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Analysis of Innovation Drivers of New and Old Kinetic Energy Conversion Using a Hybrid Multiple-Criteria Decision-Making Model in the Post-COVID-19 Era: A Chinese Case

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Abstract: To overcome the continuous decline in its gross domestic product growth rate, China has advocated new and old kinetic energy conversion (NOKEC) as a policy for sustainable economic development in the post-COVID-19 era. The innovation drivers of NOKEC are the key to promoting sustainable economic development. However, the innovation drivers have various orientations, and their selection requires multiple-criteria decision-making (MCDM). This study proposes a modified Delphi method combined with the best–worst method (BWM) as a research framework for selecting and ranking innovation drivers. Our results show the validity of this integrated research framework on a case based in China in the post-COVID-19 era. The results reveal 21 innovation-driven factors of NOKEC with varying levels of relative importance. These results may provide a basis for policymakers and researchers with a useful further understanding of the importance and prioritizing of innovation drivers. In this study, BWM uses 4% fewer pairwise comparisons than AHP, and the consistency ratio is in the range of 0.00 to 0.24.

Keywords: new and old kinetic energy conversion; multiple-criteria decision-making; modified Delphi method; best–worst method; post-COVID-19

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1. Introduction

Over the past several decades, China's economy has achieved rapid economic growth and its gross domestic product (GDP) has steadily risen in the world rankings. According to statistics data of the National Bureau of Statistics of China [1], China became the second largest economy in the world in 2010, and by 2021, it already accounts for 18.45% of the world's GDP. However, over the past decade, China's GDP growth rate has shown weakness and a downward trend has emerged. Specifically, the economic growth rate dropped from 10.6% in 2010 to less than 7% in 2015, which was the lowest growth rate in 25 years. By 2021, the economy grew at 8.1% [1], and the glory of double-digit growth rates was no longer there. Looking back at the changes over the years, China first played the role of the world's factory in globalization, and then encountered anti-globalization propositions put forward by some developed countries such as the European Union, Japan, and the United States [2]. More recently, due to the COVID-19 pandemic outbreak, many governments proposed their own industrial localization policies in response to the disruption problem of global supply chains during the epidemic, which will further hinder the development of globalization [3]. Looking at the current propositions of various governments, it can be predicted with certainty that many industries will experience some fundamental changes in the future. For examples, TSMC, the top semiconductor foundry, was invited to set up new factories in the United States through the subsidy program. Similarly, the European Union, South Korea, Japan, and China have also introduced subsidy policies, hoping to increase domestic production rates to reduce the risk of semiconductor supply chains [4]. Therefore, China needs new development drivers for its next economic growth, whether it is facing the impact of artificial anti-globalization policies or the impact of the rampant COVID-19 epidemic.

Most experts on China's economy have argued that improving economic development requires adjusting production factors and the industrial structure [5]. The sustainability of economic development varies by country due to differences in economic structures and development levels [6]. China formulated the 'Strengthen the New Kinetic Energy of Economic Development and Accelerate the New and Old Kinetic Energy Conversion' initiative [7] to provide suggestions for maintaining sustainable economic development based on its unique economic structure [8]. Old kinetic energy is the traditional driving force of economic development. Traditional industries and business models mainly rely on substantial natural resource inputs, investment, and low value-added product exports. By contrast, new kinetic energy refers to new technologies, industries, and business models that drive economic development during periods of technological revolution and industrial transformation [9,10]. New kinetic energy focuses on the intensive development of quality and efficiency, and it is characterized by innovation, high value-added technology, and resource conservation [9]. Yang et al. [11] revealed that the factors that traditionally supported China's long-term economic growth have undergone changes in the recent past. When traditional kinetic energy weakens, a necessary response is to simultaneously cultivate new kinetic energy and transform traditional kinetic energy. Therefore, regardless of whether one is discussing the Chinese government or an enterprise, new and old kinetic energy conversion (NOKEC) is a novel problem for institutional change [8].

These changes of kinetic energy can shift the economic development mode from one that is factor-driven to one that is innovation-driven [9,10,12,13]. The literature on NOKEC can be classified into two categories: discussions of the transformation and upgrading of individual enterprises with case studies [14–16] and investigations of industrial development trends and suggestions for future development based on historical economic data [17–19]. Case studies typically focus only on individual enterprises and therefore tend to lack a macro perspective. As such, the NOKEC approach, which is based on historical economic data, is more macroscopic and objective than the case study method is. However, a high degree of complexity exists regarding the specific measures that are required. Therefore, a comprehensive review of the problem of complexity, a systematic identification of the drivers of innovation, and an understanding of their relative importance are all critical research topics.

The Delphi method can treat a complex issue and is also an applicable method when there is incomplete knowledge of a problem [20,21]. This method adopts iterative investigation and elicitation of expert feedback to ensure that the opinions that are obtained gradually tend toward consistency and the conclusions generated are consistent and reliable [22]. However, the typical Delphi method presents disadvantages in that performing surveys is time intensive and controlling the schedule is difficult. The modified Delphi method was proposed to address these shortcomings [23]. It has been utilized in economic studies in fields such as cross-border economic forecasting [24], sustainable development of the bioeconomic environment [25], and the assessment of resource use efficiency [26].

In addition, determining the relative importance of innovation drivers for NOKEC has implications for practical decision-making. Adopting systematic methods to evaluate and choose among execution plans can improve the quality of strategic decisions. Saaty [27–29] proposed the analytic hierarchy process (AHP) method to address the multiple-criteria decision-making (MCDM) issue to assist decision makers assess and prioritize their alternatives.

AHP is a qualitative and quantitative MCDM method that implements a series of pairwise comparisons between decision elements to determine the optimal choice, and it has a wide range of practical uses [30,31]. However, the use of AHP frequently involves a substantial number of pairwise comparisons, which leads to distorted data due to the decision makers' impatience. Therefore, Rezaei [32] developed the best–worst method (BWM) to overcome the disadvantages of AHP. The BWM is also an MCDM tool, but it requires fewer pair comparisons than AHP does, and more critically, it provides superior consistency to that of AHP [33]. Since it was proposed in 2015, the BWM has been widely used in numerous fields such as technological innovation [34], risk assessment [35], supply chain management [33,36–38], R&D performance management [39], eco-industrial park evaluation [40], freight logistics eco-innovation [41], and art gallery assessment [42].

This study developed an integrated approach for extracting the innovation drivers of NOKEC from the literature and then provides the weightings and rankings of these drivers. There are two purposes of this research: first, to establish the innovation drivers of NOKEC; second, to rank the innovation factors. The contributions of our proposed model are twofold. First, the literature on NOKEC has not produced a comprehensive method of exploring and extracting innovation drivers. This study addressed this deficiency by proposing a modified method. Second, the entropy method is a common method used to calculate index weights in NOKEC literature [43–45]. To the best of our knowledge, our work is a pioneer study, aiming at applying BWM to assess the relative weights of the innovation drivers and to ranking them. Specifically, this study extracted and ranked the innovation drivers of NOKEC of the Fujian province in China in the post-COVID-19 era by using an integrated approach comprising the modified Delphi method and BWM.

The remainder of this paper is organized as follows: Section 2 reviews the relevant literature on NOKEC and China's economic development and proposes the initial innovation drivers of NOKEC. Section 3 presents the proposed framework of the integrated modified Delphi method, BWM. Section 4 presents a Chinese case study on economic sustainability and development to validate the proposed integrated model. Section 5 presents a discussion of the results. The final section provides this study's conclusion and suggestions for future research.

2. Literature Review

The modified Delphi method exhibits a high level of practicality and has been widely adopted to solve uncertainty problems. The BWM is a decision-making method that has emerged in recent years to provide superior comparison and reliability than AHP can for MCDM issues.

