organizational arrangement, and basic conditions; has fully realized the equipment and business on cloud; has the ability of APP independent innovation, as well as industrial knowledge precipitation and reuse; has widely carried out platform-based model innovation; and competitiveness, economic and social benefits are remarkable.

4. Results and Discussion

According to the evaluation process of the application and performance for the power generation equipment IIP, the questionnaire on the importance across indexes and the index scoring questionnaire are sent to experts related to the platform. All the returned questionnaires are processed. In the questionnaire on the importance across indexes, there are 24 fuzzy judgement matrices in total, and 22 matrices that do not meet consistency condition are adjusted using PSO. Considering that some fuzzy judgment matrices are very small, with only two indexes, in order to meet the consistency of the fuzzy judgment matrix and reflect the differences in index weights, after multiple experiments, the parameters of PSO are set as follows: $P = 5$, $K = 10$, $w = 0.5$, and $c_1 = c_2 = 2$. Then, the weights of indexes at the same level with the same affiliation are obtained, and based on the Equation (8), the global weights of all the indexes are calculated as shown in Table 3.

From the index global weights in Table 3, the maximum weight of the first-level index is the platform technology capability (A2 = 0.2573), which means that when the platform technology capability is strong, the platform basic condition, application services, and economic benefits of the IIP can be effectively guaranteed. At the second level, the important indexes mainly include industrial equipment connection ability (B1 = 0.0845), network connection ability (B3 = 0.0838), industrial product connection ability (B2 = 0.0832), platform research and development investment (B16 = 0.0666), platform output benefit (B17 = 0.0633), storage computing service (B12 = 0.0621), application development service (B13 = 0.0618), platform competitiveness (B19 = 0.0617), etc. For the third level, the important indexes include number of platform solutions (C57 = 0.0365), computing capability (C42 = 0.0355), cumulative revenue amount of the platform (C59 = 0.0332), platform gateway adaptation capability (C14 = 0.0300), etc. In addition, these important indexes will have a significant impact on the evaluation results.

Table 3. The index weight results.

First Level Index	Global/SAME Level Weight	Second Level Index	Same Level Weight	Global Weight	Third Level Index	Same Level Weight	Global Weight
A1: Platform basic condition	0.2515	B1: Industrial equipment connection ability	0.3358	0.0845	C1	0.2504	0.0212
					C2	0.2531	0.0214
					C3	0.2533	0.0214
					C4	0.2432	0.0206
		B2: Industrial product connection ability	0.3309	0.0832	C5	0.1673	0.0139
					C6	0.1537	0.0128
					C7	0.1456	0.0121
					C8	0.1456	0.0121
					C9	0.1374	0.0114
					C10	0.1306	0.0109
					C11	0.1197	0.0100
		B3: Network connection ability	0.3333	0.0838	C12	0.3053	0.0256
					C13	0.3371	0.0283
					C14	0.3576	0.0300
A2: Platform technology capability	0.2573	B4: Construction and operation of platform	0.1393	0.0358	C15	0.3396	0.0122
					C16	0.3269	0.0117
					C17	0.3334	0.0119
		B5: Edge computing ability	0.1357	0.0349	C18	0.5829	0.0203
					C19	0.4171	0.0146
		B6: Industrial data management ability	0.1146	0.0295	C20	0.2515	0.0074
					C21	0.2576	0.0076
					C22	0.2559	0.0075
					C23	0.2350	0.0069
		B7: Industrial knowledge precipitation and reuse ability	0.1319	0.0340	C24	0.2541	0.0086
					C25	0.2631	0.0089
					C26	0.2373	0.0081
					C27	0.2454	0.0083
		B8: Industrial microservice ability	0.1141	0.0294	C28	0.3442	0.0101
					C29	0.3320	0.0098
					C30	0.3238	0.0095
		B9: Industrial APP service ability	0.1157	0.0298	C31	0.2090	0.0062
					C32	0.2016	0.0060
					C33	0.2031	0.0061
					C34	0.1895	0.0056
					C35	0.1968	0.0059
		B10: User management ability	0.1215	0.0313	C36	0.3385	0.0106
					C37	0.3281	0.0103
					C38	0.3333	0.0104
		B11: Developer management ability	0.1271	0.0327	C39	0.3381	0.0111
					C40	0.3333	0.0109
					C41	0.3286	0.0107
A3: Platform application service capability	0.2401	B12: Storage computing service	0.2585	0.0621	C42	0.5714	0.0355
					C43	0.4286	0.0266
		B13: Application development service	0.2575	0.0618	C44	0.3340	0.0206
					C45	0.3395	0.0210
					C46	0.3265	0.0202
		B14: Inter-platform invocation service	0.2399	0.0576	C47	0.3566	0.0205
					C48	0.3199	0.0184
					C49	0.3235	0.0186
		B15: Security protection service	0.2441	0.0586	C50	0.3349	0.0196
					C51	0.3333	0.0195
					C52	0.3318	0.0194
A4: Platform input-output capability	0.2510	B16: Platform research and development investment	0.2653	0.0666	C53	0.2656	0.0177
					C54	0.2383	0.0159
					C55	0.2514	0.0167
					C56	0.2447	0.0163
		B17: Platform output benefit	0.2522	0.0633	C57	0.5769	0.0365
					C58	0.4231	0.0268
		B18: Platform application effect	0.2370	0.0595	C59	0.5573	0.0332
					C60	0.4427	0.0263
		B19: Platform competitiveness	0.2456	0.0617	C61	0.2049	0.0126
					C62	0.2105	0.0130
					C63	0.2021	0.0125
					C64	0.1889	0.0117
					C65	0.1937	0.0110

