Research Article

Dynamic Fusion Simulation Method of Intertemporal Decision Preferences of Large Groups in Weak Relationships

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The fusion of large group decision-making preferences is generally based on hard constraints, and the general low-consensus heterogeneous preference interaction situation of weak relationship decision-making under soft constraints has not been investigated. This study puts forward the preference connotation structure and preference attributes of the intertemporal decision-making of weak relationships groups, objective preference comparison standards between individuals, preference interaction neighborhoods between individuals, preference learning adjustment rules, and preference cycle interaction result evaluation connotations. On this basis, this research constructs a multistage and multiple-round intertemporal decision-making preference dynamic fusion theory and a method for weak relationship large groups. The simulation results verify and support the constructed preference fusion theory and method, indicating that a relatively rational interactive learning and adjustment process can improve the group decision-making performance of the key digital technology R&D team for offshore wind power project construction, operation, and maintenance and effectively improve the convergence level, convergence time, comprehensive decision-making benefits, and decision-making cognition. In the increasingly open large group intertemporal decision-making situation, these research viewpoints and conclusions will help to expand the strong relationship hypotheses of preference fusion in previous group decision-making research. The research opinions and conclusions supplement the theory and method of preference interaction fusion under soft constraints in large group decision-making.

1. Introduction

Considering the heterogeneous preference structure of participants’ cultural background and experience differences and improving the consensus model of decision-making for assembling group preferences are important research contents for the optimization of information conversion function of group decision-making. The research conducted so far has formed a more systematic heterogeneous preference fusion theory for utility value [1], preference order [2], multiplicative preference relations [3], fuzzy preference relations [4], and other heterogeneous preference structures. Based on this, as an extension of the problem of minority preference structure in group decision-making, the consensus gathering and coordination of large group decision-making constitute a hot issue in group decision-making research in recent years, and the existing results focus on the basic characteristics of large participant group size (often larger than 20 people) and the existence of some noncooperative behaviors and mainly carry out the research on the attributes of noncooperative behaviors under hard constraints (the task or social connection of decision-making participants is relatively close), such as noncooperative behavior attribute research, large group behavior preference feature mining, and decision group weight coordination method. For example, many scholars have focused on the cooperation degree index [5]; noncooperative individuals/small group characteristics [6]; noncooperative behavioral preferences [1]; and differences in subgroup consensus patterns [7] based on data mining of fuzzy mean clustering,
group behavioral effects in decision-making, and characteristics of cooperation itself (timeliness, fairness, and professionalism), forming a theory and model underlying weight adjustment for large group decision-making. However, existing studies have focused more on the characterization and coordination of weighting factors of both cooperative and noncooperative groups under hard constraints as the main factors affecting the convergence efficiency of consensus in large group decision-making, while ignoring the heterogeneous preferences of decision participants arising in the soft-constrained (looser task or social relationships of decision participants) large group environment and ignoring the group preference interaction characteristics that are prevalent within noncooperative behaviors in decision-making. For example, enterprises organize bidding and procurement, the government implements emergency management, and research institutions conduct professional evaluations, all of which are large group decisions under hard constraints. On the other hand, enterprises carry out entrepreneurial project preparation, government organizations collect policy recommendations, research institutions implement cross-disciplinary project evaluation, etc., which belongs to large group decision-making under soft constraints. Since the latter's decision-making process is difficult to standardize, and the decision-making task association and the decision-maker's social relationship are looser, more uncertainty is faced in preference fusion.

