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Enterprise intelligent procurement management model exploration

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【Abstract】 With the development of big data analysis, blockchain and other technologies, the supply chain of enterprises is transforming to lean and intelligent. As an important link in the enterprise supply chain, the intelligent transformation of procurement plays an important role in the improvement of the supply chain efficiency, therefore, the construction of a common method supporting the intelligent upgrade of the enterprise procurement business has become a key concern for enterprise managers. Based on the balanced scorecard theory and the supply chain maturity model, this study combines the actual situation of procurement management in Chinese energy enterprises and constructs a procurement benchmarking system that balances the development direction of the industry and the actual needs of enterprises. Meanwhile, based on the grounded theory, three major themes of the intelligent procurement system (digital business module, procurement synergy mechanism and procurement ecosystem) are extracted to provide a methodological reference for the construction of intelligent procurement systems of energy enterprises. The study concludes with a case study of China National Energy Group Materials Company to demonstrate the application of the intelligent procurement system built in this paper, with a view to providing methodological reference for the intelligent procurement management in energy enterprises.

【Keywords】 Intelligent Procurement; Supply Chain; Procurement Ecosystem; Energy Business Procurement

1 Introduction

Procurement, as a key link in the production and operation of an enterprise, occupies an unparalleled position in the enterprise. The procurement of materials for an enterprise includes the procurement of materials and services needed to conduct business. Procurement management is the implementation of scientific and effective management of the whole procurement process, and thus reduce the production and operating costs of enterprises, accelerate the flow of funds, optimize the allocation, increase the profitability of enterprises, thereby enhancing the efficiency of enterprise business processing, and promote sustainable development[1]. Currently, the digital transformation of Chinese enterprises is in full swing, which is conducive to the optimization of the industrial landscape and the modernization of the industrial chain, helping the deep integration of the digital economy and the real economy, and promoting high-quality economic development. In this new era, strengthening the intrinsic linkage between information technology and production operations, accelerating the construction of intelligent procurement, and promoting the formation of " intelligent enterprises" to help companies grow sustainably have become important issues for energy enterprises[2].

In addition, in the process of information technology to promote the transformation and development of the supply chain, the traditional material management model has gradually failed to meet the needs of the times[3], with a series of drawbacks such as lax supervision, unclear authority and responsibility, outdated procurement methods, lack of an overall material procurement plan, procurement management system, etc., which are also forcing energy enterprises to carry out intelligent procurement[4-6].

At the same time, some enterprises have succeeded in digital transformation and applied the concept of intelligent procurement in practice, and their experience is worth learning from[7].

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Therefore, we must take these first-class enterprises as benchmarks and carry out benchmarking management, compare, analyze, and evaluate them from all aspects with benchmark enterprises, improve our shortcomings by learning others' advanced experiences, to catch up with the benchmark enterprises and achieve a virtuous cycle of excellent performance, which helps enterprises to become bigger and stronger.

In summary, the research questions of this paper are:

RQ1： How to build a benchmarking system and help enterprises to manage benchmarking so that they can accurately evaluate their own operation level in the industry?

RQ2：How can companies in the energy industry establish a scientific and efficient intelligent procurement system?

2 Literature Review

2.1 Balanced Scorecard

The balanced scorecard is a strategy-focused business management tool that helps companies to effectively manage performance with clear advantages and significant results. The balanced scorecard dismantles the strategic objectives of a company in multiple dimensions, implements them into actionable and measurable indicators and target values in four dimensions: finance, customers, internal operational processes, and learning and growth, and implements strategic planning through charts, cards, and tables. Paul R. Niven discusses in detail how to reasonably construct a balanced scorecard performance management system[8].

Current research by scholars focuses on solving the problem of how to use the balanced scorecard to develop an appraisal system to improve corporate performance. Ali analyzed the existing index appraisal of the company from the perspective of a balanced scorecard and redesigned the performance appraisal index of the company[9]. Agostino creatively combined economic value added with a balanced scorecard and applied it to the existing performance appraisal system of the company[10]. Kevin took a British bank as a case study and combined a balanced scorecard and core competitiveness theory with the existing performance appraisal system, through which the new performance appraisal system could achieve the improvement of the bank's comprehensive competitive strength.

Abdullah and Alharbi et al. made specific analyses on the feasibility of applying the balanced scorecard in banks and securities companies, respectively, and carried out the optimization of performance evaluation based on the balanced scorecard[11-13].

At the same time, scholars have conducted relevant studies on the setting of performance appraisal indicators under the guidance of balanced scorecard theory. In his study, Afriliana pointed out that the index design of performance management should be scientific, standardized and refined to enhance authority[14]. Sainaghi argued that the setting of performance indicators should be considered in an integrated manner according to the nature of the position, evaluated comprehensively in terms of the performance of functions and the completion of quantitative indicators to be objective and effective, and new performance appraisal indicators should be set according to the adjustment of institutional functions to ultimately improve the efficiency of performance management and help the realization of corporate strategies[15].

2.2 Supply Chain Maturity

Supply chain management maturity is an important index to measure the level and capability of supply chain management, and it analyzes and describes the supply chain from different management perspectives, management levels, and management objects to form a comprehensive supply chain management performance evaluation system which derives the key factors that restrict the operation of the whole supply chain, and analyzes the efficiency, effectiveness and efficacy brought by management inputs, thus helping the supply chain to be dynamically optimized.

Research on supply chain maturity is currently focused on the construction of maturity models, and the management consulting firm PRTM proposed the PMG supply chain maturity model in 2001, reflecting the relationship between enterprise supply chain performance and operational capabilities at different stages[16-17]. Gartner, an international consulting firm, proposed a demand-driven value network maturity model based on the DDVN model system in

2003, which divides supply chain maturity into five maturity stages: passive-responsive, internal functional division, integrated, demand-driven value network, and network value creation, and the maturity of these five stages increases in turn, and accordingly, the supply chain operational capability of enterprises are also stronger[18]. Kevin McCormak in 2004 proposed a supply chain business process maturity model in his study of supply chain management maturity models, which analyzed the relationship between business processes and supply chain performance by landing on coordinated organizations and business processes formed by strategic partners with an emphasis on competition[19-21]. The institute for Business Value investigated the supply chain evolution and transformation process of leading companies in the industry and proposed the IBM supply chain maturity model for continuous improvement in 2005, which is used to measure the degree of customer centricity and responsiveness of the supply chain and the supply chain process integration strategies under different stages[22-24]. According to the above research on the construction of supply chain maturity model, it can be found that business process and supplier relationship are important measurement factors for supply chain performance evaluation, which provides a reference basis for the construction of the subsequent evaluation system in this paper.