Then, with the index scoring questionnaire, as shown in Appendix A, the expert score of each bottom index can be obtained, and the evaluation scores of other indexes can be obtained based on the Equation (9), as shown in Table 4.

Table 4. The evaluation results of power generation equipment IIP.

First Level Index	Same Level Weight	Evaluation Score	Second Level Index	Same Level Weight	Evaluation Score	Third Level Index	Same Level Weight	Expert Score
A1	0.2515	47.9617	B1	0.3358	35.008	C1	0.2504	50
						C2	0.2531	30
						C3	0.2533	30
						C4	0.2432	30
			B2	0.3309	29.997	C5	0.1673	30
						C6	0.1537	30
						C7	0.1456	30
						C8	0.1456	30
						C9	0.1374	30
						C10	0.1306	30
						C11	0.1197	30
			B3	0.3333	78.848	C12	0.3053	60
						C13	0.3371	100
						C14	0.3576	75
A2	0.2573	66.4115	B4	0.1393	99.99	C15	0.3396	100
						C16	0.3269	100
						C17	0.3334	100
			B5	0.1357	79.145	C18	0.5829	100
						C19	0.4171	50
			B6	0.1146	100	C20	0.2515	100
						C21	0.2576	100
						C22	0.2559	100
						C23	0.2350	100
			B7	0.1319	47.175	C24	0.2541	30
						C25	0.2631	30
						C26	0.2373	30
						C27	0.2454	100
			B8	0.1141	46.19	C28	0.3442	30
						C29	0.3320	30
						C30	0.3238	80
			B9	0.1157	66.228	C31	0.2090	100
						C32	0.2016	50
						C33	0.2031	30
						C34	0.1895	50
						C35	0.1968	100
			B10	0.1215	53.328	C36	0.3385	30
						C37	0.3281	30
						C38	0.3333	100
			B11	0.1271	36.572	C39	0.3381	30
						C40	0.3333	30
						C41	0.3286	50
A3	0.2401	59.4589	B12	0.2585	50	C42	0.5714	50
						C43	0.4286	50
			B13	0.2575	83.19	C44	0.3340	70
						C45	0.3395	80
						C46	0.3265	100
			B14	0.2399	30	C47	0.3566	30
						C48	0.3199	30
						C49	0.3235	30
			B15	0.2441	73.394	C50	0.3349	80
						C51	0.3333	100
						C52	0.3318	40