Weak relationships reflected by soft constraints were originally proposed by Grannovetter in the study of the strength of social network relationships [8], referring to the relationships established between actors through brief social contacts, which are generally characterized by broad participation groups, heterogeneity of participating individuals, low tenure of participating relationships, and unstructured participation processes. In recent years, along with the emergence of new decision-making contexts such as innovation and entrepreneurship, sharing economy, and digital intelligence change, the rapidly changing competitive environment and cooperation model not only put higher demands on the openness and management flexibility of organizations, but also make the soft constraint of large group decision-making preference aggregation based on weak relationships begin to emerge. For example, the Energy Paradox (EP) is an important problem that hinders the diffusion of smart green technologies [9], and Kamble et al. [10] use large group decision-making techniques to identify and rank the best big data-driven circular economy practices in the auto parts industry. Numerous scholars have explored the irrational factors of long-run consumption behavior in loose group relationships in terms of information validity, cost-benefit transfer, consumption level, and soft structural constraints [3,4], showing that although smart green products and technologies have lower energy costs and more significant social benefits in the medium and long term, the decision-making participant groups generally present relatively high short-term alternative economic and psychological costs, making large groups of weak relationship people often exhibit a certain degree of interterm decision-making properties due to fragmented individual preferences and complex decision connotations. In this regard, in a few representative papers of soft constraint consensus studies, Palomares et al. [11] proposed a web consensus model under heterogeneous preferences; Perez et al. [12] improved the method of coordinating the preference similarity of high, medium, and low individuals and groups; Dong et al. [13] constructed an overall preference adjustment model for noncooperative groups based on prospect theory; Mandal et al. [14] constructed a large-scale and consensus model based on the Pythagorean language preference relationship by considering the degree of nonmembership and hesitancy of experts; Meng et al. [15] proposed a group decision-making method based on the dual multiplication language preference relationship for the decision-maker's asymmetric qualitative judgment hesitancy. However, they did not investigate the general low-consensus situations of noncooperative group preference adjustment model to carry out thematic research and have not yet systematically proposed the characterization and fusion methods of decision preference traits and interaction attributes of large groups in weak relation.

The research so far has shown that heterogeneous preference fusion in large group decision-making has important research value, but the existing results have mainly formed the basic theory and model of weight adjustment of cooperative/noncooperative groups in large group decision-making with hard constraints, while the basic theory of preference fusion of large groups in weak relationships has not been systematically proposed for soft constraints. It is found that the characteristics of "similar knowledge, ability, and value orientation of participants," "relatively concentrated preferences of a few individuals," and "relatively clear preference interaction orientation among individuals" are different from those of large group decision-making under hard constraints [16]. This leads to a narrow scope of communication between decision-makers, a lack of regulation of the relationship of authority, and difficulties in aggregating consensus [17], which greatly increases the cost and reduces the efficiency of group decision-making. Considering that the basic characteristics of large group decision-making in weak relations are that large-scale individuals jointly express decentralized preferences, individuals only interact with some of their neighbors, and the information scope involved in the interaction is narrow [16–18], this study defines large group decision-making in weak relations as an informal cooperative relationship formed on a temporary basis, in which subjects consisting of heterogeneous partners with different domain strengths interact in a low familiarity situation in the process of making multiple rounds of judgmental choices and finally reaching a unified opinion on the executable solutions. Aiming at this definition, the interaction state and law of large groups of weak relationships coincide with the view that individuals choose to form optimal decisions at different stages in Intertemporal Decision Theory [19] (weighing costs, values, and risks). Based on the above considerations, this study will analyze the content, form, and process evaluation of individuals in large groups influenced by others and their own influence on others, which can provide a reference for supplementing the soft constraints of preference interaction in large groups of weak relationships.
2. Problem Description of Intertemporal Decision-Making for Large Groups in Weak Relationships

2.1. Preference Implication Structure of Intertemporal Decision-Making in Weak Relationships of Large Groups. Weak relationship decision-making has the basic characteristic of large-scale individuals jointly expressing dispersed preferences. Related progress shows that due to the large number of individuals involved in decision-making, informal forms of cooperation, and high preference heterogeneity, there is a high degree of initial disagreement, low communication effectiveness, and weak willingness to cooperate in the process of group interaction to form consensus. Jackson et al. [20] pointed out that the larger size of decision participants in open situations (often larger than 20); the personality characteristics, knowledge, and industry background of decision-makers; and other factors lead to a higher possibility of cognitive bias among individuals. Han et al. [21] found that in the absence of effective decision constraints and optimal value decisions, not only do group opinions have the characteristic of bursting out with external stimuli, but they also often lead to higher initial disagreement in decisions due to the lack of conflict regulation ability.

The above characteristics suggest that the scale of decision individuals, the high heterogeneity, and the tendency of opinion emergence influenced by the environment will make decision-making in weak relations unable to produce a unified view at the initial interaction stage, and it is necessary to clarify the initial state and conditions that may affect decision-making concerning group size, preference heterogeneity attributes, and dynamic characteristics. In this regard, further research on interperiod selection and large group interaction found that participants’ understanding of their own expected values, decision implementation period, and cognitive ability are the main factors influencing group consensus, and they affect the content, distribution pattern and potential interaction paths, and the steady state of decision preferences of decision-makers through the decision information structure jointly formed by a large number of random opinions, which has an important impact on the content and the process of decision preference convergence of large groups in weak relationships. This has an important impact on the content and process of decision preference integration of large groups in weak relationships.

Based on the above analysis, the following hypotheses are given for the attributes of large groups in weak relationships and their inter-decisional preference connotations.