2.3 Grounded Theory

Grounded theory is a qualitative research method that uses a systematic procedure to develop and generalize a certain theory by reasoning, comparison, hypothesis testing, and theory construction for a certain phenomenon, which is based on systematic collection of data to find the core concepts that reflect the essence of the phenomenon, and then constructs a relevant social theory through the connections between these concepts.

Grounded theory has a complete set of operational processes. Anselm Strauss et al. proposed a "six-step" process for the grounding process, which consists of theoretical sampling, data collection, coding the data and generating concepts from them - repeated comparisons between data, forming theoretical concepts and establishing connections between concepts, constructing theories and judging them. Anselm-Strauss et al. proposed a "six-step" grounding process, which is as follows: theoretical sampling - data collection - coding of data and generating concepts from them - repeated comparisons between data, concepts, and data-concepts - forming theoretical concepts and establishing connections between concepts - constructing theory and evaluate it. Andreas proposed a "five-stage" approach to grounded theory, as follows: research design (define the research question and the sampling scope through literature review and sample selection) - data collection (collect relevant cases or samples) - data sorting - data analysis (code the data at three levels and refine the corresponding theory) --Literature comparison[25]. Despite the different stages of division, these are only differences in operational procedures. In summary, grounded theory can be roughly divided into four parts: clarifying the problem, data collection, data analysis, and theoretical description.

Meanwhile, as the development of the grounded theory becomes more and more mature, its application in the Internet, medical care and education has become more extensive. Guided by the grounded theory approach, Thelen conducted an inductive analysis and relational sorting of factors influencing the information interaction behavior of academic APP users through open coding, spindle coding and selective coding[26-27]. Deng Huilan, on the other hand, took applets as the research object, explored the marketing dimensions of collocation applets and constructed a framework model for the realization of marketing innovation using the grounded theory research method[28]. Ryuichi Ohta analyzed the relationship between health care professionals and patients using grounded theory, and found that conflict management, regulation through participation, and seamless care were the three main ways to effectively ease the relationship[29-32]. Gina Laura Gullo, on the other hand, used six Mid-Atlantic principals as subjects in a study that used explicit coding and analytical procedures using grounded theory to explore the extent to which factors such as principals' personal biases and preferences influence disciplinary decision-making as a process[33].

3 Methodology

In this study, the construction of an intelligent procurement system can be divided into three steps. The first step is to build a benchmarking index system by combining the balanced scorecard theory and the supply chain maturity model, the second step is to set the corresponding evaluation

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criteria for benchmarking analysis, and the last step is to propose a plan for the construction of the company's intelligent procurement system by combining the benchmarking results with the development direction of intelligent procurement. The specific steps are described as follows:

STEP1：Construction of material procurement benchmarking index system based on balanced scorecard

The selection of benchmarking indicators need to reflect the actual needs of enterprises, so in the selection of indicators, this study summarizes the five key points of procurement management through expert interviews: procurement cost control, perfect procurement system, set up professional procurement team, build a whole life cycle management system of suppliers, and procurement quality control. The benchmarking indexes are selected from four dimensions: cost, process, suppliers, and procurement team. The benchmarking index system of procurement management was constructed as shown in Table 1 below.

Table 1 Procurement management benchmarking index system

Benchmarking dimension	Benchmarking index
Procurement cost control	Procurement cost control
Procurement process management	Procurement process informatization level
	Procurement process standardization level
Supplier management	Supplier relationship management
	Daily management of suppliers
	Supplier procurement sustainability
Procurement team building	Procurement staff training
	Procurement team performance appraisal

STEP2: Determination of material procurement benchmarking criteria based on supply chain maturity model

After constructing the procurement management benchmarking index system, this step establishes corresponding evaluation criteria for each index in the system, so that enterprises can position their own material procurement level. When setting the benchmarking method, two evaluation methods are set for the type of indicators. For the indicator of procurement cost control, the method of competitive benchmarking or functional benchmarking is used. For the three types of indicators of procurement process management, supplier management and procurement team building, supply chain maturity evaluation is adopted. The maturity evaluation model adopted in this benchmarking is based on the existing theoretical model, combined with the company's material procurement management concerns, and the evaluation results are divided into five levels: figuring out level (I level), standardization level (II level), control level (III level), optimization level (IV level) and integration level (V level). The evaluation criteria are set according to the content of indicators. The specific benchmarking system evaluation criteria are shown in Table 2 below.

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Table 2 Evaluation criteria for benchmarking system

Serial number	Indicator name	Indicator definition and purpose of setting	Data source	Benchmarking methods and standards
1	Procurement cost control	The control of costs related to procurement of raw materials and components, including purchase order costs, management costs of procurement planning staff, and management costs of procurement staff, etc. To measure the reasonableness of the company's procurement cost control	Company's annual report and related information Competitive	benchmarking/functional benchmarking ① Competitive benchmarking: benchmarking cost control related practices with direct competitors. ② Functional benchmarking: benchmarking cost control practices with companies in the same industry but not in the same market.
2	Procurement process informationization level	Aiming to measure the digitalization of the company's procurement process and the company's ability to share information (including planning management, supplier management informationization and platform integration)	Actual research and relevant company information	Supply chain maturity evaluation Mapping level (Level I): Procurement materials have numbers Standardization level (Level II): Procurement materials have unique numbers Control level (Level III): Information of materials is incorporated into standardized management, ensuring smooth information channels and making full use of various means to strengthen cooperation with suppliers. Optimization level (IV level): Material codes automatically flow in the system after the first input, and a scientific and reasonable information management mechanism has been established. Integration level (V level): The information of purchasing materials is connected with the information of customers and the information of suppliers.
3	Procurement process standardization level	Aiming to measure the degree of standardization and standardization of the company's process	Actual research and relevant information of the company	Supply chain maturity evaluation Fumbling level (Level I): No standardized business standards and much manual intervention Standardization level (Level II): standardized management within the department Control level (III): standardized processes between departments of the company Optimization level (IV): business processes between enterprises and partners are standardized Integration level (V): Automatic adjustment of production, procurement and logistics plans according to customer needs, standardization and synergy of business processes