Table 4. *Cont.*

First Level Index	Same Level Weight	Evaluation Score	Second Level Index	Same Level Weight	Evaluation Score	Third Level Index	Same Level Weight	Expert Score
A4	0.2510	41.4859	B16	0.2653	34.894	C53 C54 C55 C56	0.2656 0.2383 0.2514 0.2447	30 30 30 50
			B17	0.2522	41.538	C57 C58	0.5769 0.4231	50 30
			B18	0.2370	50	C59 C60	0.5573 0.4427	50 50
			B19	0.2456	40.32	C61 C62 C63 C64 C65	0.2049 0.2105 0.2021 0.1889 0.1937	50 50 50 50 0
Total score	53.839		—	—	—	—	—	—

In Table 4, the total evaluation score of the power generation equipment IIP is 53.839 points. According to the evaluation grade, the application level and performance of the power generation equipment IIP is C level. It shows that the enterprise has carried out relatively perfect strategic formulation and organizational arrangement; the basic conditions are basically perfect; the key equipment and core business are realized on the cloud; the competitiveness of the enterprise has been significantly improved; and obvious results have been achieved in improving quality, reducing cost, and increasing efficiency.

In addition, in the evaluation scores, the platform technology capability has the highest score (A2 = 66.4115), indicating that the platform has relatively strong technical capability, while the platform application service capability (A3 = 59.4589) should be enhanced, and the indexes that need to be improved are the platform basic condition (A1 = 47.9617) and the platform input–output capability (A4 = 41.4859).

For the first-level index A1, the corresponding second-level indexes that should be increased include, in particular, the industrial equipment connection ability (B1 = 35.008) and the industrial product connection ability (B2 = 29.997), which are specifically reflected in the third-level indexes, such as the connection number of the processing equipment (C1 = 50), logistics equipment (C2 = 30), quality inspection equipment (C3 = 30), and other equipment (C4 = 30), and the wind power generator set (C5 = 30), photovoltaic generator set (C6 = 30), thermal power generator set (C7 = 30), gas power generator set (C8 = 30), water power generator set (C9 = 30), nuclear power generator set (C10 = 30), and other units (C11 = 30). So, these connection numbers of the equipment and products should be increased.

For the first-level index A2, the corresponding second-level indexes that need to be improved are the developer management ability (B11 = 36.572), the industrial microservice ability (B8 = 46.19), the industrial knowledge precipitation and reuse ability (B7 = 47.175), and the user management ability (B10 = 53.328). In addition, these weaknesses are reflected in third-level indexes including the number of business process models (C24 = 30), industry mechanism models (C25 = 30), data algorithm models (C26 = 30), general microservice components (C28 = 30), dedicated microservice components (C29 = 30), registered users (C36 = 30), paid users (C37 = 30), third-party developers (C39 = 30), third-party active developers (C40 = 30), and developer operation management (C41 = 50).

For the first-level index A3, the corresponding second-level indexes that need improvement include the inter-platform invocation service (B14 = 30) and the storage computing service (B12 = 50), which are reflected in third-level indexes including the computing capability (C42 = 50) and storage capability (C43 = 50), the number of cross-platform invocation models (C47 = 30), the cross-platform invocation microservices (C48 = 30), and the cross-platform invocation APPs (C49 = 30).

For the first-level index A4, all the second-level and third-level indexes should be improved, including the platform research and development investment (B16 = 34.894), the platform output benefit (B17 = 41.538), the platform application effect (B18 = 50), and the platform competitiveness (B19 = 40.32), as well as the number of salespersons (C53 = 30), development persons (C54 = 30), and maintenance persons (C55 = 30), as well as the number of industries covered by the platform (C58 = 30) and other third level indexes, especially the emergency response (C65 = 0), to which there should be paid more attention.

In a word, the above results can help enterprise to identify its own shortcomings and take targeted measures to improve the application level and performance of IIP in the power generation equipment industry.