2.1. Modified Delphi Method

The Delphi method has frequently been used for the collection and evaluation of expert opinions for group decision-making [46–48]. It is mainly suitable for problems for which quantitative data cannot be used for prediction due to data insufficiency and uncertainty. The Delphi method was first used to formulate national defense policies and was subsequently applied in other fields such as industry, transportation, and health [20]. More recently, it has been widely used in education, social science, health care, medical research, and energy [26,48–51].

The Delphi method, also known as the expert survey method, undertakes communication through anonymous questionnaire surveys. In the initial stage, respondents provide their professional opinions on the topics of discussion, and these opinions are continuously integrated and revised to obtain the results, which are reported to participants anonymously. This method implements a process of repeated questionnaire surveys that is only finalized after the members of the expert group have reached a consensus on the relevant topics [52–54]. In the process of collective expert decision-making, the Delphi method retains the advantages of collective decision-making and avoids the interference that might result from face-to-face communication among the respondents [21].

Murry and Hammons [21] proposed a modified Delphi method to address the main weaknesses of the conventional Delphi method, namely its time-intensiveness and difficulty in controlling the schedule. The modified Delphi method retains the advantages of the Delphi method but simplifies the questionnaire process. The methods of its implementation and statistical application are roughly the same as those of the traditional Delphi method. The difference is that the modified Delphi method adopts a structured questionnaire developed from a literature review instead of the open-ended questions used in the first stage of the conventional Delphi method [46,55]. The modified Delphi method has several advantages: it saves a substantial amount of time, reduces the conjecture that can result from open-ended questions, and it results in an increased questionnaire response rate [21]. The modified Delphi method has been widely adopted in numerous fields, such as management science, education, banking, health care, and public transport [53,56–58].

2.2. BWM

The BWM is an approach for solving MCDM problems that assesses several alternatives by using certain criteria to select the optimal alternative [32,59]. The first step of the BWM requires the decision-maker to select the optimal (e.g., most critical or desirable) and the least optimal (e.g., least critical or desirable) alternatives. Next, pairwise comparisons between each best or worst criterion and the other criteria are conducted. The third step is to compute the weights of the criteria and alternatives. In the final step, the weights of the criteria and alternatives are summed, and the final selection among the alternatives is implemented according to the weights obtained.

AHP, which is also a pairwise comparison-based method, is among the most popular MCDM tools, and it has typically been adopted to the BWM in determining the reliability of comparisons. Rezaei [32] argued that the BWM is superior to AHP because the BWM requires fewer pairwise comparisons and results in more consistent comparisons than AHP does.

Numerous methods of addressing the problems of MCDM have been thoroughly discussed in the literature [36]. Most relevant studies on the integrated Delphi method with MCDM tools have adopted AHP, whereas a few have used the technique for order preference by similarity to ideal solution (TOPSIS). The literature on the combination of the Delphi method and MCDM tools is presented in Table 1. The present study adopts a novel research framework that integrates the modified Delphi method and the BWM.

Table 1. Literatures integrating Delphi and MCDM tool.

Source	Methodology	Subject
Hsu et al. [60]	Fuzzy Delphi and AHP	Lubricant regenerative technology selection
Chen and Wang [61]	Fuzzy Delphi and AHP	Developing global business intelligence
Vidal et al. [62]	Delphi and AHP	Evaluating the complexity of projects
Joshi et al. [63]	Delphi, AHP, and TOPSIS	Performance improvement
Cho and Lee [64]	Delphi and FAHP	Assessing commercialization opportunities
Kim et al. [65]	Delphi and AHP	Selecting the priorities of WEEE for recycling
Meesapawong et al. [66]	Delphi and AHP	Planning innovation orientation
Sun et al. [67]	Delphi and AHP	Selection of key technologies
Billig and Thrän [50]	Delphi and AHP	Evaluation of biomethane technologies
Bouzon et al. [68]	Fuzzy Delphi and FAHP	Identification and analysis of reverse logistics barriers
Delbari et al. [69]	Delphi and AHP	Investigation of key competitiveness indicators
Pham et al. [70]	Fuzzy Delphi and TOPSIS	Locating logistics centers
Shah et al. [51]	Delphi and FAHP	Analysis of barriers to the adoption of cleaner energy technologies
Brunnhofer et al. [71]	Delphi, SWOT, and AHP	Analysis of biorefinery transition
Shen et al. [72]	Delphi and AHP	Constructing the evaluation index system of nursing
Boulomytis et al. [73]	Delphi and AHP	Detection of flood influence criteria

2.3. Innovation Drivers for NOKEC

The concept of kinetic energy was derived from physics and refers to the energy of an object due to its motion. Introducing "kinetic energy" to the economic framework refers to the energy that promotes economic development [9,12].

Xue et al. [8] argued that NOKEC requires a certain level of industrial development and the implementation of new development concepts in China. In addition, NOKEC hastens the alleviation of various risks and contradictions, which therefore reduces systemic and regional economic risks [10]. The concepts of new and old kinetic energy in economic development do not refer to advanced and backward, respectively, but rather represent a dynamic relationship [9,10,12]. Old kinetic energy can be converted into new kinetic energy by improving efficiency and quality. New kinetic energy can devolve into old kinetic energy because of economic and social development and technological innovation. Scholars of China's economy have argued that traditional forces continue to play a critical role despite knowledge and technology having become key drivers of economic development in recent years [74].

China National Knowledge Infrastructure (CNKI), Google Scholar, Web of Science, and Scopus were selected for this study's review of the NOKEC literature. CNKI is China's national digital library and comprises academic journals, dissertations, and various publications. In this study, we searched for all journal articles containing the keywords "new and old kinetic energy conversion", the period covered was 2015–2022, a total of 202 related journal articles were retrieved from CNKI and a total of 27 related journal articles from other search engines. After reviewing all 229 papers, 23 innovation drivers were determined and classified into six dimensions: talent (D1), achievement (D2), system (D3), finance (D4), organization (D5), and resources (D6). The hierarchy and description of the innovation-driven factors for NOKEC are presented in Figure 1 and follow respectively.

Talent (D1) refers to personnel assessment and incentives (C11) and innovative employee (C12). Personnel assessment and incentives (C11) means that innovation results are measurement indicators of performance evaluation and a technology shareholding system is implemented [10,75]. Innovative employee (C12) refers to divide human resource capabilities into classifications such as high-level skilled workers, entrepreneurs and innovators, young innovators, overseas engineers, and short-term and part-time innovation workers [45,76,77].

Achievement (D2) contains a transformation platform of scientific and technological achievements (C21), and transformation modes of scientific and technological achievements (C22). The transformation platform of scientific and technological achievements (C21) means that an intermediary that can effectively improve transformation efficiency, reduce transformation costs, and promote the commercialization of technological innovation [10,13,78,79]. The transformation mode of scientific and technological achievements (C22) refers to a market-oriented operating mode that increases the efficiency of resource allocation [13,80].