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4	Supplier relationship management	Aiming to measure the degree of cooperation and supply chain collaboration potential between the company and its suppliers	Actual research and relevant company information	Supply chain maturity evaluation Mapping level (Level I): management at different levels according to different suppliers, with quality and price as the core Standardization level (Level II): We can establish long-term cooperation mechanism with suppliers, safeguard the legitimate rights and interests of suppliers, and trust each other. Control level (III): strictly in accordance with the company's procurement plan, strengthen technical management and quality management, establish a proven quality management system, and understand the various attributes of products Optimization level (IV level): establish good cooperative relationship with suppliers, give full play to the role of both sides, and formulate strategic plans for scientific development in strict accordance with the actual situation of both sides Integration level (V level): strengthen the focus on the supply roll on the management, managers can also participate in the management of the work, and strictly develop a strategic goal plan
5	Daily management of suppliers	Aim to measure the company's daily evaluation and tracking of suppliers	Actual research and relevant company information	Supply chain maturity evaluation Mapping level (Level I): Focused discussion on product quality, quantity and delivery time Standardization level (Level II): Establish feedback mechanism to understand the actual needs of suppliers and ensure the quality and quantity of products Control level (III): actively promote the improvement of product quality, and take various measures to create a favorable external environment for the development of various activities Optimization level (IV): Give full play to the role of suppliers, improve the quality management system, improve the quality of products and control the cost of products within a reasonable range Integration level (V level): understand the actual needs of suppliers, set scientific and reasonable strategic management goals, promote product quality improvement, and improve the development mechanism
6	Supplier procurement sustainability	Aiming to measure the potential of establishing a green and sustainable modern supply chain between the company and suppliers	Actual research and relevant company information	Supply chain maturity evaluation Mapping level (Level I): Not to cooperate with non-compliant suppliers Standardization level (Level II): requires sustainable cooperation with suppliers Control level (Level III): Suppliers are required to strictly follow the requirements of national laws and the internal norms of the industry to clarify their responsibilities

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				and combine social and economic benefits Optimization level (IV): meeting the certification requirements of green procurement and reflecting positive data of "sustainability" in the annual report of the company Integration level (V level): We are a leader in green procurement, green supply chain, and "sustainability", and are regarded as a model by society.
7	Procurement staff training	The company conducts regular training activities for procurement personnel on procurement concepts and professional skills. The purpose is to measure the professionalism of the company's procurement team and the company's management level of procurement personnel.	Actual research and company-related information	Supply chain maturity evaluation Mapping level (Level I): Only induction training for procurement personnel is conducted Standardization level (Level II): Regular general training for procurement personnel Control level (III): Procurement training group is established to help procurement personnel communicate with each other Optimization level (Level IV): There is a complete training system for procurement personnel and training exchanges with other business departments of the company. Integration level (V level): There are exchanges and cooperation with companies of the same type, helping employees to know different procurement systems, focusing on self-improvement of employees and meeting their needs for self-identity.
8	Procurement team performance appraisal	Aiming to measure the comprehensiveness of the company's procurement staff performance appraisal system and the application of performance appraisal results	Actual research and relevant company information	Supply chain maturity evaluation Mapping level (Level I): There is no job description and no clear performance appraisal standard for the procurement team Standardization level (Level II): The procurement team has been set up with job descriptions and corresponding performance assessment standards, but they are not clear enough. Control level (III): clear job descriptions and performance assessment standards have been set, but the differentiation of different roles in the team is not reflected. Optimization level (IV): set up job descriptions and performance assessment standards for different roles in the procurement team according to business needs Integration level (V level): Differentiated job descriptions and performance appraisal standards for the procurement team from the perspective of supply chain optimization

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STEP3: Constructing an intelligent procurement system based on grounded theory

This study proposes the construction of an intelligent procurement system, the proposition initially has no theoretical assumptions, so the method of grounded theory can be used: collection of data - data coding - induction of data - conclusion analysis. The specific implementation steps are as follows: firstly, the relevant data information needed for the study is collected through a variety of ways such as interviews, observations, and network collection; secondly, the original information is processed to refine the core concepts; then similar concepts are refined and summarized, and the core categories are summarized by in-depth analysis and their interrelationships are identified; finally, the corresponding theory is proposed based on the construction of the relevant framework. The iterative coding operation of the obtained information is the key part of this research method, and there are three main coding steps, namely, open, spindle and selective coding.

In open coding, the original data are compared and analyzed according to their original form, and the initial concepts are discovered by open-ended registration of the original data, and the initial concepts are generalized and defined to complete the convergence analysis of the data.

In spindle coding, the original materials, the initial concepts obtained from the primary coding, and the subcategories obtained from the primary coding are "broken up" in the open coding, and then clustered together through the same level of comparative analysis, and then reorganized to form the spindle categories.

In the process of selective coding, the above-mentioned main categories were further analyzed, summarized and inducted, and the relationship between each category was understood in-depth, and the main logic was highlighted, and the core and secondary categories were summarized. Finally, the key themes of the intelligent procurement system are derived, and the theoretical system of intelligent procurement can be constructed accordingly.

4 Case Study

This section applies the three steps in Part III to demonstrate the process of building an enterprise intelligent procurement system, taking China National Energy Group Materials Company as an example.

4.1 Company Profile

China Energy Investment (hereinafter referred to as "CHN Energy") is the world's largest coal supplier, thermal power operator, wind power operator and coal-to-oil and coal chemicals producer. In October 2019, by the general idea of "integrated operation and professional management" in the restructuring and integration plan, CHN Energy reorganized and established a professional material procurement company, with the strategic goal of building a first-class procurement management system and creating a world-class model enterprise. In 2019, the total amount of non-tender procurement of the Group has exceeded 50 billion yuan.

Currently, in order to further improve its own procurement management level and build the company's core competitiveness in procurement, the material company strengthens top-level design, improves institutional mechanisms, optimizes organizational structure, and builds the ability and strength to have the ability to set industry standards and lead the development of the industry based on the standardized construction of procurement, services and processes. At the same time, it takes innovation as the leader, improve the automation level of procurement demand, planning, release and evaluation, promote the construction of intelligent procurement in depth, and actively apply big data and other information technology to build the cockpit of material indexing management, and realize the improvement of material management level.