5. Conclusions

The development of China's IIP has entered a critical period; so, in order to ensure the sustained and stable development and effective economic benefits of the IIP, it is crucial to evaluate the application and performance of the IIP. Therefore, taking a power generation equipment IIP as the research object, an evaluation index system of the application and performance for the power generation equipment IIP is proposed in this paper via four dimensions, including 19 aspects and 65 bottom indexes. During the evaluation process of the IIP, the FAHP is used to construct the fuzzy judgement matrix, and PSO is designed to adjust the fuzzy judgement matrices that do not meet the consistency condition in the FAHP; thus, it is used to determine the weights of the indexes. Then, based on the expert scores obtained from the questionnaire survey, evaluation results are calculated, and the total evaluation score of the power generation equipment IIP is 53.839 points, which belongs to C level, indicating that the overall level of the application and performance of this power generation equipment IIP should be improved. In addition, according to the calculation results, the important indexes are pointed out, such as the indexes A2, B1, B2, B3, B12, B13, B16, B17, B19, C14, C42, C57, C59, etc. In addition, the weak points that need to be improved are also identified. For the index A1, sub-indexes such as B1, B2, C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11 should be improved. For the index A2, the sub-indexes that need improvement include B7, B8, B10, B11, C24, C25, C26, C28, C29, C36, C37, C39, C40, C41. For the index A3, the sub-indexes that need to be enhanced include B12, B14, C42, C43, C47, C48, C49. For the index A4, all the sub-indexes need improvement, including B16~B19 and C53~C65.

So, through the application and performance evaluation of the IIP in the power generation equipment industry via the proposed method, the challenges and limitations faced in the application of the IIP in the power generation equipment industry can be found, and potential solutions to these challenges can be provided. In addition, the evaluation method proposed in this paper presents significant guidance in the analysis of similar problems.

Therefore, based on the evaluation index system, the application and performance of the power generation equipment IIP can be defined and quantified, and by using of the FAHP and PSO methods, the application effect of the power generation equipment IIP can be measured and monitored in order to guide the improvement of the power generation equipment IIP so as to ensure the sustainable development of the power generation equipment industry.

Furthermore, the application and performance evaluation of the IIP in the power generation equipment industry can accelerate the promotion of energy revolution and promote the green and low-carbon transformation of power generation equipment enterprises to realize the "dual carbon" target, thus finally achieving green and sustainable development.

In the future, to achieve the stable development and effective benefits of power generation equipment IIP enterprises, this project will consider analyzing more power generation equipment IIPs to reflect the overall performance and development trends of the power generation equipment industry and will use a subjective and objective combination weight method to evaluate the application effect of IIPs in the power generation equipment industry.

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Appendix A

Table A1. Evaluation content and scoring criteria for power generation equipment IIP.

Third Level Index	Evaluation Content	Scoring Criteria/Point
C1: Connection number of processing equipment	A. Connection number $\leq$ 100 B. Connection number in 100~500 C. Connection number in 500~1000 D. Connection number $\geq$ 1000	A = 30 B = 50 C = 80 D = 100
C2: Connection number of logistics equipment	A. Connection number $\leq$ 100 B. Connection number in 100~500 C. Connection number in 500~1000 D. Connection number $\geq$ 1000	A = 30 B = 50 C = 80 D = 100
C3: Connection number of quality inspection equipment	A. Connection number $\leq$ 50 B. Connection number in 50~100 C. Connection number in 100~500 D. Connection number $\geq$ 500	A = 30 B = 50 C = 80 D = 100
C4: Connection number of other equipment	A. Connection number $\leq$ 500 B. Connection number in 500~1000 C. Connection number in 1000~2500 D. Connection number $\geq$ 2500	A = 30 B = 50 C = 80 D = 100
C5: Connection number of wind power generator set	A. Connection number $\leq$ 10,000 B. Connection number in 10,000~20,000 C. Connection number in 20,000~50,000 D. Connection number $\geq$ 50,000	A = 30 B = 50 C = 80 D = 100
C6: Connection number of photovoltaic generator set	A. Connection number $\leq$ 10,000 B. Connection number in 10,000~20,000 C. Connection number in 20,000~50,000 D. Connection number $\geq$ 50,000	A = 30 B = 50 C = 80 D = 100
C7: Connection number of thermal power generator set	A. Connection number $\leq$ 1000 B. Connection number in 1000~2000 C. Connection number in 2000~5000 D. Connection number $\geq$ 5000	A = 30 B = 50 C = 80 D = 100
C8: Connection number of gas power generator set	A. Connection number $\leq$ 500 B. Connection number in 500~1000 C. Connection number in 1000~1500 D. Connection number $\geq$ 1500	A = 30 B = 50 C = 80 D = 100