Hypothesis 1. A larger group with similar decision $G(g_n)$ ($n \geq 20$) needs but distinct differences in individual traits expresses decision information jointly under a sequential decision condition with period number $I(i \geq 1$ and is an integer), and the individuals $g$ in this group are considered equal, have no significant interference of affiliation, and are randomly distributed.

Hypothesis 2. Assuming that the individuals $g$ have the basic preference content of three variables, including decision expectation $V(v_{gi})$, decision execution period $T(t_{gi})$, and decision perception level $K(k_{gi})$ in the period of $i$, the set of decision preferences of the weakly related group is $A = \{ a_{gi} \}$, $a_{gi} = (v_{gi}, t_{gi}, k_{gi})$, and it constitutes the basic content and initial state of the dynamic fusion of decision preferences of the weakly related large group.

2.2. Expectation and Execution Cycle Attributes of Intertemporal Decision Preferences of Weakly Related Large Groups

2.2.1. Decision Expectancy Attributes of Intertemporal Decision Preferences of Weakly Related Large Groups. Intertemporal decision expectations [22] are the combined reflection of decision-makers’ needs, situations, and expectations in their intertemporal decision-making process. Related advances suggest that the level of gain in a dispersed, low-repetition decision situation or the level of loss in a loss related situation is the main trade-off for decision-makers [22] and that their subjective preference for this personal preference in general presents a random distribution corresponding to demographic properties.

Based on the above analysis, the following hypothesis is given for the expected individual attributes of interperiod decision preferences of large groups in weak relations.

Hypothesis 3. The individual $g$ on the future value of the decision in the period $i$ decision is $v_{gi}$; the larger its value, the better the comprehensive benefit it represents; and the initial $v_{gi}$ of the decision stage is randomly distributed.

2.2.2. Decision Execution Cycle Attributes of Cross-Period Decision Preferences for Large Groups of Weak Relationships. The execution cycle of an intertemporal decision [23] refers to the decision-maker’s choice of different execution cycles when faced with multiple options of the same value due to the time cost and forward risk of the intertemporal decision process. Related progress has shown that the time perception trait of decision-makers has a differential effect, usually decision-makers have a time overestimation tendency, their time poverty will lead to a more stable “subjective time stretch,” and those who overestimate time will choose the near-term option in the intertemporal decision [23], thus limiting their forward-looking behavior.

Based on the above analysis, the following hypothesis is given for the decision execution cycle attribute of the intertemporal decision preferences of the weakly related large group.

Hypothesis 4. The individual $g$ in the period $i$ decision is $t_{gi}$; the larger its value, the more optimistic the judgment of decision continuity it represents; and the decision initial stage of $t_{gi}$ is dominated by the recent option, where $t_{gi} \in [1, 10]$ and is an integer, routinely 1–3 for short term, 4–7 for medium term, and 8 and above for long term.
2.2.3. The Relative Trends of Individual Decision Expectation and Execution Cycle Attributes. Hyperbolic discounting modeling has shown that the immediate base utility in intertemporal choice changes with the adjustment of the decision cycle; i.e., the decision-maker’s execution cycle will first change in response to the adjusted salience of the integrated utility level, while the decision expectation will change passively with the decision cycle [24]. Related advances have also shown that when decision-makers are in a low expectation or negative state, their tolerance and self-control will be significantly reduced, and they are more inclined to ignore long-term values and choose to obtain short-term values [23]; i.e., individual decision expectations have a tendency of adaptive selection with the decision cycle conditional on a clear trend of overall utility change.

Based on the above analysis, the following hypothesis is given for the relationship between individual expectations and execution cycle in intertemporal decision-making for large groups in weak relationships.

Hypothesis 5. When the integrated utility level changes, the decision-making individual $g$’s $v_{gi}$ will be adjusted by adaptive selection along with the change of the integrated utility level $t_{gi}$; i.e., when the integrated utility level $t_{gi}$ is raised (lowered), $v_{gi}$ is raised or unchanged (lowered or unchanged), at which time the adjustment of $v_{gi}$ will be made opportunistically, where $v_{gi}$ is the subjective judgment value of the future value of the decision by the individual $g$ in the decision period $i$, and $t_{gi}$ is the subjective judgment value of the implementation period of the decision by the individual $g$ in the decision period $i$.