System (D3) contains innovative management mechanism (C31), innovation and entrepreneurship strategy (C32), technology-based enterprises (C33), mainstay of innovation (C34), key common technologies (C35), innovation and entrepreneurship environment (C36), intellectual property rights (C37), and innovative fault tolerance (C38). Innovative management mechanism (C31) refers to eliminate policies that protect traditional practices and interfere with the development of key industries and establishment of a mechanism responding to the needs of market development [43,81–83]. Innovation and entrepreneurship strategy (C32) means the formulation of strategies for the development of innovation and innovation-driven entrepreneurship, which accelerate the conversion of new and old kinetic energy [13,19,84]. Technology-based enterprises (C33) refers to development of high-tech enterprises based on big data, cloud computing, mobile Internet, Internet of Things, and intelligent manufacturing [43,77,78,84–86]. Mainstay of innovation (C34) means that companies are encouraged to set up R&D centers to respond quickly and effectively to environmental changes [9,78–80,82]. Key common technologies (C35) refers to the involvement of new-generation information technology, high-end manufacturing, biology, green and low-carbon industries, and digital creativity in national key development industries [80,87,88]. Innovation and entrepreneurship environment (C36) means the construction of policies, systems, and innovative service models to elicit new kinetic energy [10,12,76,77,79]. Intellectual property rights (C37) refers to promoting domestic management innovation in the judicial enforcement of intellectual property rights as a basic system that encourages innovation and modern intellectual property management capabilities [89,90]. Innovative fault tolerance (C38) refers to integrated risk control and technological innovation to reduce the probability of innovation errors [10,91–93].

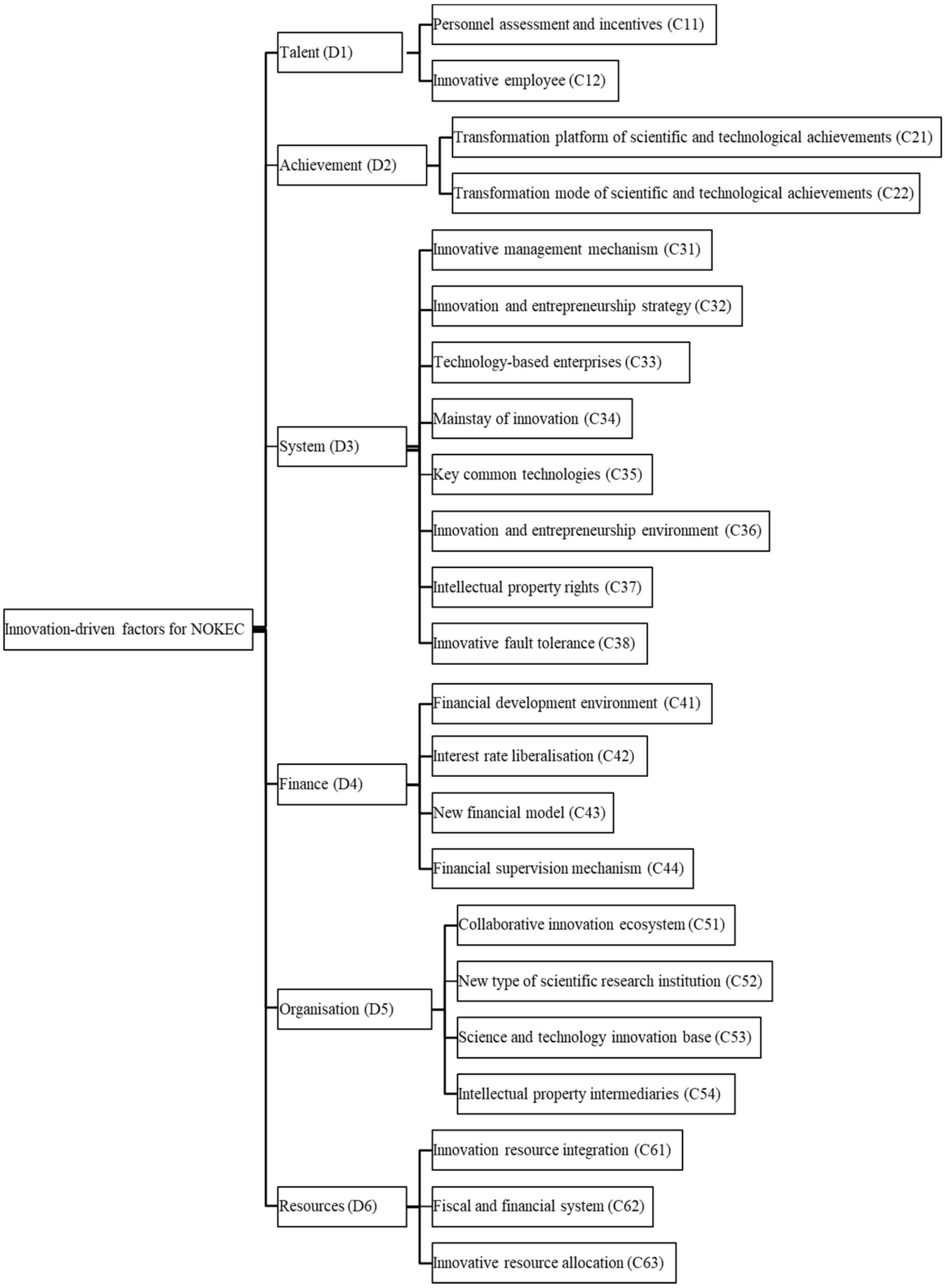

Figure 1. Hierarchy of innovation-driven factors for NOKEC.

Finance (D4) contains financial development environment (C41), interest rate liberalization (C42), new financial model (C43), and financial supervision mechanism (C44). Financial development environment (C41) means establishment of a financial system that supports entrepreneurial innovation and diversification and that promotes the development of trust [15,94]. Interest rate liberalization (C42) refers to encouraging interest rate competition among financial institutions to facilitate the flow of funds to newly established enterprises [15,95,96]. New financial model (C43) includes science/technology finance, green finance, internet finance, supply chain finance, and consumer finance [17,44,77,97,98]. Financial supervision mechanism (C44) refers to comprehensively utilizing new methods to allow financial supervision to maintain tolerable risks [15,99,100].

Organization (D5) contains collaborative innovation ecosystem (C51), new type of scientific research institution (C52), science and technology innovation base (C53), and intellectual property intermediaries (C54). Collaborative innovation ecosystem (C51) refers to addressing the technological bottlenecks that restrict industrial transformation and upgrading, build strategic alliances to promote industrial and technological innovation, and lead the development of emerging industries with collective technology [43,77,79]. New type of scientific research institution (C52) refers to establishing a market-oriented international strategic institution to develop science and technology [93]. Science and technology innovation base (C53) refers to establishing critical channels for key technological industries according to national strategic needs [17,77,101]. Intellectual property intermediaries (C54) means training intermediaries to cooperate with well-known international intellectual property institutions to accelerate the development of intellectual property [102–104].

Resources (D6) contains innovation resource integration (C61), fiscal and financial system (C62), and innovative resource allocation (C63). Innovation resource integration (C61) means that adopting a rational and effective allocation of scientific and technological resources can generate a means of achieving overall aggregation [77,89,105,106]. Fiscal and financial system (C62) refers to encouraging the withdrawal of the old kinetic energy and introduction of new kinetic energy to build a financially supported and diversified organization [85,94]. Innovative resource allocation (C63) refers to the allocation and use of innovative resources by different innovative entities in certain areas [43,77,86,88,89,107].

3. Integrated Modified Delphi–BWM Framework

In light of the discussion in Section 2, this study adopted a combination of the modified Delphi method and BWM to extract and compute the relative weights of the innovation drivers for NOKEC. An overview of the integrated modified Delphi–BWM model is presented in Figure 2.