Table A1. *Cont.*

Third Level Index	Evaluation Content	Scoring Criteria/Point
C9: Connection number of water power generator set	A. Connection number $\leq$ 100 B. Connection number in 100~250 C. Connection number in 250~500 D. Connection number $\geq$ 500	A = 30 B = 50 C = 80 D = 100
C10: Connection number of nuclear power generator set	A. Connection number $\leq$ 15 B. Connection number in 15~30 C. Connection number in 30~50 D. Connection number $\geq$ 50	A = 30 B = 50 C = 80 D = 100
C11: Connection number of other units	A. Connection number $\leq$ 1000 B. Connection number in 1000~2500 C. Connection number in 2500~5000 D. Connection number $\geq$ 5000	A = 30 B = 50 C = 80 D = 100
C12: New generation information communication technology	The new generation of information communication technologies of enterprise application include (multi-choice): A. NB-IoT B. SDN C. 5G D. Wifi6 E. TSN F. PON G. IPv6	50 points for 2 items; add 1 item and add 10 points
C13: Number of compatible adaptations for industrial protocol	A. Platform compatible with 10 industrial protocols B. Platform compatible with 20 industrial protocols C. Platform compatible with 30 industrial protocols D. Platform compatible with 50 industrial protocols	A = 30 B = 50 C = 80 D = 100
C14: Platform gateway adaptation capability	Adaptability of various gateways adopted by the platform (multi-choice): A. Developing a protocol conversion and parsing module, and integrating it into the platform edge to ensure the platform's adaptability and high integration level B. Adopting mature protocol conversion and parsing modules, supporting mainstream universal protocol parsing, and improving the platform's universal adaptation ability C. Following multiple common protocols D. Supporting customized development of data conversion and transmission solutions based on user needs	Each item amounts to 25 points
C15: Platform infrastructure construction mode	A. The infrastructure of the platform is self -building B. The infrastructure of the platform belongs to rental, such as Alibaba Cloud, Tencent Cloud, Huawei Cloud, etc.	A = 100 B = 50
C16: Platform operation mode	A. Independent operation B. Non independent operation	A = 100 B = 50
C17: Platform intellectual property rights	A. Platform owned intellectual property rights B. Shared intellectual property rights with third party C. The platform does not have its own intellectual property rights	A = 100 B = 50 C = 30
C18: Edge data processing capability	The main functions that edge processing solutions can support (multi-choice): A. Data collection B. Data storage C. Network transmission D. Intelligent analysis	Each item amounts to 25 points