4.2 CHN Energy Procurement Management Benchmarking

Taking into full consideration the characteristics of the power industry and the nature of enterprises pursuing economic benefits, and considering the comprehensive strength of each energy enterprise company in various aspects, this study selects State Grid Corporation, China Petroleum & Chemical Corporation and Huawei Technologies Co. The benchmarking results are shown in Table 3 below.

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Table 3 Procurement management benchmarking results of material companies

Serial number	Indicator Name	Benchmarking Evaluation	Benchmarking Result
1	Procurement cost control	State Grid Corporation and Sinopec, as energy state-owned enterprises, adopt the way that the headquarter makes plans and the material department purchases to meet the demand, which greatly controls the material procurement cost. Huawei, as a private enterprise, has set up a procurement management committee and established a material expert group to meet procurement needs.	The company and State Grid, Sinopec are also energy state-owned enterprises, and they all adopt centralized control of material procurement. We can learn from Huawei's material expert group to reduce procurement costs.
2	Procurement process informationization level	In terms of informationization construction, the company has made certain achievements in bidding platform and procurement platform construction, and material procurement information has been incorporated into standardized management and can be passed between platforms to a certain extent. However, at the same time, since the integration of platforms has not yet been reached, the standards between platforms are not fully consistent, so material information needs to be passed through interfaces and relationships are established through mapping such as numbering, which creates certain obstacles to the flow of data between platforms and leads to a lack of synergy between platforms. Therefore, the level of informationization of the company's procurement process is at the control level.	Control level (Level III)
3	Procurement process standardization level	In terms of process standardization, the company has established a number of standards for each business content, and the standardization of work among various departments within the company is high, but from the perspective of modern supply chain construction, the company lacks standard unification with suppliers and other partners. Therefore, the company is at the control level in terms of process standardization.	Control level (Level III)
4	Supplier relationship management	In terms of supplier relationship management, the company has established long-term cooperative relationships with some suppliers by establishing a supplier pool, and the legitimate rights and interests of suppliers are maintained through the development of various standards. However, there is a lack of further grading and classification of suppliers to screen out high-quality suppliers to establish strategic partnership from the perspective of supply chain, so as to reduce the risk of material procurement. At the same time, the way of	Normative level (Level II)

		application of the company's supplier evaluation results needs to be improved, and the refinement of supplier grading and classification according to the importance of materials and the establishment of cooperative relationships with different suppliers are needed, therefore, the company's supplier relationship management is rated at the normative level.	
5	Daily management of suppliers	In terms of daily management of suppliers, the company currently mainly uses the contract as the standard for evaluating the performance of suppliers and evaluating the quality of supplier supply, and has only established a relatively single feedback mechanism and lacks corresponding measures in the daily tracking and evaluation of suppliers. Therefore, the Company's daily management of suppliers is rated at the standard level.	Normative level (Level II)
6	Supplier procurement sustainability	In terms of supplier procurement sustainability, according to the disclosure of the company's annual report, the company has continued to increase its investment in environmental protection in recent years to build a green and low-carbon enterprise, and so far no general or above environmental pollution events as stipulated in the National Emergency Response Plan for Environmental Incidents have occurred, while the company has reduced fuel waste and thus pollution through continuous technological improvement, and the coal-fired units currently under implementation, such as the "ultra-low emission" retrofit, also reflect the company's positive performance in terms of "sustainability". The "ultra-low emission" renovation of coal-fired units currently underway also reflects the company's positive performance in terms of "sustainability". As a result, the company is rated at the Optimization level for the indicator of sustainability of supplier procurement.	Optimization Level (Level IV)
7	Procurement staff training	In terms of training of procurement personnel, according to the company news description, the company has carried out many training activities for procurement personnel in recent years and strived for upstream. However, there are not many inter-company procurement exchange activities, reflecting the company's lack of communication in external procurement business exchange. Therefore, in the indicator of procurement staff training, the company is rated as optimization level.	Optimization Level (Level IV)
8	Procurement team performance appraisal	As for the performance appraisal management of the procurement team, the company has set corresponding appraisal standards for the procurement staff, but the appraisal standards are different from the job description and the actual procurement work, so it is necessary to further set the job description and corresponding performance appraisal standards according to the actual procurement work and the different roles in the procurement team. Therefore, the company's performance appraisal of the procurement team is rated as normative level.	Normative level (Level II)

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Through the analysis of procurement benchmarking results, this study finds that, in general, the procurement management level of the material company is good, with a relatively perfect management framework and corresponding management standards, but there is still some room for improvement compared with the top-ranking enterprises in the industry. Among the four dimensions of procurement cost control, procurement process management, supplier management and procurement team building, the company's performance in two dimensions of supplier management and procurement team building is slightly lower than that in two dimensions of cost control and process management, and there are obvious shortcomings that restrict the overall improvement of the company's material management level.

The company has room for further optimization in procurement cost control and process management, and there are links that need to be filled in supplier management and procurement team building. In the follow-up study, we will propose corresponding solutions to the problems exposed in each dimension and propose a path to improve the procurement management level of the material company.

4.3 Building an Intelligent Procurement System for CHN Energy

4.3.1 Case material coding and keyword extraction

Nvivo 10.0 is a powerful qualitative research software that can create corresponding indexes and allow theorizing on non-numerical, unstructured source material such as text. The software is very helpful for research using grounded theory, enabling the creation of logical relationships and theoretical models through coding and searching. In this paper, we use this software to enter primary materials, code the materials, and test the hypotheses to finally form a theoretical model.

1. Data collection. This study mainly focuses on the management and employees of the procurement department of the material company and adopts online interviews to obtain data. Around three aspects of material company procurement existing problems, intelligent procurement concerns and future intelligent procurement development direction, we investigate deeply into material company to obtain first-hand information of intelligent procurement concerns and process the original information.

2. Open coding. In this phase, the original materials that have been entered into Nvivo 10.0 are analyzed. A total of 75 tags were mined in this phase, and 52 related concepts were summarized from these tags, such as healthcare services, carriers and technological tools, and healthcare development models and platforms. By analyzing and organizing the logical relationships between these concepts, a total of 25 initial categories, such as efficiency of procurement processes, platform integration, and procurement control, were finally obtained and expressed by Nn.

3. Spindle coding. In the second stage, the main axis coding is performed based on the coding results of the previous stage to integrate similar concepts into a unified category and to ensure the mutual exclusivity of the main categories. The above 25 initial categories are further grouped into 7 main categories by principal axis coding, and the results of principal axis coding are shown in Table 4 below.