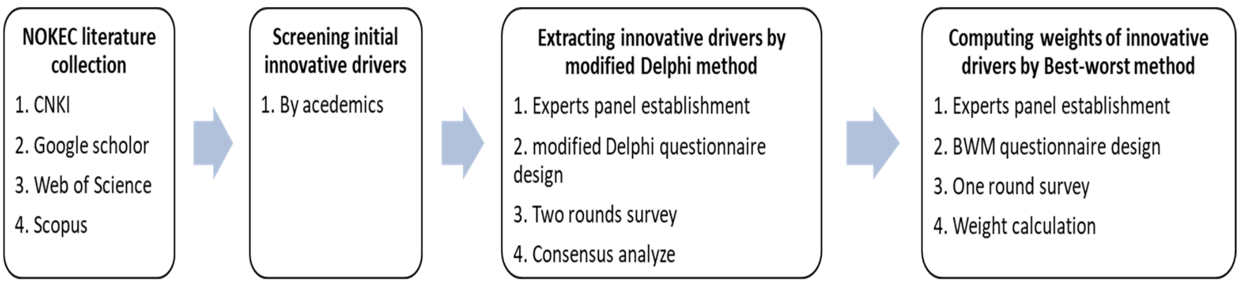

Figure 2. Overview of integrated modified Delphi–BWM.

3.1. Computational Steps of the Integrated Modified Delphi–BWM

1. For the questionnaire in the modified Delphi method, the 23 innovation drivers of NOKEC were extracted and arranged in a questionnaire based on the literature review and conducted by the subject experts.

2. For the questionnaire survey and analysis, the experts were invited to participate in the two-round modified Delphi survey. The results of the consensus of expert opinions were used as the threshold for screening the innovation drivers.
3. For the BWM survey, the BWM-style hierarchical questionnaire design and survey were developed using the innovation drivers identified in item 2.
4. In the computation of the weights of the innovation-driven factors, this study calculated the weight of each innovation driver based on the data obtained by BWM as described in item 3.

3.2. Modified Delphi Design

3.2.1. Questionnaire Design

The modified Delphi questionnaire adopted a closed structure and was compiled from the innovation-driven factors extracted from this study's literature review. This study adopted a 5-point Likert scale, with importance measured as very important, moderately important, neutral, of limited importance, and of very limited importance. The questionnaire required participants to select one answer based on their opinion of the importance of each statement. Participants were able to submit comments on any of the items with their completed questionnaires.

3.2.2. Participant Selection

The Delphi method does not use random sampling to recruit expert groups because its purpose is not to represent a population [49]. In the Delphi method, participants are defined as experts with specific expertise [57]. Groups of heterogeneous members provide higher credibility and acceptance than groups of homogeneous members do, because assessment of a heterogeneous group is more likely to result in various viewpoints that cover all possible aspects of the research topic. For groups of heterogeneous respondents, 5–10 experts per group is the optimal range [108]. This study adopted Iqbal and Young's (2009) suggestion for the optimal number of participants and considered the effective response rate of the questionnaire. Therefore, more than five copies of questionnaires were distributed to each group.

The participants in the modified Delphi survey comprised experts from academia, industry, and the government. A total of 55 respondents were invited, including 10 academics, 10 government officials, and 35 senior industry executives. Fujian was the selected province of study due to its rapid economic development prior to 2016 and notable decline in GDP growth thereafter. The province's GDP growth rate was greater than 10% for several years immediately prior to 2016, but its GDP growth rate in 2021 was only 8.0% [109].

3.3. Modified Delphi Survey and Data Analysis

Two rounds of surveys were conducted in this study. A structured questionnaire was sent to 55 participants by post and email. Participants were required to rate the importance of the 23 items. The first round of the survey was conducted over a weeks' time. When the first round of the survey was completed, consensus and feedback analysis was conducted. Items that did not reach the consensus screening threshold were included in the second-round questionnaires. Respondents in the second-round survey comprised of the participants who responded to the first-round survey. Similarly, the second-round survey was over one weeks' time, and a reminder notice was sent on the fourth day after the second-round questionnaire was issued. After the second round of the survey was completed, analysis of the consensus was again conducted; the consensus analysis of the two-round survey was then integrated, and the innovation drivers of the modified Delphi survey were thereby determined.

3.4. BWM Questionnaire Design, Survey, and Weight Computation

The BWM is an easy-to-implement and effective MCDM method. Its theoretical concept comprises two steps. The first step is the selection of the best and worst criteria (alternatives) from all criteria (alternatives). The second step comprises a comparison of the best criterion (alternative) with all the criteria (alternatives) and a comparison of all the criteria (alternatives) with the worst criterion (alternative). In the comparisons, two vector systems are formed and then a simple model is constructed to determine the optimal weight of each criterion (alternative) and the consistency ratio. In this paper, an innovation driver is treated as a criterion of the BWM based on the following five steps [32,59]:

Step 1. Identify the set of dimensions or criteria.

The set of the criteria C = (c_1, c_2, . . . , c_n), where n represents the number of all criteria, was identified by the participants to make a decision. In this study, the set of criteria resulted from the modified Delphi survey.

Step 2. Identify the best and worst dimension and criterion.

Participants individually selected the best (i.e., the most significant, influential, or desirable) and worst (i.e., the least significant, desirable, or critical) criteria from the set **C** = (c_1, c_2, . . . , c_n). If more than two criteria were simultaneously selected as the best or worst, the authors selected one as the representative.

Step 3. Determine the preferences for the best criterion over each dimension and criterion.

Given m participants and n criteria, each participant made a pairwise comparison of the best criterion with all other criteria. The preferences were scored on a scale of 1–9, with a larger number indicating a greater preference. The resulting best-to-others (BO) vector was determined as follows:

$$A^e_{Bj} = (a^e_{B1}, a^e_{B2}, \ldots, a^e_{Bn}); j = 1, \ldots,\ n; e = 1, \ldots, m \tag{1}$$

where A^e_{Bj} represents the preference of the best criterion (B) over criterion j by the eth participant. Based on this formula, $A^e_{BB} = 1$.

Step 4. Determine the preference for each criterion over the worst dimension and criterion.

Each participant was required to conduct a pairwise comparison of their preferences for each criterion with the worst criterion. This preference was scored between 1 and 9, with a larger number indicating a greater relative preference. The resulting others-to-worst (OW) vector was obtained as follows:

$$A^e_{jW} = (a^e_{1W}, a^e_{2W}, \ldots, a^e_{nW}\ )^T; j = 1, \ldots,\ n; e = 1, \ldots, m \tag{2}$$

where A^e_{jW} indicates the preference of criterion j over the worst criterion (W) by the eth participant. Again, this formula indicates that $A^e_{WW} = 1$.

Step 5. Calculate the optimal weights of the dimensions or criteria (w^*_1,w^*_2, . . . ,w^*_n).

A linear programming with the BO and WO vectors was applied to resolve the optimal weights (w^*_1,w^*_2, . . . ,w^*_n). The minimized and maximum absolute differences between $|w_B - a_{Bj}w_j|$ and $|w_j - a_{jw}w_w|$ revealed a minimized error distance that is formulated as follows [59]:

$$\begin{gathered} min\ \ \max_j \{ |w_B - a_{Bj}w_j|, |w_j - a_{jW}w_W| \} \\ s.t.\ \textstyle\sum_j w_j = 1 \\ w_j \geq 0, for\ all\ j \end{gathered} \tag{3}$$

Equation (3) was converted into a linear programming formula as follows:

$$\begin{gathered} min\ \zeta^* \\ s.t.\ \sum_j w_j = 1 \\ \left|w_B - a_{Bj}w_j\right| \le \zeta^*, for\ all\ j \\ \left|w_j - a_{jW}w_W\right| \le \zeta^*, for\ all\ j \\ w_j \ge 0,\ for\ all\ j \end{gathered} \quad (4)$$

Equation (4) is linear and has a unique solution, and in it exists an alternative value i regarding criterion j in some decision-making problems. It generates the optimal weights (w_1^*,w_2^*, ... ,w_n^*) and the optimal values of ζ, which are represented as ζ^*. ζ^* is treated as the BWM's consistency ratio. The closer the consistency ratio ζ^* is to zero, the closer the consensus of the decision makers is. We can judge the quality of the questionnaire survey by evaluating the consistency of the comparison system, and ζ^* is a crucial indicator of the consistency test.