Table A1. *Cont.*

Third Level Index	Evaluation Content	Scoring Criteria/Point
C19: Edge data response delay	The minimum response delay: A. Over 50 milliseconds B. 10~50 milliseconds C. 1~10 milliseconds D. Less than 1 millisecond	A = 30 B = 50 C = 80 D = 100
C20: Data management measure	The relevant measures implemented by enterprise around data regulatory management include (multi-choice): A. Data quality management B. Data classification and hierarchical management C. Data integration management D. Data standardization management E. Metadata management	Each item amounts to 20 points
C21: Data management scope	The management scopes around data regulatory management include (multi-choice): A. Research and design data B. Production and manufacturing data C. Operation and management data D. Product service data	Each item amounts to 25 points
C22: Heterogeneous data conversion	The supported data types for heterogeneous data conversion include (multi-choice): A. Structured data B. Semi-structured data C. Unstructured data	One item amounts to 50 points, two items amount to 80 points, and three items amount to 100 points
C23: Big data application ability	Based on the IIP, the industrial big data mining and application capabilities include (multi-choice): A. Utilizing IIP to achieve cloud-based classification and hierarchical storage of various types of data such as enterprise research and development, production, operation, and services B. Using the relevant tools provided by the IIP for data collection, cleaning, mining analysis, data visualization and other work C. Relying on IIP for correlation analysis between enterprise data and external data, achieving innovative application and open sharing of data D. Relying on the component tools provided by the IIP to build big data applications in specific scenarios	Each item amounts to 25 points
C24: Number of business process models	A. Number $\leq$ 50 B. Number in 50~100 C. Number in 100~250 D. Number $\geq$ 250	A = 30 B = 50 C = 80 D = 100
C25: Number of industry mechanism models	A. Number $\leq$ 50 B. Number in 50~100 C. Number in 100~250 D. Number $\geq$ 250	A = 30 B = 50 C = 80 D = 100
C26: Number of data algorithm models	A. Number $\leq$ 50 B. Number in 50~100 C. Number in 100~250 D. Number $\geq$ 250	A = 30 B = 50 C = 80 D = 100
C27: Number of other models	A. Number $\leq$ 50 B. Number in 50~100 C. Number in 100~250 D. Number $\geq$ 250	A = 30 B = 50 C = 80 D = 100

Table A1. *Cont.*

Third Level Index	Evaluation Content	Scoring Criteria/Point
C28: Number of general microservice components	A. Number $\leq$ 25 B. Number in 25~50 C. Number in 50~100 D. Number $\geq$ 100	A = 30 B = 50 C = 80 D = 100
C29: Number of dedicated microservice components	A. Number $\leq$ 25 B. Number in 25~50 C. Number in 50~100 D. Number $\geq$ 100	A = 30 B = 50 C = 80 D = 100
C30: Microservice development environment and tools	A. No microservices release, invocation environment and tools, industrial microservices are uniformly released by the operator B. Providing microservices release, invocation environment and tools, and supporting relevant parties to release, invoke and optimize microservices online C. Providing microservices release, invocation environment and tools, and supporting relevant parties to conduct full lifecycle management on microservices development, testing, release, invocation, optimization, and other links online	A = 50 B = 80 C = 100
C31: Industrial APP types	Various industrial APPs provided based on cloud computing service architecture include (multi-choice): A. Safety production industry APP B. Quality control industry APP C. Designing industry APP D. Operation management industry APP E. Maintenance service industry APP F. Energy-saving and emission reduction industry APP G. Supply chain management industry APP H. Manufacturing industry APP I. Warehousing and logistics industry APP	One item amounts to 20 points; add one item and add 10 points.
C32: Number of industrial APPs	A. Number $\leq$ 50 B. Number in 50~100 C. Number in 100~250 D. Number $\geq$ 250	A = 30 B = 50 C = 80 D = 100
C33: Number of industrial APP subscriptions	A. Number $\leq$ 500 B. Number in 500~1000 C. Number in 1000~2500 D. Number $\geq$ 2500	A = 30 B = 50 C = 80 D = 100
C34: Industrial APP users	The form of using industrial APP by users: A. Customized APP for specific customers based on their needs B. APP designed for specific industry users based on industry common needs C. APP for multiple industries based on common needs across industries	A = 50 B = 80 C = 100
C35: Industrial APP operation management	Supporting the functions of industrial APP include (multi-choice): A. Search B. Authentication C. Transaction D. Running E. Maintenance	Each item amounts to 20 points