4. Selective coding. According to the relationship and conceptual hierarchy among the seven main categories in the second stage of spindle coding, they were further classified inductively, and the seven main categories were further categorized into three core categories: digital business module, procurement synergy mechanism, and procurement ecosystem. The correspondence between the core categories and the main categories is shown in Table 5.

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Table 4 Spindle coding process

Number	Main Scope	Initial Scope
1	Efficiency of each procurement process	N_1 process specification, N_{12} manual operation of each procurement process, N_{24} procurement cost
2	Data capture and analysis capability	N_2 manual entry of basic data, N_3 data captur, N_{14} data analysis
3	Platform integration	N_4 procurement e-commerce platform, N_5 cross-platform procurement, N_{15} scale up platform
4	Information communication and sharing	N_6 information communication, N_7 information sharing, N_8 product information, N_{16} supply information, N_{17} inventory cost
5	Procurement control	N_9 work behavior regulation, N_{10} business traceability, N_{18} bid evaluation management, N_{21} procurement supervision
6	Supplier management	N_{19} daily performance tracking, N_{20} supplier evaluation, N_{22} supply quality, N_{23} supplier reward and punishment
7	Corporate talent and culture	N_{11} procurement concept promotion, N_{13} staff training, N_{25} man-job matching

Table 5 Selective coding process

Number	Core scope	Main scope
1	Digital business module	Efficiency of each link of procurement, data capture and analysis capability
2	Procurement synergy mechanism	Platform integration, information communication and sharing, corporate talent and culture
3	Procurement ecosystem	Procurement control, supplier management

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4.3.2 The transformation path of intelligent procurement of CHN Energy

Combined with the three key words of building an intelligent procurement system extracted from the previous grounded theory, based on the actual procurement management of material companies, a perfect intelligent procurement system can be built to help enterprises achieve sustainable development through the three levels of creating digital business modules, building an intelligent procurement synergy mechanism and establishing an intelligent procurement ecosystem.

1. Creating Digital Business Modules

The first step in the intelligent transformation of material management is to lay a solid foundation for the intelligent transformation by combining big data analysis, 5G technology, and blockchain technology with each business module to digitize and visualize business processes and increase the agility of business execution[34].

At this stage, enterprises first need to identify specific business optimization modules (as shown in Figure 1) from the strategy, management, and execution layers, based on actual business requirements. Among them, the strategy level focuses on early warning monitoring, the management level focuses on benefits analysis, and the executive level focuses on efficiency analysis. On this basis, the corresponding business module technology application methods are designed starting from five management links: planning management, procurement management, bid evaluation (assessment) management, contract management, and supplier management.

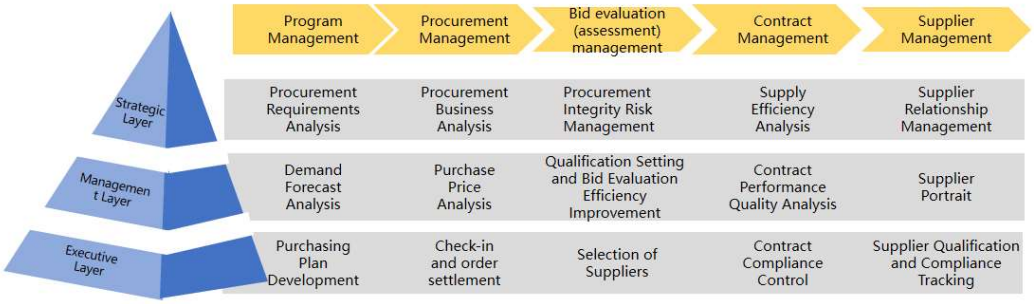

Figure 1 The Main Business Modules of Intelligent Procurement

Plan management process. The reporting of corporate procurement plans varies slightly depending on the procurement implementation model. For centralized procurement, the reporting of enterprise procurement plan often has a fixed time point, and the difficulty of plan management is relatively small. Compared with centralized procurement, decentralized procurement is mostly for small amounts and multi-species procurement, and there is no fixed time limit for the reporting of demand plan, which is more flexible, but it also causes the demand to be more scattered in time and quantity, which increases the procurement cost and decreases the bargaining power of single procurement, thus increases the difficulty for enterprise plan management and restricts the enterprise to realize lean in material procurement. Therefore, the implementation of high level, multi-dimensional forecasting of material demand is a key business module that needs further improvement in the planning and management of enterprises.

Procurement Management. Forbidding procurement, due to the large quantity and amount of procurement, suppliers tend to obtain a competitive advantage by lowering their quotations, but at the same time, to ensure their own profits, they may reduce costs and pose certain risks to procurement quality. For non-tendering procurement, due to the small amount of each order, considering practical factors such as transportation costs, suppliers with regional advantages are more aggressive in quoting, and the dominant position of suppliers in the market has a strong inverse correlation with the aggressiveness of quoting, and the willingness of suppliers with voice or relative monopoly in the market to participate in quoting is relatively weak, and enterprises have weak bargaining power for quality suppliers in the procurement process, leaving them less room to choose suppliers[35]. Therefore, in procurement management, enterprises need to focus on the analysis of historical procurement data, supplier winning price and performance, to provide

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reliable data reference for the development of procurement business and supplier selection.

Bid evaluation (assessment) management process. Due to the large number of bidding and procurement projects carried out by enterprises each year, the workload of procurement evaluation (evaluation) links, at the same time, the degree of human participation is high, in the evaluation process, there is a bid evaluation (assessment) away from the procurement document qualification and performance requirements, insufficient reasons for rejecting the bid preferred quotes "sick" recommendation and other phenomena. The risk of procurement integrity is increased. Therefore, in the bid evaluation (assessment) process, it is the focus of this session to control the procurement integrity risk by combining the application of technology and to uniformly set the evaluation criteria and personalize the output.

Contract management process. Contract management not only refers to the signing and filing of the contract but also includes quality control in the process of contract performance. Due to the large number of suppliers involved in the procurement business, the implementation of the whole process of quality control of contract compliance for each order will cause an increase in operating costs, which is inconsistent with the actual development needs of enterprises. Therefore, in the contract management process, it is necessary to develop corresponding management standards, combined with the application of information technology, to establish the basis for the digitalization of enterprise contract compliance management.