2.3. Decision Perception Level Attributes of Intertemporal Decision Preferences of Weakly Related Large Groups. For computational simplicity, previous studies on Discounted Utility Model (DUM) in intertemporal choice theory usually assume the existence of a static baseline discount rate [24] to measure the difference between observations and optimal choices, or estimate and form an aggregated discount rate consistent with the observations based on the hypothetical model. However, recent studies related to the energy efficiency paradox of intertemporal choice behavior have found that individual heterogeneity makes the discount rate significantly different among decision-makers, and thus considering the differences in individual discount rates and their variation characteristics from multidimensional discounting factors (e.g., hyperbolic discounting, quantity effects, and framing effects) [25] is important to reveal the underlying logic of decision-maker’s idiosyncratic choice behavior.

In view of this, to better reflect the influence of multidimensional discounting factors on the level of discounting and the trend of changes in the decision-maker’s position, the concept of cognitive level of intertemporal decision-making is proposed here, which is defined as the degree of decision-maker’s understanding of the aforementioned reasons and trends of changes in decision expectations and decision execution cycle attributes. Related advances have shown that individuals’ cognitive abilities are subjectively regulated differently by their “state self-control” and “trait self-control” [26]; people always tend to assign more benefits (or losses) than near-term benefits (or losses) when they do not know each other well [25]. Although increasing the time discount helps to form a consensus on short-term issues, the particular time discount will continue to decrease with knowledge learning and experience accumulation, and the increase in the individual cognitive ability it brings will be more helpful to improve participants’ understanding of the main factors affecting decision effectiveness (cost, value, risk, etc.) [23], thus fundamentally enhancing the level of decision consensus; the actual statistics on individual time preferences also show that the discount rate is dynamic and generally indicates a decreasing pattern with time.

Based on the above analysis, the following hypotheses are given for the individual attributes of the perceived level of intertemporal decision preferences of large groups in weak relations.

Hypothesis 6. Assume that the level of subjective judgment of the reliability of the decision individual $g$ in the decision period $i$ is $K(k_{gi})$; its value denotes the opposite of the value of the time discount rate, that is, $k_{gi} \in (0, 1)$; and the larger the value, the higher the cognitive level. It is believed that the current and future expectation level and the decision implementation cycle can be treated rationally balanced by decision-maker, where $k_{gi} \in (0, 0.3)$ is low cognitive level, $k_{gi} \in [0.3, 0.6]$ medium cognitive level, and $k_{gi} \in [0.6, 1]$ high cognitive level.

Hypothesis 7. Under the condition that the complex influences of the decision environment interfere, the value $K$ of the individual $g$’s cognitive level in each period of decision-making tends to increase uniformly, i.e.,

\begin{equation}
K(k_{gi}) = k_{gi(i-1)} + k'_{gi},
\end{equation}

\begin{equation}
k'_{gi} = \frac{1 - k_{gi(i-1)}}{m \cdot k_{gi(i-1)}},
\end{equation}

where $m$ is a larger real number; when $i = 1$, $k_{gi(i)}$ is the time discount rate of the individual $g$ in period 1; $k_{gi}$ is the coefficient of the time discount rate with the number of transactions, which is influenced by the combination of demographic characteristics; the overall adjustment of $k_{gi}$ is small; and the adjustment decreases with the increase of cognitive level. Since it is usually difficult to adjust cognition for very large $k_{gi}$ (tending to 1) or very small (tending to 0) individuals, (1) and (2) hold when $k_{gi} \in (k_a, k_b)$ $(0 \ll k_a \ll k_b \ll 1)$, and only when $k_{gi} \leq k_a$, the individual $g$ will default to a smaller, constant value in the next period.

3. Basis for Comparison of Individual Interperiod Decision Preferences for Large Groups of Weak Relationships

3.1. Objective Comparison Criteria of Interindividual Preferences. The analysis of Sections 2.1 to 2.3 shows that the decision information $a_{gi} = (v_{gi}, t_{gi}, k_{gi})$ expressed by
individuals in each period is subjective and not directly comparable among individuals in the interperiod decision-making process of weakly related large groups. Related advances have shown that there are significant differences in the interactability properties of individual preference information in decision situations of weak relationships, and the interaction information of the group is narrow in scope; i.e., it is formally filled with a large number of multiple sources and types of subjective indirect information about decision interactions, but in substance, there is relatively little objective direct information that can produce knowledge growth, ability enhancement, or cognitive updating for different interaction objects [27]. In this regard, Jackson et al. [20] argued that groups would collectively shape the cognitive processing style and thought inertia of decision information, transforming the uncertainty of this information with respect to the integrated expectation level of established decision-makers [21] in order to become valid information and be received, selected, and iterated by themselves.