4. Empirical Results

4.1. Modified Delphi Design

The questionnaire of the modified Delphi approach comprised of 6 dimensions and 23 criteria. The dimensions and criteria are defined in Section 2 and summarized in Table 2.

Table 2. Innovation-driven dimension and criteria of modified Delphi questionnaire.

Dimension	Criteria
Talent (D1)	Personnel assessment and incentive (C11), Innovative employee (C12)
Achievement (D2)	Transformation platform of scientific and technological achievements (C21), Transformation mode of scientific and technological achievements (C22)
System (D3)	Innovative management mechanism (C31), Innovation and entrepreneurship strategy (C32), Technology-based enterprises (C33), Mainstay of innovation (C34), Key common technologies (C35), Innovation and entrepreneurship environment (C36), Intellectual property rights (C37), Innovative fault tolerance (C38)
Finance (D4)	Financial development environment (C41), Interest rate liberalization (C42), New financial model (C43), Financial supervision mechanism (C44)
Organisation (D5)	Collaborative innovation ecosystem (C51), New type of scientific research institution (C52), Science and technology innovation base (C53), Intellectual property intermediaries (C54)
Resources (D6)	Innovation resource integration (C61), Fiscal and financial system (C62), Innovative resource allocation (C63)

Consensus analysis and element ordering were conducted using the feedback data from the questionnaire survey. In the Delphi method, consensus analysis is particularly crucial, but the probability that participants can reach complete consensus on certain issues is limited. Consensus is typically defined by establishing an arbitrary percentage of experts who agree with each other on the survey, but this percentage must be defined before the survey begins. Numerous Delphi-based studies have used a degree of consistency to quantify expert consensus. Various percentages have been used, with the final measures typically determined after the analyses. However, if a nominal scale or a Likert scale is used to express the degree of consistency, it is particularly meaningful to determine the consistency through a certain degree of consistency [23]. Putnam et al. [110] suggested that more than 80% of respondents selecting the top two options of the Likert scale (i.e., desirable and very desirable) for an item should be considered a consensus. Consequently, this study considered a total proportion of the first two items (i.e., very important and moderately important) greater than 80% to be the threshold for consensus.

4.2. Modified Delphi Survey and Data Analysis

4.2.1. First-Round Survey and Data Analysis

Of the 55 distributed questionnaires, only 44 participants responded, resulting in an effective questionnaire recovery rate of 80%.

Descriptive statistics were used to analyze the basic data of the respondents. The results of the analysis of the respondents' years of work experience, occupations, and titles in the first round of the survey are presented in Table 3. This data revealed that all the respondents had worked for more than 10 years. Specifically, 12 respondents (27.3%) had worked for 26–30 years; 9 respondents (20.5%) had worked for 16–20 years, and 8 respondents (18.2%) had worked for more than 30 years. Respondents with more than 21 years of work experience accounted for a large proportion (61.4%) of the total. Based on our analysis of the industries in which the respondents worked, the largest number (11, 25%) worked in the food industry. This is followed by the technology industry (9 respondents, 20.5%) and the real estate and financial industries (6 respondents each, 13.6%). According to the data on respondents' job titles, 18 were professional managers (40.9%), representing the largest percentage; this was followed by 9 general managers (20.5%).

Table 3. Descriptive statistical description of respondents of modified Delphi survey.

Working Years			Occupation			Job Title		
Working Years	**Number of People**	**Proportion (%)**	**Industry**	**Number of People**	**Proportion (%)**	**Job Title**	**Number of People**	**Proportion (%)**
11–15	8	18.2	Food	11	25	Chairman	2	4.5
16–20	9	20.5	Technology	9	20.5	General Manager	9	20.5
21–25	7	15.9	Real Estate	6	13.6	Deputy General Manager	4	9.1
26–30	12	27.3	Financial	7	15.9	Manager	18	40.9
Over 30	8	18.2	Academic	6	13.6	Professor/ Associate Professor	6	13.6
			Government	5	11.4	Section Chief	2	4.5
						Economist	3	6.8

The primary purpose of the first round of the modified Delphi survey is to determine a consensus. In our study, if the proportion of respondents answering "very important" and "moderately important" on an individual item exceeded 80%, a consensus on the item was determined to have been achieved among the respondents. However, if this proportion was less than 80%, the respondents were determined to have failed to achieve a consensus on the respective item. Items for which consensus was not reached in the first round of the survey were included in the second round of the survey.

The results of the first round of the survey are presented in Table 4. Five items achieved "very important" and "moderately important" responses that accounted for less than 80% of the total: mainstay of innovation (C34; 77.3%), interest rate liberalization (C42; 76.7%), innovative fault tolerance (C38; 72.8%), collaborative innovation ecosystem (C51; 79.6%), and new type of scientific research institution (C52; 79.5%). However, after reviewing the proportions of responses to these five questions, we discovered that "very important" and "moderately important" responses to collaborative innovation ecosystem (C51) and new type of scientific research institution (C52) accounted for approximately 79.5% of the totals and were thus determined to have achieved consensus. Therefore, after the completion of the first round of the survey, 20 items were determined to have reached the consensus level of 80%, whereas three items failed to meet the consensus threshold.

Table 4. Results of the first-round survey of modified Delphi method.

Criteria	No. of Response	Score Average	5-Very Important	4-Moderately Important	3-Neutral	2-Limited Importance	1-Very Limited Importance	Ideas from Respondents
Personnel assessment and incentive (C11)	44	4.82	36 (82%)	8 (18%)	0 (0%)	0 (0%)	0 (0%)	
Intellectual property rights (C37)	44	4.70	34 (78%)	8 (18%)	1 (2%)	1 (2%)	0 (0%)	
Innovative employee (C12)	43	4.47	22 (51%)	19 (44%)	2 (5%)	0 (0%)	0 (0%)	The demand for high-level employee is different based on different development stages of the enterprise
Financial supervision mechanism (C44)	43	4.47	25 (58%)	13 (30%)	5 (12%)	0 (0%)	0 (0%)	
Transformation mode of scientific and technological achievements (C22)	44	4.43	23 (52%)	18 (41%)	2 (5%)	1 (2%)	0 (0%)	
Innovative management mechanism (C31)	43	4.40	23 (54%)	15 (35%)	4 (9%)	1 (2%)	0 (0%)	Innovation should be combined with the strategic needs of enterprises.
Fiscal and financial system (C62)	44	4.36	24 (54%)	13 (30%)	6 (14%)	1 (2%)	0 (0%)	
Transformation platform of scientific and technological achievements (C21)	44	4.34	18 (41%)	23 (52%)	3 (7%)	0 (0%)	0 (0%)	
Innovation and entrepreneurship environment (C36)	43	4.30	18 (42%)	21 (49%)	3 (7%)	1 (2%)	0 (0%)	
Innovation and Entrepreneurship Strategy (C32)	44	4.27	18 (41%)	21 (48%)	4 (9%)	1 (2%)	0 (0%)	
Technology-based enterprises (C33)	44	4.27	17 (39%)	22 (50%)	5 (11%)	0 (0%)	0 (0%)	
Science and technology Innovation base (C53)	44	4.27	17 (39%)	22 (50%)	5 (11%)	0 (0%)	0 (0%)	
Key common technologies (C35)	44	4.23	17 (39%)	21 (48%)	5 (11%)	1 (2%)	0 (0%)	
New financial model (C43)	44	4.23	17 (39%)	20 (45%)	7 (16%)	0 (0%)	0 (0%)	
Innovative resource integration (C61)	44	4.20	19 (43%)	17 (38%)	6 (14%)	2 (5%)	0 (0%)	
Innovative resource allocation (C63)	44	4.20	18 (41%)	19 (43%)	5 (11%)	2 (5%)	0 (0%)	
Collaborative innovation ecosystem (C51)	44	4.18	19 (43.2%)	16 (36.4%)	7 (15.9%)	2 (4.5%)	0 (0%)	
New type of scientific research institution (C52)	44	4.18	18 (40.9%)	17 (38.6%)	8 (18.2%)	1 (2.3%)	0 (0%)	
Financial development environment (C41)	41	4.15	13 (32%)	21 (51%)	7 (17%)	0 (0%)	0 (0%)	1. The supervision system should be perfect.
Intellectual property intermediaries (C54)	43	4.14	13 (30%)	23 (54%)	7 (16%)	0 (0%)	0 (0%)	
Mainstay of innovation (C34)	44	4.11	16 (36.4%)	18 (40.9%)	9 (20.5%)	1 (2.3%)	0 (0%)	
Innovation fault tolerance (C38)	44	3.98	12 (27.3%)	20 (45.5%)	11(25.0%)	1 (2.3%)	0 (0%)	
Interest rate liberalization (C42)	43	3.98	12 (27.9%)	21 (48.8%)	8 (18.6%)	1 (2.3%)	1 (2.3%)	