Supplier management process. Due to the variety of procurement categories, a large number of packages, and high procurement frequency, the suppliers involved in the quotation process have a wide range of abilities and qualities, with obvious differences[36]. For suppliers with different supply capabilities, enterprises need to focus on optimizing supplier relationship management, supplier image system construction, supplier qualification audit, and supplier daily performance evaluation, combined with technical means, to improve the digital level of supplier management.

To better demonstrate the optimization of each aspect of the material procurement intelligent transformation, the business module technology application methods are described in detail, as shown in Table 6 below.

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Table 6 Description of the technology application of each enterprise business module

Serial Number	Management	Modules	Scene Description	Technologies
1	Program Management	Demand Forecast Analysis	Based on historical procurement application data and inventory data, it predicts the time and quantity of material procurement, provides a reference for bulk procurement and provides a reference for enterprises to merge similar orders, reduce the number of bidding times, and improve the amount and bargaining power of a single bid[37].	Big Data Analytics
2	Procurement	Purchase Price Analysis	Based on historical procurement application data and inventory data, it predicts the time and quantity of material procurement, provides a reference for bulk procurement and provides a reference for enterprises to merge similar orders, reduce the number of bidding times, and improve the amount and bargaining power of a single bid.	Big Data Analytics
3		Purchase Quality Control	We set unique codes for purchased materials, manage the whole life cycle of products, and record overhauls, replacement parts, and breakdowns in the process of materials used from the time they are delivered by suppliers. Strengthen the quality sampling of materials, and control the quality of purchased materials from the perspective of the whole product life cycle[38].	Big Data Analytics and Blockchain Technology
4	Bid Evaluation (Assessment) Management	Quoter Qualification Setting and Evaluation Clause Preparation	Based on the material category, analyze the status quo of the relevant indicators of suppliers and set project access conditions; according to the changes in key indicators in the supplier group portrait, adjust the indicators and weights in the procurement evaluation template, so as to improve the overall level of suppliers in the category in terms of production equipment.	Big Data Analytics and Blockchain Technology
5		Supplier Evaluation Scoring	Based on internal historical data, external data information platform, or other industry internal information database connection, understand suppliers' bidding information and performance in other enterprises within the industry. Evaluate suppliers based on their historical bid data and performance data. In non-bidding evaluation, the supplier part score is given automatically by the system based on the supplier evaluation results. The supplier scores in the fixed evaluation reduce the evaluation workload, limit the discretion of evaluation experts, and eliminate the tendency of scoring and selective review in the supplier scoring.	Big Data Analytics and Blockchain Technology
6	Contract Management	Contract Compliance Control	Focusing on suppliers with poor performance, the material department should strengthen real-time monitoring of supplier capacity, and timely interview key suppliers to urge rectification; and appropriately increase punitive clauses for such specific situations.	Big Data Analytics and Blockchain Technology
7		Supplier Relationship Management	Based on the supplier performance and supplier image in each material category, we classify suppliers and establish different cooperation levels with quality suppliers to enhance	Big Data Analytics

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			communication with upstream and downstream entities in the supply chain, thereby reducing sourcing costs, improving procurement quality, and reducing procurement risks.	
8	Supplier Management	Holographic Imaging of Suppliers	Based on various types of supplier data (such as supplier quotes, supplier preferences, etc.), we comprehensively analyze and process the data, simulate the basic characteristics of suppliers, and continuously mine the data, dynamically analyze the indicators and make future predictions, helping enterprises understand the characteristics of their suppliers from a macro perspective, combining the material management aspects with supplier portraits, using the evaluation results for management improvement, and improving the quality of supplier management as a whole.	Big Data Analytics
9		Supplier Qualification Review	Based on internal historical data, external data information platform, or other internal industry information database connection, learn the supplier's bidding information and performance status in other enterprises within the industry. This can be used as a reference for supplier qualification review, not just for basic information review, to improve supplier quality from the source and reduce procurement risk.	Blockchain Technology
10		Daily Supplier Compliance Tracking	Tracking supplier performance based on material categories. For key materials or suppliers cooperating for the first time, the supplier's performance will be tracked and evaluated regularly in the form of video by building a remote performance tracking system. For non-priority materials and long-term suppliers with good performance, performance sampling inspection will be conducted. To improve the efficiency of daily supplier compliance management and solve the cross-regional supplier compliance tracking problem.	5G Technology

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2. Building an Intelligent Procurement Synergy Mechanism

After completing the digital transformation of business modules and building the digital foundation of enterprise intelligent procurement, the transformation of enterprise intelligent procurement will enter the second phase, which is the synergy between departments and platforms within the enterprise, as well as the mechanism synergy between enterprise and upstream and downstream. While building the coordination mechanism, the focus of the enterprise should not be limited to the internal processes of the company, but also from the perspective of the supply chain, and establish a synergy mechanism with the main body of the supply chain, to build the company as the main body of the intelligent procurement ecosystem. Therefore, it is possible to start from four dimensions, namely real-time supply and demand synergy, procurement and ecosystem synergy, customer and data-driven quality experience, and talent and change culture. This is illustrated in Figure 2 below.