In fact, as a classical model for assessing the value of intertemporal choice time preferences, the hyperbolic discounting model [28], formed based on the improvement of the exponential discounting model, can provide a methodological reference for achieving the integrated conversion of objective and direct information about preferences in the above context. The conventional hyperbolic discounting model describes a time-varying preference, where the discount rate decreases with increasing discounting time; i.e., there is a “Present Bias” phenomenon in preference [29], except that the model does not take into account the association of decisions in each period (assuming that periods are independent of each other) and the individual time preference (i.e., the cognitive preference in this study). The assumptions of the decision scenarios are consistent with the previous analysis, except that the model does not take into account differences in decision associations across periods (assuming that periods are independent of each other) and individual time preferences (i.e., cognitive preferences in this study). Accordingly, the hyperbolic discounting model will be used in this study, replacing the established decision time in the original model with one that reflects the relative changing state \( t_{gi} \) (as shown in Hypothesis 5) and replacing the time discount rate in the original model, in which all individuals change equally and the discounted connotation is single, with a decentralized change in the cognitive level \( k_{gi} \) (as shown in Hypothesis 7). Considering the joint effect of the three types of weak relation preferences, the discounted combined expectation level \( V^{'} \) will be used as the criterion for cross-referencing interindividual decision preferences.

Based on the above analysis, the objective comparison criteria of interindividual preferences for interperiod decision-making in large groups of weak relationships are defined as follows.

**Definition 1.** The comprehensive expectation level that integrates the individual \( g \) decision expectation, the implementation cycle, and the cognitive level \( v_{gi}^{'} \) at which it is located is the objective comparison criterion for the current discounted value of multidimensional preference information among individuals, i.e.,

\[
v_{gi}^{'} = k_{gi}^e v_{gi},
\]

where \( k_{gi} \) is the level of subjective judgment of the individual \( g \) on the reliability of the decision in the period \( i \), \( t_{gi} \) is the value of subjective judgment of the individual \( g \) on the implementation cycle of the decision in the period \( i \), and \( v_{gi} \) is the value of subjective judgment of the individual \( g \) on the future value of the decision in the period \( i \).

### 3.2. Interaction Neighborhood Definition of Interindividual Preferences

**Definition 1** provides an objective comparison criterion for interindividual preferences, but not all decision-makers interact with their preferences accordingly, and intertemporal decision-making individuals in large groups of weak relationships also exhibit the basic characteristic that “individuals interact with only some of their neighbors.” Related advances suggest that stateful factors have an indirect effect on decision-makers’ expectations and that they tend to cooperate with individuals of similar value level [30], while uncertain or ineffective decision rules tend to trigger “random matching in proximity” or social categorization processes similar to informal organizations [31], and defensiveness of decision-makers. The defensiveness of individuals may prevent groups from forming effective interaction neighborhoods and consensus states. These factors together lead to the coexistence of a wide range of interactions and a narrow range of effective choices in weakly related decision situations. Although formally there are more decision participants and higher interaction possibilities, the substantive interaction range of decision-makers in the interaction process is smaller due to the interference of the decision interaction domain.

In response to the above characteristics, advances in the study of opinion dynamics in the analysis of opinion evolution process and mechanism suggest that objects within the confidence interval of individuals can be regarded as potential interactors, but the Defuant model for discrete opinions and the Hegselmann–Krause (later referred to as HK) model for continuous opinions in this field are currently difficult to meet. However, the Defuant model for discrete views and the Hegselmann–Krause (HK) model for continuous views, both of which are classical models in this field, have difficulties in meeting the above contextual needs and do not consider the influence of themselves and the environment on the evolution of individual views [32]. Among them, the Defuant model only considers the interaction between two random individuals within the confidence threshold in each period as the interaction object, and the completely random and two-person interaction setting cannot reflect the gradual self-classification process of the weakly related group. The HK model treats all individuals within the confidence threshold in each period as the interaction object, ignoring the limited decision rationality interference of the weakly related group. In view of this, considering that the
hypothesized situation is more similar to the HK model, this study proposes a basic scheme to determine the interaction mode and threshold setting method of the bounded trust model for the different stages of weakly related group interaction, from the initial small random selection to the later stable complete selection within subgroups, and for the interaction neighborhoods and their potential ways that may affect the main interaction process.

Based on the above analysis, the interindividual preference interaction neighborhood for interphase decision-making in weakly related large groups is defined as follows.