Table A1. *Cont.*

Third Level Index	Evaluation Content	Scoring Criteria/Point
C36: Number of registered users	A. Number $\leq$ 500 B. Number in 500~1000 C. Number in 1000~2500 D. Number $\geq$ 2500	A = 30 B = 50 C = 80 D = 100
C37: Number of paid users	A. Number $\leq$ 100 B. Number in 100~250 C. Number in 250~500 D. Number $\geq$ 500	A = 30 B = 50 C = 80 D = 100
C38: Registered user management	The functions that can support registered enterprise management include (multi-choice): A. User rights management B. User requirements management C. Transaction management D. User maintenance	Each item amounts to 25 points
C39: Number of third-party developers	A. Number $\leq$1000 B. Number in 1000~5000 C. Number in 5000~10,000 D. Number $\geq$10,000	A = 30 B = 50 C = 80 D = 100
C40: Number of third-party active developers	A. Number $\leq$100 B. Number in 100~500 C. Number in 500~1000 D. Number $\geq$1000	A = 30 B = 50 C = 80 D = 100
C41: Developer operation management	The functions that support developers include (multi-choice): A. Requirements release and acquisition B. Application development, testing, and release C. Knowledge and resource sharing D. Communication and interaction E. Network marketing F. Technical support	One item amounts to 50 points; add one item and add 10 points
C42: Computing capability	A. CPU resources $\leq$ 500 cores B. CPU resources in 500~1000 cores C. CPU resources in 1000~2500 cores D. CPU resources $\geq$ 2500 cores	A = 30 B = 50 C = 80 D = 100
C43: Storage capability	A. Storage capability $\leq$ 100 TB B. Storage capability in 100 TB~1 PB C. Storage capability in 1 PB~10 PB D. Storage capability $\geq$ 10 PB	A = 30 B = 50 C = 80 D = 100
C44: Supportable application development languages	The application development languages supported by the platform include (multi-choice): A. Java B. C++ C. C# D. PHP E. Python F. Ruby	One item amounts to 50 points; add one item and add 10 points
C45: Supportable application management links	Supportable application management links include (multi-choice): A. Development B. Test C. Simulation D. Implementation E. Running and scheduling F. Optimization function G. None of the above	From A to F, one item amounts to 50 points; add one item and add 10 points If G, then add 0 points

Table A1. *Cont.*

Third Level Index	Evaluation Content	Scoring Criteria/Point
C46: Supportable application development measures	Supportable application development measures include (multi-choice): A. Supporting the use of visual drag and drop method for application development B. Supporting the application development based on source code C. None of the above	For A and B, each item amounts to 50 points If C, then add 0 points
C47: Number of cross-platform invocation models	A. Number $\leq$ 500 B. Number in 500~1000 C. Number in 1000~2500 D. Number $\geq$ 2500	A = 30 B = 50 C = 80 D = 100
C48: Number of cross-platform invocation microservices	A. Number $\leq$ 500 B. Number in 500~1000 C. Number in 1000~2500 D. Number $\geq$ 2500	A = 30 B = 50 C = 80 D = 100
C49: Number of cross-platform invocation APPs	A. Number $\leq$ 500 B. Number in 500~1000 C. Number in 1000~2500 D. Number $\geq$ 2500	A = 30 B = 50 C = 80 D = 100
C50: Platform information security system	Construction of platform information security system: A. No information security system B. Information security system has established preliminarily that covers some aspects and fields of information security protection, and information security incidents occur sometime C. Information security system has established basically, covering key links and main areas of information security protection, and effectively controlling information security incidents D. Establishing a comprehensive information security system that covers all aspects and fields of information security protection, and no information security incidents have occurred in the past three years	A = 30 B = 50 C = 80 D = 100
C51: Platform data security technology	The platform data security technologies include (multi-choice): A. User identification and authentication technology B. Access control technology C. View mechanism technology D. Audit log maintenance technology E. Data encrypt technology	Each item amounts to 20 points
C52: Platform network security protection technology	Platform network security protection technologies include (multi-choice): A. Carrying out network security management by setting up firewalls, network isolation, etc. B. Implementing network information transmission security management through encryption, authentication, etc. C. Implementing network security hazard protection through vulnerability scanning, intrusion detection, etc. D. Security protection of network and host system through Antivirus software E. Proactive network security protection through intrusion tracking, attack absorption and transfer, honeypot, forensics, and automatic counterattack, etc.	Each item amounts to 20 points