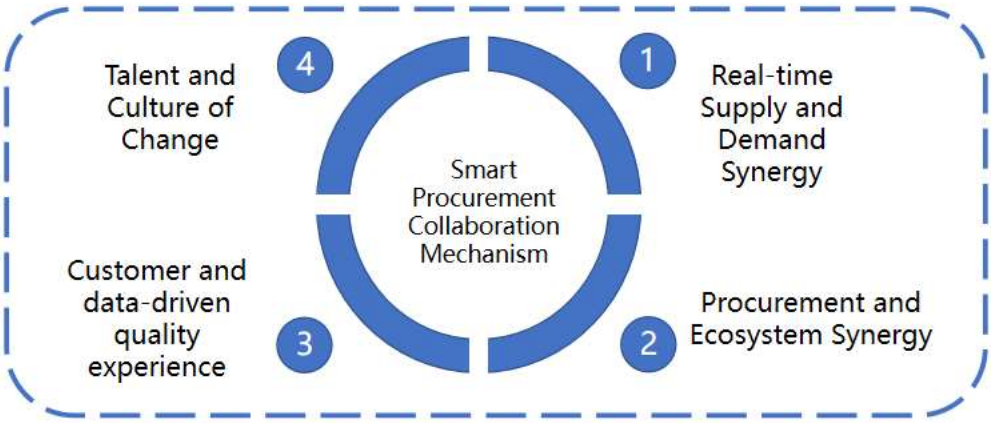

Figure 2 Intelligent Procurement Synergy Mechanism Construction

Real-time Supply and Demand Synergy. The supply-demand synergy focuses on clearing information flow channels and making data flow efficiently among various entities to reduce supply chain waste caused by the "bullwhip effect". Since there is no limit to the time for reporting, at the same time demand is scattered, it is more difficult for enterprises to manage demand and bargain for procurement[39]. Therefore, displaying demand information in the system and updating it in real-time can increase the speed of material demand information flow in the system and enhance synergy between enterprises and suppliers. In the process of supply chain digital transformation, Lenovo uses an information platform to display real-time demand information and enterprise forecasts of future months' demand to suppliers, which reduces the amount of stockpiling by first-tier suppliers from 120% to 110% of actual demand, and also reduces the amount of stockpiling by second-and third-tier suppliers. The supply chain reduces resource waste by about $7 billion. Therefore, it is important to strengthen the information platform, so that the actual demand information and the enterprise's forecast of the future demand can be transmitted to suppliers promptly, and at the same time, establish an inventory information-sharing mechanism with suppliers, so that enterprises can keep abreast of the suppliers' supply capacity, to reasonably arrange procurement activities[19, 40-41]. For non-bidding procurement, the implementation of supply-demand synergy is the key to reduce the waste of supply chain resources, and better utilize its advantages of short duration, convenience, and high efficiency, thus realizing the enterprise's intelligent procurement.

Procurement and Ecosystem Synergy. The construction of procurement and eco-system involves many related subjects in procurement, such as procurement agencies (enterprise procurement department), buyers, suppliers, and customers. In this paper, we focus on the synergy of interests between procurement agencies, purchasers, and suppliers. By building a community of interests, we place all parties in the same ecosystem, and all parties in the system are a community of interests. At the same time, the compatibility of the system can accommodate new external suppliers to join the eco-system at any time, thus building an agile and adaptable procurement and eco-system[42]. For companies whose main business is non-tendering procurement, building procurement and ecosystem synergy mechanism can further reduce the supply risk caused by high supplier mobility, different quality, and unstable cooperation cycle on the one hand, and solve the

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problems of weak bargaining power, procurement cost and high risk caused by high demand frequency and small single purchase volume on the other. Sourcing and ecosystem synergy can provide a relatively stable supply and demand environment for procurement agencies, buyers, and suppliers, so that enterprises can form a scale effect in both procurement bargaining and supplier management, thus ensuring procurement quality, reducing procurement costs, and improving procurement efficiency.

Customer and data-driven quality experience. The quality of materials is often closely related to the safety and stable production of the industry, which requires stricter control over the quality of materials. Due to the characteristics of non-tendering procurement, it is difficult to trace the quality of materials without the support of corresponding technical means, and through the application of blockchain technology, and accurate traceability system for materials can be built to digitize material flows, and big data analysis technology allows products to "speak" and build end-to-end visual analysis, thus providing enterprises with a more accurate tracking system[43]. It provides data reference and experience for improving procurement quality and making intelligent decisions for preferred suppliers, and is data-driven, taking into account the quality experience of buyers, and constantly improving the procurement quality control level.

Talent and change culture. The application of technology, the establishment of synergy mechanisms, focusing on enhancing the enterprise in the procurement of intelligent transformation of the hardware support, besides, enterprises also need to pay attention to the "soft power" training, to create a concept of the advanced, high-quality, rigorous attitude of the procurement team, which is strong protection of enterprise procurement of intelligent transformation. The staff must promote the concept of intelligent procurement management, and according to the business content of the establishment of positions, the development of a clear description of job responsibilities, building a matching performance evaluation and compensation management system, so that the concept of intelligent procurement to the team of each employee. The system will solidify the standards in the intelligent procurement for the management process, which is conducive to the internal talent training, to create a culture of change, so that enterprises have strong human resources support in the procurement of intelligent transformation process.

3. Establishing an Intelligent Procurement Ecosystem

The ultimate goal for enterprises to realize the transformation of material procurement intelligence is to visualize and digitize the supply chain, while at the same time enabling the data flow in the supply chain to become an engine for enterprise performance improvement, building an intelligent procurement ecosystem, and making optimal procurement decisions from the supply chain as a whole. Therefore, enterprises need to make a comprehensive layout from the perspective of the supply chain, which can be divided into three levels: forecasting to supply, order to settlement, and product lifecycle management (as shown in Figure 3).

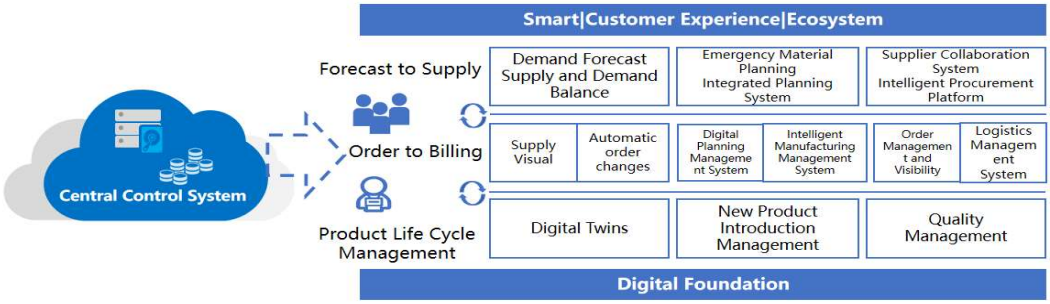

Figure 3 Intelligent procurement Ecosystem Architecture

In the intelligent procurement ecosystem, data is important productivity and its quality often determines the final procurement decision level. Therefore, real-time data update, data accuracy and uniqueness, and data governance are the foundation for the intelligent transformation of enterprise material procurement. At the same time, connecting the various entities in the supply chain with high-quality data, achieving end-to-end full chain coverage of the supply chain, and setting key control points from a global perspective are the keys to achieving global synergy in the intelligent procurement ecosystem[44-45].