4.2.2. Second-Round Survey and Data Analysis

The items in the second round of the survey comprised the three items that did not reach the consensus threshold in the first round of the survey: mainstay of innovation (C34; 77.3%), interest rate liberalization (C42; 76.7%), and innovative fault tolerance (C38; 72.8%). The second-round questionnaire was distributed to the 44 respondents of the first-round questionnaire and collected 1 week later. A total of 31 questionnaires were collected in the second round of the survey, for an effective response rate of 70.5%.

The results of the second-round survey, presented in Table 5, revealed that the total proportion of "very important" and "moderately important" response options accounted for less than 80% of the total for two of the three items: interest rate liberalization (C42; 77.4%) and innovative fault tolerance (C38; 77.4%). Therefore, the second-round survey excluded them because they failed to reach the consensus threshold. As such, a total of 21 innovation-driven factors were extracted from the results of the two-round modified Delphi survey.

Table 5. Results of the second-round survey of modified Delphi method.

Criteria	No. of Response	Score Average	5-Very Important	4-Moderately Important	3-Neutral	2-Limited Importance	1-Very Limited Importance
Interest rate liberalization (C42)	31	3.97	7 (22.6%)	17 (54.8%)	6 (19.4%)	1 (3.2%)	0 (0%)
Innovative fault tolerance (C38)	31	4.03	9 (29.0%)	15 (48.4%)	6 (19.4%)	1 (3.2%)	0 (0%)
Mainstay of innovation (C34)	31	4.39	17 (54.8%)	10 (32.3%)	3 (9.7%)	1 (3.2%)	0 (0%)

4.3. BWM Questionnaire Design, Survey, and Weights of the Innovation Drivers

The BWM matrix design and survey are described in the following five steps:

Step 1. Identify the set of innovation-driven dimensions or criteria.

The first step in the BWM approach is to establish a comparison matrix of innovation-driven dimensions or criteria. The data from questionnaire survey is for BWM matrix. The set of 6 dimensions and 21 criteria from previous step of modified Delphi were summarized in Sections 2.2 and 4.2.2, respectively (and presented in Table 6). The dimensions and criteria are for BWM questionnaire.

Table 6. BWM set of Dimension/criteria.

Dimension	Criteria
Talent (D1)	Personnel assessment and incentive (C11), Innovative employee (C12)
Achievement (D2)	Transformation platform of scientific and technological achievements (C21), Transformation mode of scientific and technological achievements (C22)
System (D3)	Innovative management mechanism (C31), Innovation and entrepreneurship strategy (C32), Technology-based enterprises (C33), Mainstay of innovation (C34), Key common technologies (C35), Innovation and entrepreneurship environment (C36), Intellectual property rights (C37)
Finance (D4)	Financial development environment (C41), New financial model (C43), Financial supervision mechanism (C44)
Organization (D5)	Collaborative innovation ecosystem (C51), New type of scientific research institution (C52), Science and technology innovation base (C53), Intellectual property intermediaries (C54)
Resources (D6)	Innovation resource integration (C61), Fiscal and financial system (C62), Innovative resource allocation (C63)

Step 2. Identify the best and worst dimension and criterion.

In the second step, each expert selected the best and worst items among the dimensions and criteria. Differences in the professional fields of the experts resulted in different identified best and worst criteria. If more than one item was selected as the best or worst item, only one was selected as the representative. The BWM questionnaire required a detailed face-to-face explanation, after which seven experts involved in the Delphi survey expressed their willingness to participate in the BWM comparison survey. The number of experts in BWM we used in this paper is seven which is consistent with the number of an experts panel commonly used in the literature [111–113]. Two of these experts were from academia and the other five were from industry. Of the five industry experts, two were general managers, two were senior executives, and one was a firm chairperson.

Each expert's selection results for the best and worst dimension and criterion are summarized in Tables 7 and 8. A comparison of the experts' dimension preferences revealed that four experts (No. 1, 2, 3, and 6) considered talent (D1) to be the best; three experts (No. 2, 3, and 4) believed that finance (D4) was the worst; and no expert considered system (D3) to be the best or worst. In addition, most of the criteria were selected by the experts as the best or worst. However, no experts identified the innovation and entrepreneurship environment (C36) as the best or worst. No expert listed mainstay of innovation (C34) or science and technology innovation base (C53) as the best option, and no expert identified technology-based enterprises (C33), key common technologies (C35), or new type of scientific research institution (C52) as the worst option.

Table 7. Best and worst dimension identified by experts.

Dimension	Preference	
	Best	Worst
D1	1, 2, 3, 6	
D2	4, 5	7
D3		
D4		2, 3, 4
D5	7	5
D6		1, 6

Note: number means expert no.

Step 3. Determine preferences for the best criterion (B) over each dimension and criterion.

In this step, each expert compared the selected best dimension and criterion with all the other dimensions and criteria in pairs with preference scores ranging from 1 to 9. A score of 1 means that the preference for the two items is equal, and the larger the score, the greater the preference for the best item is. The pairwise comparison matrix of criteria was compiled using the same format as that of the dimension matrix. The results of the BO preference comparison of the dimensions are presented in Table 9, and the results of the BO preference comparison of the criteria are presented in Table 10.

Step 4. Determine the preference for each dimension and criterion over the worst dimension and criterion (W).

The fourth step is similar to the third step, with the key difference being that the experts' preferences for the worst dimension and criterion selected in the second step were compared in pairs with all dimensions and criteria. Again, the preferences were scored on a scale of 1–9. A score of 1 indicates that the degree of preference for the two items is equal, and the larger the score is, the higher the degree of dislike is for the worst item relative to the other item. The results of the OW preference comparison of the dimensions are presented in Table 11, and the results of the preference comparison of the OW of the criteria are presented in Table 12.

Step 5. Compute the optimal weights of the dimensions and criteria (w_1^*,w_2^*, … ,w_n^*).

The fifth step comprises the computation of the weights of the dimensions and criteria by the linear programming method of BWM. The data were obtained as described in Steps 3 and 4 of Section 4.3. This study adopted solver linear BWM [114] to perform the computation. A simple arithmetic mean was calculated for each dimension and criterion for the weight calculation. Table 13 illustrates the weights and consistency ratios of the dimensions from the seven experts. The consistency ratios ranged between 0.06 and 0.07, indicating that the results of the preference comparison were reliable. Table 14 presents the weights and consistency ratios of the criteria. The consistency ratios ranged between 0.00 and 0.24, indicating that the results of the preference comparison were also reliable. Finally, the weights of each dimension and criterion were integrated, and the global weights of the criteria and their rankings are presented in Table 15.