**Definition 2.** Under the influence of limited decision rationality, individuals will only be likely to interact with proximity \(l(2 \leq l \leq 7)\) to one decision-maker, where, for simplicity, the decision group will be divided into an integer number of subgroups \(nl\) with redundant individuals forming a subgroup and preference interaction and convergence occurring only in the subgroup.

Based on the analytical framework of consensus distance and confidence region for group decision-making under heterogeneous preferences in the literature [16,17], Definition 3 is proposed as the trade-off condition for preference interaction by taking the relative differences in the discounted composite expectation among individuals and the threshold of interaction confidence of the corresponding context.

**Definition 3.** The interaction of \(g\) and \(g'\) among neighboring \(l\) decision-makers depends on the relative difference \(\Delta_{gg'}\) of the discounted composite expectation and the comparison state of the interaction confidence threshold \(\varepsilon(\varepsilon_a, \varepsilon_b)\) between individuals in a certain decision environment, i.e.,

\[
\Delta_{gg'} = \frac{v_{g'i} - v_{gi}}{v_{gi}},
\]

where \(v_{gi}^{'}\) is the composite expectation level that takes into account the individual \(g\) decision expectation, execution cycle, and cognitive level; let \(0 < \varepsilon_a < \varepsilon_b < \varepsilon, \varepsilon > 1\), and only when \(\varepsilon_a < \Delta_{gg'} < \varepsilon_b\), the interactions between individuals will take place; otherwise, no interactions will take place between individuals. The characteristics of \(\varepsilon_a\) and \(\varepsilon_b\) are described in Definition 4.

**Definition 4.** The confidence threshold \(\varepsilon\) of interindividual interactions is influenced by the combination of group learning cost, learning inertia, learning feasibility, etc. It belongs to a certain type of interaction consensus in a specific decision environment, and its value is relatively stable. The value is relatively stable, where, considering the influence of learning cost and learning inertia, \(\varepsilon_a\) represents the lowest limit of individuals’ willingness to learn in a group; considering the influence of learning feasibility, \(\varepsilon_b\) represents the highest limit of individuals’ willingness to learn in a group.

4. Simulation Scenario of Dynamic Fusion of Intertemporal Decision Preferences for Weakly Related Large Groups

The aforementioned Hypotheses 1 to 7 and Definitions 1 to 4 portray the basic context for carrying out the interaction and fusion of cross-period decision preferences of weak relationship large groups. On this basis, the Hegselmann–Krause model (bounded trust model), which is used to deal with the interaction of linkage variables among individuals in a multisubject situation, is used as the basis for the general process of cyclic interaction of group views until they stabilize or reach the decision needs; the adjustment rules and decision performance measurement criteria for the integration of their own solutions and learning contents in the adjacent phases of the weakly related large groups are proposed; and then the overall process of dynamic integration of decision preferences across phases for weakly related large groups is proposed inductively.

4.1. Interindividual Preference Learning Adjustment Rules in the Interaction Neighborhood. The HK model mentioned in Section 3.2 is the usual method for dealing with the interaction of multisubject linkage variables in this context and has the advantage of theoretical analysis in predicting and describing the macro behavior of the group. However, by default, the HK model takes the information about the arithmetic mean of all individuals within the confidence threshold in each period directly as the learning outcome of the interacting subjects, assuming that individuals’ views are always updated to the mean of all views (including their own) within the ideal confidence threshold [32], which obviously does not take into account the fact that individuals with interaction prerequisites are still indirectly influenced by the learning style and efficiency loss among them. In fact, individuals in interterm decision-making usually do not directly replace the reference object’s solution with their own choice, but they integrate their own solutions in adjacent decision stages with the learning content in order to form a new decision perspective and put it into the next stage of the decision process.

Based on the above analysis, the preference learning adjustment rules among individuals in the interaction neighborhood of a weakly related large group are defined as follows.

**Definition 5.** Individual \(g\) in each decision period and all participants \(g''\) who meet the criteria of the decision neighborhood are treated as interaction learning objects.