Finally, enterprises need to implement closed-loop management of the system's operations from the perspective of operations management, which can be divided into four parts. The first is

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to make good use of operational dashboards. The first is to make good use of the operations dashboard, which displays business conditions in the system platform in real-time and displays data analysis results according to common business analysis dimensions to help management make decisions. The second is journey analysis, which explores the causes of management problems through the analysis of material data and provides suggestions for improvement based on the analysis results. Third, improve fault management[46]. By tracking the traces of faulty materials reported in the system, the corresponding causes of material failures can be analyzed and corresponding solutions can be given. Fourth, a closed-loop execution process, so that the data and business information between platforms are automatically associated, according to the business process settings to complete the corresponding instructions, after completing a work cycle, automatically enter the next cycle.

In summary, the intelligent procurement ecosystem is a 360-degree approach to perceive, monitor, discover, and solve problems, transforming the flow of materials between the various entities into the interaction of data on the platform, thus achieving supply chain visualization, reducing supply chain risk, and enhancing supply chain agility and adaptability. The future has come, professional procurement not only needs to improve the business capabilities of the corporate procurement team but also needs to have a global perspective and the ability to analyze the business figures, to provide strong support for intelligent decision-making in procurement. Change the cognition of their positioning, from passive procurement to active procurement, and become the intelligent decision-making brain of material procurement. Taking the national energy e-buy platform as an example. by integrating procurement, sales, logistics, suppliers, finance, taxation, government affairs, and other resources, it can better meet the supply chain integration service needs of related enterprises of the National Energy Group, provide full-process supply chain services for the platform's partners, improve supply chain management efficiency, enhance the core competitiveness of enterprises in the market, and ultimately achieve win-win development of the supply chain platform ecosystem.

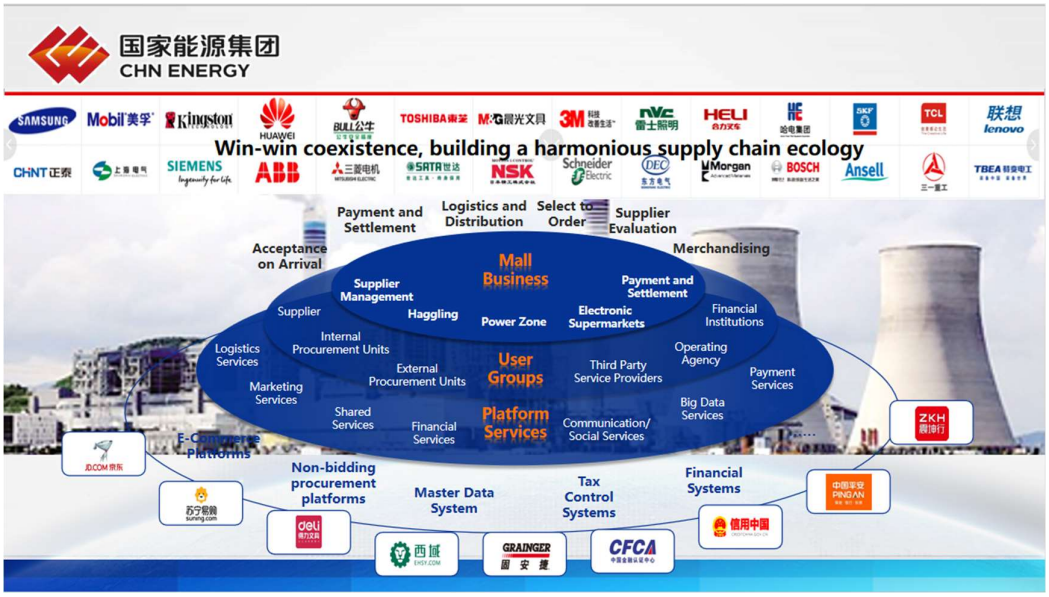

Figure 4 National energy e-buy intelligent procurement ecosystem

5 Conclusions

This study proposes a method to build an intelligent procurement system for energy industry enterprises by combining the balanced scorecard, the supply chain maturity model and the grounded theory. By combining the balanced scorecard theory, the supply chain maturity model and the research results of energy industry enterprises, this paper constructs a material procurement benchmarking system to provide reference for energy enterprises to conduct procurement benchmarking management. By applying the grounded theory, the method and key points of the construction of enterprise intelligent procurement model are proposed: digital business module,

procurement synergy mechanism, and procurement ecosystem. Meanwhile, the way of practical application of the research methods in this paper is illustrated in the context of the construction process of the intelligent procurement model of China National Energy Group Materials Company.

In order to provide a basis for further research, and to critically reflect on our pilotstudy, its strengths and weaknesses will be discussed in the following.

The managerial significance of this study can be summarized in two points. First, the material procurement benchmarking system constructed in this study has reference value for the material management benchmarking of energy industry enterprises. The benchmarking system is constructed from the perspective of supply chain management, combining the actual situation of the industry and expert opinions, taking into account the actual needs of enterprises and the development trend of the industry, so it has good reference significance for energy industry enterprises. Secondly, this study provides clear ideas and operable methods for enterprises to build an ingtelligent procurement system, and provides support for enterprise managers to develop a ingtelligent transformation path for material procurement according to the process method of "locating the problem - analyzing the problem - solving the problem".

However, the shortcomings of the study are not to be neglected. First, the possible bias of literature selection, as the literature review is conducted around the research questions, so there may be some bias in conducting the literature review in this study. Second, the applicability of the research conclusions. The conclusions of this study are based on the literature review combined with the cases of energy companies, therefore, for other industry companies, the conclusions of this paper need to be improved in conjunction with the industry reality.

In future research, we can refer to and analyze the ways and means of constructing material procurement models for enterprises in several industries to provide support for the universality of this study's conclusions.

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Author Contributors

YANG Bai-xing provided the idea of this paper and led the research arrangement. YANG Sai also made a great contribution to complete the manuscript. All authors made an effort to improve the final version.

Author Biography

Yang Baixing, Director of Purchasing Management Department of China National Energy Group Materials Co., Ltd. graduated from Shandong Agricultural Mechanization College in July 1988, majoring in electric power system and its automation, with a bachelor's degree, joined the workforce in October 1988, served as Deputy General Manager of Shandong Distribution Center of China Guodian Corporation Materials Group Co. Ltd. and Director of Procurement Management Department. He has been engaged in material procurement and supply chain management for a long time. He has won the first prize of the five-year classic case of enterprise management innovation in the electric power industry, the excellent achievement award of informationization in the electric power industry, the 2015 national electric power industry enterprise management innovation achievement award, and the second prize of bidding agency business integration of China Guodian Corporation.

Conflict of interest

YANG Bai-xing and YANG Sai declare that they have no conflict of interest.

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