Table A1. *Cont.*

Third Level Index	Evaluation Content	Scoring Criteria/Point
C53: Number of salespersons	A. Number $\leq$ 20 B. Number in 20~50 C. Number in 50~100 D. Number $\geq$ 100	A = 30 B = 50 C = 80 D = 100
C54: Number of development persons	A. Number $\leq$ 100 B. Number in 100~250 C. Number in 250~500 D. Number $\geq$ 500	A = 30 B = 50 C = 80 D = 100
C55: Number of maintenance persons	A. Number $\leq$ 20 B. Number in 20~50 C. Number in 50~100 D. Number $\geq$ 100	A = 30 B = 50 C = 80 D = 100
C56: Cumulative investment amount of the platform	A. Investment amount $\leq$ 50 million RMB B. Investment amount in 50 ~100 million RMB C. Investment amount in 100~500 million RMB D. Investment amount $\geq$ 500 million RMB	A = 30 B = 50 C = 80 D = 100
C57: Number of platform solutions	A. Number $\leq$ 15 B. Number in 15~30 C. Number in 30~50 D. Number $\geq$ 50	A = 30 B = 50 C = 80 D = 100
C58: Number of industries covered by the platform	A. Number $\leq$ 5 B. Number in 5~10 C. Number in 10~15 D. Number $\geq$ 15	A = 30 B = 50 C = 80 D = 100
C59: Cumulative revenue amount of the platform	A. Revenue amount $\leq$ 10 million RMB B. Revenue amount in 10 ~50 million RMB C. Revenue amount in 50~100 million RMB D. Revenue amount $\geq$ 100 million RMB	A = 30 B = 50 C = 80 D = 100
C60: Return on investment of the platform	A. Return on investment $\leq$ 5% B. Return on investment in 5%~10% C. Return on investment in 10%~20% D. Return on investment $\geq$ 20%	A = 30 B = 50 C = 80 D = 100
C61: Research and development capability	The average shortening rate of new product development cycle after applying IIP in enterprises is: A. Shortening rate $\leq$ 5% B. Shortening rate in 5%~10% C. Shortening rate in 10%~20% D. Shortening rate $\geq$ 20%	A = 30 B = 50 C = 80 D = 100
C62: Equipment efficiency	After applying IIP in enterprises, the average utilization rate of equipment has increased: A. Increasing rate $\leq$ 5% B. Increasing rate in 5%~10% C. Increasing rate in 10%~20% D. Increasing rate $\geq$ 20%	A = 30 B = 50 C = 80 D = 100
C63: Product quality	After applying IIP in enterprises, the average increasing rate of product quality is: A. Increasing rate $\leq$ 5% B. Increasing rate in 5%~10% C. Increasing rate in 10%~20% D. Increasing rate $\geq$ 20%	A = 30 B = 50 C = 80 D = 100

Table A1. *Cont.*

Third Level Index	Evaluation Content	Scoring Criteria/Point
C64: Service level	After applying IIP in enterprises, the on-time delivery rate of orders has increased: A. Increasing rate $\leq$ 5% B. Increasing rate in 5%~10% C. Increasing rate in 10%~20% D. Increasing rate $\geq$ 20%	A = 30 B = 50 C = 80 D = 100
C65: Emergency response	The emergency response capabilities after enterprises applying IIP include (multi-choice): A. Capable of dynamically monitoring and risk warning the operational situation of enterprises and industrial chains B. Relying on the platform to quickly organize various resources and make emergency response to sudden events C. Relying on the platform to meet special strategic needs and achieve rapid and flexible production transition D. None of the above	From A to C, one item amounts to 50 points; two items amount to 80 points, and three items amount to 100 points If D, then add 0 points

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