**Definition 6.** Due to the narrow interaction information scope and the limitation of interindividual learning effectiveness, the learning adjustment in each decision phase is only for the converted composite expectation \(v_{gi}\) in the current period, and the decision perception level \(K(k_{gi})\) in individual preferences will be adjusted independently according to Hypothesis 5.
Definition 7. The individual $g$ decision-maker converges the absolute values of the differences of all learnable objects $v_{gi}^0$ by the efficiency coefficients $\lambda \in (0, 1)$ to obtain the composite expectation $v_{gi}^{(i+1)}$ in the period $(i + 1)$, which forms the new decision preference $v_{gi}^{(i+1)} = \left(v_{gi}^{(i+1)} + k_{gi}^{(i+1)}\right)$, i.e.,

$$\begin{align*}
v_{gi}^{(i+1)} &= v_{gi}^i + \frac{\lambda \cdot v_{gi}^i}{I}, \\
v_{gi}^i &= \sum_{g'}(v_{gi}^{i'} - v_{gi}^i),
\end{align*}$$

(5)

(6)

where $v_{gi}^i$ is the sum of the differences between the composite expectations of an individual $g$ in the decision neighborhood in the period $i$, $g''$ is the number of participants who meet the criteria of the decision neighborhood; and $I$ is the number of nearby individuals $g$ who may interact with an individual. According to Definition 2, when $n/l$ is a noninteger and an individual is in a subgroup of less than $l$ decision-makers, the $l$ in (5) represents the actual number of subgroups.

Solving (5), according to (3), we get $v_{gi}^{(i+1)} = v_{gi}^{(i+1)}/k_{gi}^{(i+1)}$, $v_{gi}^{(i+1)} = v_{gi}^{(i+1)}(1 - k_{gi}^{(i+1)}m/v_{gi}^{(i+1)})$, on the basis of which we can make $v_{gi}^{(i+1)}$ be $x$, $v_{gi}^{(i+1)}$ be $c$, and $k_{gi}^{(i+1)}$ be $b$, and convert (5) to (7):

$$b^{\rho_{gi}^{(i+1)} \cdot x} = c. \quad (7)$$

In the above equation, since Hypotheses 4 and 5 give the basic assumption of maintaining relative stability of $t_{gi}^{(i+1)}$ and adjusting with the comprehensive utility value first, here we will use the trial assignment method to solve the $k_{gi}^{(i+1)}$ independently adjusted and combined with the change of $v_{gi}^{(i+1)}$ value according to Definition 6. Firstly, we will formulate the possible value of $t_{gi}^{(i+1)}$ and then iteratively solve the parameter value that best satisfies the $v_{gi}^{(i+1)}$ to get solution accuracy (relatively smooth change) in the feasible value space.

4.2. Result Evaluation Scheme of Preference Cyclic Interaction. Combined with Hypotheses 1–7, Definitions 1–7, and the rule setting of (1)–(7), the decision-making individuals within each subgroup involved in the decision-making are adjusted for preference interaction and learning, their average expectation level and decision execution cycle are continuously adjusted, their cognitive level is constantly improved, the decision-making group as a whole will show the state that it is difficult to reach the preference interaction neighborhood, and the preference interaction gradually stagnates. In order to examine the “decision performance” of this group viewpoint cyclic interaction until stabilization process, the corresponding decision performance observation indexes are designed here by combining two indicators of individual viewpoint cyclic iterative convergence level and convergence time, which are usually examined in dynamic group decision-making studies [16,17]. In particular, the convergence level indicates the convergence of group views when the magnetization rate of stable opinions in the group (i.e., the proportion of individuals $g_n$ whose views no longer interact in the total number of the group to the total number of the group) converges to 1. In terms of convergence time, the number of decision periods when the group satisfies the precondition of convergence level is the convergence time of group views. In addition, because the decision goals of the weak relationship large groups are relatively consistent, individuals in the same decision environment usually only have information bias in individual cognitive ability, so the situation of complete dispersion of decision information and the inability to generate interaction does not occur. However, in order to reflect the effect of magnetization rate in the relativity of differences between individuals, this study will also consider the sum of the differences of comprehensive expectations between individuals in the decision neighborhood as this study will also consider the sum of the combined expectations $y$ between individuals in the decision neighborhood as an auxiliary indicator for judging the convergence level of preference information.

Based on the above analysis, the following rules are defined for evaluating the results of the cyclic interaction of preferences of large groups in weak relationships.

Definition 8. When the individuals of a group of subgroups in a period are unable to reach the preference interaction domain, the subgroup will not interact with preferences in the next period, and the preference learning adjustment result of the current period is used as the final decision information.