Table 8. Best and worst criteria identified by experts.

Preference	Criteria																				
	C11	C12	C21	C22	C31	C32	C33	C34	C35	C36	C37	C41	C43	C44	C51	C52	C53	C54	C61	C62	C63
Best	3, 4, 5, 7	1, 2, 6	3, 4, 7	1, 2, 5, 6	7	2, 3	1		5, 6		4	2	1, 5, 6	3, 4, 7	3, 5, 6, 7	1, 2		4	1, 3, 6, 7	5	2, 4
Worst	1, 2, 6	3, 4, 5, 7	1, 2, 5, 6	3, 4, 7	4	6, 7		1, 5			2, 3	6, 7	2, 3, 4	1, 5	2		4, 6	1, 3, 5, 7	4	2	1, 3, 5, 6, 7

Table 9. BO vectors of dimensions.

Respondent No.	Best Dim.	D1	D2	D3	D4	D5	D6
1	D1	1	1	2	1	3	2
2	D1	1	7	8	7	6	7
3	D1	1	1	2	5	2	1
4	D2	5	1	4	6	3	6
5	D2	7	1	3	3	6	5
6	D1	1	7	5	6	3	8
7	D5	3	5	3	4	1	4

Table 10. BO vectors of criteria.

Respondent No.	Best Criteria	C11	C12	C21	C22	C31	C32	C33	C34	C35	C36	C37	C41	C43	C44	C51	C52	C53	C54	C61	C62	C63
1	C12	3	1																			
2	C12	7	1																			
3	C11	1	5																			
4	C11	1	5																			
5	C11	1	6																			
6	C12	5	1																			
7	C11	1	8																			
1	C22			3	1																	
2	C22			7	1																	
3	C21			1	5																	
4	C21			1	2																	

Table 10. *Cont.*

Respondent No.	Best Criteria	C11	C12	C21	C22	C31	C32	C33	C34	C35	C36	C37	C41	C43	C44	C51	C52	C53	C54	C61	C62	C63
5	C22			5	1																	
6	C22			7	1																	
7	C21			1	8																	
1	C33					4	2	1	3	2	3	2										
2	C32					7	1	4	3	3	2	6										
3	C32					2	1	3	2	3	2	5										
4	C37					9	2	3	4	2	4	1										
5	C35					4	3	3	5	1	3	2										
6	C35					4	7	8	6	1	8	1										
7	C31					1	7	3	5	4	5	5										
1	C43												3	1	5							
2	C41												1	5	4							
3	C44												1	2	1							
4	C44												4	7	1							
5	C43												3	1	7							
6	C43												5	1	4							
7	C44												7	4	1							
1	C52															3	1	4	7			
2	C52															6	1	5	4			
3	C51															1	2	3	5			
4	C54															2	3	4	1			
5	C51															1	3	4	7			
6	C51															1	5	5	1			
7	C51															1	5	3	6			
1	C61																			1	4	5
2	C63																			3	6	1
3	C61																			1	2	6
4	C63																			3	2	1
5	C62																			7	1	6
6	C61																			1	1	8
7	C61																			1	2	5

Table 11. OW vectors of dimensions.

Respondent No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Worst Dim.	D6	D4	D4	D4	D5	D6	D2
D1	3	8	5	2	2	8	2
D2	3	1	5	7	8	1	1
D3	2	1	6	3	3	2	2
D4	3	1	1	1	3	2	2
D5	2	2	5	4	1	1	7
D6	1	2	6	2	2	1	2

Table 12. OW vectors of criteria.

Respondent No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Worst Criteria	C11	C11	C12	C12	C12	C11	C12	C21	C21	C22	C22	C21	C21	C22	C34	C37	C37	C31	C34	C32	C32
C11	1	1	5	5	6	1	8														
C12	3	7	1	1	1	5	1														
C21								1	1	5	2	1	1	8							
C22								3	7	1	1	5	7	1							
C31															2	2	2	1	2	3	8
C32															3	7	5	4	2	1	1
C33															4	2	3	5	3	2	3
C34															1	3	4	2	1	2	2
C35															4	2	3	5	7	9	2
C36															2	4	2	2	3	2	3
C37															4	1	1	9	3	6	4
C41	3	4	2	2	4	1	1														

Table 12. *Cont.*

Respondent No.	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
C43	5	1	1	1	8	6	3														
C44	1	2	3	9	1	2	8														
C51								3	1	6	4	8	8	8							
C52								6	8	4	3	4	2	2							
C53								3	2	4	1	3	1	2							
C54								1	2	1	6	1	8	1							
C61															4	2	5	1	2	8	5
C62															2	1	4	3	3	8	2
C63															1	8	1	2	1	1	1

Table 13. Weights and consistency ratio of dimensions.

Respondent No.	Weight						Ksi *
	D1	D2	D3	D4	D5	D6	
1	0.20	0.26	0.13	0.26	0.09	0.07	0.06
2	0.57	0.07	0.08	0.09	0.10	0.09	0.06
3	0.22	0.22	0.14	0.03	0.14	0.25	0.06
4	0.10	0.44	0.13	0.06	0.17	0.09	0.07
5	0.07	0.44	0.17	0.17	0.06	0.10	0.06
6	0.50	0.07	0.11	0.10	0.14	0.07	0.07
7	0.26	0.07	0.15	0.12	0.40	0.12	0.07
Average	0.26	0.22	0.13	0.12	0.16	0.11	

Ksi *: consistency ratio.

Table 14. Weight and consistency ratio of criteria.

Respondent No.	Weight		Ksi *	Weight		Ksi *	Weight							Ksi *	Weight			Ksi *	Weight				Ksi *	Weight			Ksi *
	C11	C12		C21	C22		C31	C32	C33	C34	C35	C36	C37		C41	C43	C44		C51	C52	C53	C54		C61	C62	C63	
1	0.25	0.75	0.00	0.25	0.75	0.07	0.08	0.16	0.25	0.06	0.16	0.11	0.16	0.07	0.24	0.64	0.11	0.09	0.21	0.55	0.16	0.08	0.08	0.67	0.19	0.14	0.10
2	0.13	0.87	0.00	0.13	0.87	0.04	0.06	0.34	0.1	0.13	0.13	0.19	0.05	0.04	0.67	0.14	0.19	0.10	0.09	0.6	0.14	0.17	0.09	0.25	0.09	0.66	0.09
3	0.83	0.17	0.00	0.83	0.17	0.04	0.14	0.29	0.11	0.16	0.11	0.14	0.05	0.04	0.39	0.17	0.44	0.06	0.46	0.28	0.19	0.07	0.10	0.58	0.33	0.10	0.08
4	0.83	0.17	0.00	0.67	0.33	0.04	0.03	0.16	0.12	0.09	0.18	0.09	0.32	0.04	0.20	0.09	0.71	0.09	0.27	0.18	0.09	0.45	0.09	0.17	0.33	0.50	0.17
5	0.86	0.14	0.00	0.17	0.83	0.05	0.09	0.12	0.12	0.05	0.31	0.12	0.18	0.05	0.25	0.67	0.08	0.08	0.56	0.21	0.16	0.07	0.07	0.13	0.71	0.16	0.24
6	0.17	0.83	0.00	0.13	0.87	0.05	0.10	0.05	0.05	0.07	0.36	0.05	0.32	0.05	0.13	0.69	0.19	0.06	0.38	0.09	0.06	0.47	0.09	0.47	0.47	0.06	0.00
7	0.89	0.11	0.00	0.89	0.11	0.08	0.39	0.04	0.16	0.1	0.12	0.10	0.10	0.08	0.09	0.20	0.71	0.08	0.57	0.13	0.22	0.08	0.08	0.59	0.28	0.13	0.03
Average	0.57	0.43		0.44	0.56		0.13	0.17	0.13	0.09	0.20	0.11	0.17		0.28	0.37	0.35		0.36	0.29	0.14	0.2		0.41	0.34	0.25	

Ksi *: consistency ratio.

Table 15. Local and global weight of dimensions and criteria.

Dimension	Dimension Weights	Criteria	Criteria Weights	Global Weight of Criteria	Rank
Talent (D1)	0.26	Personnel assessment and incentive (C11)	0.57	0.148	1
		Innovative employee (C12)	0.43	0.112	3
Achievement (D2)	0.22	Transformation platform of scientific and technological achievements (C21)	0.44	0.097	4
		Transformation mode of scientific and technological achievements (C22)	0.56	0.123	2
System (D3)	0.13	Innovative management mechanism (C31)	0.13	0.017	18
		Innovation and entrepreneurship strategy (C32)	0.17	0.022	16
		Technology-based enterprises (C33)	0.13	0.017	18
		Mainstay of innovation (C34)	0.09	0.012	21
		Key common technologies (C35)	0.20	0.026	14
		Innovation and entrepreneurship environment (C36)	0.11	0.015	20
		Intellectual property rights (C37)	0.17	0.022	16
Finance (D4)	0.12	Financial development environment (C41)	0.28	0.034	11
		New financial model (C43)	0.37	0.045	7
		Financial supervision mechanism (C44)	0.35	0.042	9
Organization (D5)	0.16	Collaborative innovation ecosystem (C51)	0.36	0.058	5
		New type of scientific research institution (C52)	0.29	0.047	6
		Science and technology innovation base (C53)	0.14	0.023	15
		Intellectual property intermediaries (C54)	0.20	0.032	12
Resource (D6)	0.11	Innovation resource integration (C61)	0.41	0.045	7
		Fiscal and financial system (C62)	0.34	0.037	10
		Innovative resource allocation (C63)	0.25	0.028	13

In terms of the dimensions, the order of the weights is as follows: talent (D1; 26%), achievement (D2; 22%), organization (D5; 16%), system (D3; 13%), finance (D4; 12%), and resources (D6; 11%). The weights of talent (D1) and achievement (D2) both exceeded 20%, and the total weight of these two criteria was 48%. The weights of the remaining four items were all less than 16%. The four criteria with the highest global weights were personnel assessment and incentive (C11; 14.8%), transformation mode of scientific and technological achievements (C22; 12.3%), innovative employee (C12; 11.2%), and transformation platform of scientific and technological achievements (C21; 9.7%). The total weight of these four criteria was 48%. The weights of the remaining 17 items were all less than 6%, and their aggregate weight was 52%.

5. Discussion

In this study, we investigated the innovation drivers of NOKEC in China and their weights by adopting a comprehensive and systematic approach to formulate an empirical case for validating the proposed methodology. This study identified 21 innovation drivers and proposed their weights. Our results are crucial because they offer a novel perspective on NOKEC based on the integrated modified Delphi–BWM. To our knowledge, this study represents the first application of the integrated modified Delphi method–BWM to explore the innovation drivers of NOKEC in China. Although innovation drivers of NOKEC in China have been discussed in the relevant literature, prior studies have focused on individual industries [14–16] or have analyzed historical data [17–19]. By contrast, our study conducted a thorough review of the relevant literature published in 2015–2019. Consequently, the opinions of an expert panel were investigated with the BWM, and the results reveal more reliable and meaningful insights than those of prior relevant studies.

The demographic dividend was among the main drivers of China's economic development in the 1990s. However, the demographic dividend is no longer a major driving force, and high-level innovative employees are even more crucial for the ongoing development of China's economy. The empirical results of this study reveal that the most crucial task for implementing NOKEC is the introduction of high-level innovative employees (criterion ranking No. 3). The innovative employee criterion can be divided into high-level employee, entrepreneurial and innovative employee, and young innovative employee. As such, the establishment of an optimized recruitment mechanism is crucial [77]. In addition, based on the development level of strategic emerging industries, a flexible system of innovation incentives and assessment (criterion ranking No. 1) must be established to ensure the stability of China's core human resource development [83,115]. Talent is the foundation of all reforms, and tailoring the incentives and assessment system may encourage highly skilled workers to contribute their expertise in the future, thus maintaining a stream of demographic dividends, as has been suggested by numerous studies [12,79,116].

In addition, the two criteria ranking second and fourth in global weights were transformation mode of scientific and technological achievements (C22) and transformation platform of scientific and technological achievements (C21), both of which were classified in the market dimension. This indicates that the innovation mode of economic development has changed from resource utilization to technological development. Therefore, R&D achievements must be commercialized effectively to ensure a high level of economic development.

Our study demonstrates a rigorous and feasible method of identifying the innovation drivers of NOKEC. Our findings provide crucial insights on the different attributes contributing to NOKEC that should allow decision makers to fully understand and prioritize the innovation drivers. Furthermore, in the process of our empirical research, the integrated modified Delphi–BWM was proven to be superior to the Delphi AHP in terms of implementation time and data quality. This result is intuitive because the AHP requires 50 pairwise comparisons but BWM uses only 48, and the consistency ratio of BWM ranges from 0.00 to 0.24.

6. Conclusions and Research Suggestions

China has experienced a continuous decline in GDP growth. NOKEC is considered to be a highly distinctive proposal for revitalizing China's economic development, and numerous Chinese economists have argued in favor of developing the innovation drivers of NOKEC. Thus, this study proposed a modified Delphi method combined with BWM as a framework for conducting comprehensive and systematic research on the innovation drivers of NOKEC in China. The results of this study provide a basis for prioritization of the innovation drivers. A case study was undertaken to assess the validity of the integrated modified Delphi–BWM method. There are two main contributions of this study: first, to the best of our knowledge, our work is a pioneer study, aiming at applying BWM to assessing the relative weights of the innovation drivers. Second, extracting the innovation drivers of NOKEC from the literature is also a leading effort compared with other relevant studies.

The research framework and its empirical results can allow decision makers to fully understand their operating procedures and the relative importance of all the dimensions and criteria as a basis for prioritizing innovation drivers. In addition, this study can help researchers improve their understanding of theoretical economic development problems and improve on evaluations of innovation drivers for organizations.

The main limitations of this paper are manifested in two aspects: the extraction of innovation-driven factors for NOKEC and the limitations of the empirical research objects. Given the increasing amount of research on China's economic transformation and upgrading, more effective innovation drivers than those examined in our study are likely to be discovered. The period adopted in our study represents an early stage of research on this subject, so the completeness of the innovation-driven factors might inevitably become insufficient over time. In addition, China comprises a vast territory, and levels of economic development vary substantially among its regions. Therefore, extending the conclusions of this study to other regions in China might result in cognitive blind spots.

Future research should consider the substantial and far-reaching effects of the COVID-2019 pandemic on economic development. Some economists have predicted that future economic structure and business models will inevitably undergo considerable changes. Therefore, the variability of the driving factors of NOKEC should be reconfirmed in the post-COVID-19 era. In addition, the research framework proposed in this paper could be adopted to expand the scope of empirical research, such as by examining different regional economies to enhance subsequent applications of this approach. Moreover, the decision-making trial and evaluation laboratory should be adopted as a method to explore the causal relationship between the innovation drivers, thereby to improve management effectiveness.

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Abbreviations

New and old kinetic energy conversion	NOKEC
Multiple-criteria decision-making	MCDM
Best–worst method	BWM
Analytic hierarchy process	AHP
Technique for order preference by similarity to ideal solution	TOPSIS

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