Definition 9. The sum of the magnetization rate $\rho$ of the stable viewpoint in the group and the difference between the combined expectations $y$ of all individuals in the decision neighborhood is used as the convergence level of the group’s decision, and the maximum acceptable convergence time of the group is set as $t_0$. If the current period $\rho$ is greater than or equal to the limit $\omega_1 \in (0, 1)$, $y$ is less than or equal to the limit $\omega_2 \in (1, v)$, and the current decision time is less than or equal to the limit $t_0$, the previous preference interaction adjustment process ends. If the current period $\rho$ is less than $\omega_1$ or $y$ is equal to the limit $\omega_2$ and the current decision time is less than or equal to the limit $t_0$, the previous preference interaction adjustment process continues to the next round. If the current decision time is greater than $t_0$, the preference interaction process ends. Let $\tilde{g}_n$ be the individuals whose views no longer interact; the magnetization rate of stable views is

$$\rho = \frac{\sum_n \tilde{g}_n}{n}. \quad (8)$$

Definition 10. The results of preference learning adjustment of all individuals at the stage where the conditions of Definition 9 are satisfied are taken as the final decision information of the group; the convergence level ($\rho$ with $y$) and convergence time $t$ are taken as the main indexes for evaluating the dynamic interaction results of decision-
making in the group; and the arithmetic mean of the two variables of decision comprehensive expectation \( v \) and the decision cognition \( k \) of all participating individuals are taken as the auxiliary indexes for examining the dynamic interaction results of decision-making in the group.

A higher convergence level (integrated consideration of \( \rho \) with \( \gamma \)) means a better concentration of decision preferences after dynamic interaction (better effectiveness of preference information fusion). Smaller convergence time \( t \) means higher decision efficiency (lower management cost and less risk of decision fluctuation). A larger integrated expectation \( \nu t \) means a more optimistic and positive decision judgment (the difference between extreme value problem and fitness problem). A larger decision perception means a more optimistic and positive decision judgment. Larger cognitive \( k \) values represent higher levels of decision rationality and higher quality of decision information.

4.3. Preference Dynamic Fusion Simulation Process. Bringing together Hypotheses 1–7, Definitions 1–10, and the rule-setting contents of (1)–(8), we construct the proposed dynamic fusion simulation process of interperiod decision preferences for a large group in weak relationships as shown in Figure 1.

5. Simulation Case

5.1. Simulation Case Background Introduction. Offshore wind power, as a clean energy source, has been developing rapidly in the world in recent years due to its advantages of being close to the electricity load, stable power generation, not taking up land resources, etc. China’s offshore wind power construction has also achieved remarkable results. New grid-connected capacity of 0.59 GW was added in 2016, the new grid-connected capacity of offshore wind power exceeded 3 GW in 2020, and the new grid-connected capacity of offshore wind power in the first half of 2021 was 2.15 GW, a year-on-year increase of 102.0%. With the development of the offshore wind power industry, the industry’s technical and market thresholds have further increased, putting forward higher requirements for the digital design, construction, operation, and maintenance management of the project build. The offshore wind power project construction period has a long cycle, harsh conditions, short effective operating time, high engineering difficulty, complex operation and maintenance, and heavy safety management tasks. Accordingly, through the systematic construction of offshore wind power database and simulation system, offshore wind power construction monitoring and scheduling system, offshore wind power production and operation and maintenance intelligent platform, and offshore wind power digital twin system and the development of operation and maintenance boarding, underwater intelligent inspection, and other special equipment, we can realize highly efficient integrated management of offshore wind power construction sites, real-time equipment monitoring, whole life cycle operation state simulation, intelligent decision analysis of offshore wind power operation and maintenance, and material and personnel safety protection.

In this regard, a science and technology unveiling team, which undertakes the research and development of digital key technologies for offshore wind power project construction, operation, and maintenance, has organized a digital research and development camp consisting of 35 major technical joint research units using InnoCentive’s digital research and development platform. Based on each partner’s assessment of the value of their own R&D tasks and cooperation needs, we need to make a joint decision on the expected value and implementation cycle of the unveiled technology in order to further clarify the overall technology development details. Since the R&D task involves multiple professional fields, the professional knowledge base, value proposition, and risk attitude of the decision-makers are scattered, and they have to realize the R&D of special equipment, intelligent management of equipment, counter-control of equipment, and important system functions such as edge computing, edge data governance, and offline transmission in weak network environment, so there is a lack of judgment on the digital transformation of offshore wind power projects, wind power operation and maintenance efficiency, and its value. In this scenario, considering the high project value, the strong decision-making expertise, the wide range of involved areas, the large differences in the characteristics of the decision-making participants, the lack of significant economic or interpersonal relationships, and the cooperative interactions mainly based on the online R&D platform, the decision-making participant groups present as weak relationships are required to consider the expected value of the R&D project and the implementation cycle in relatively equal multiple rounds of consultation oriented to different decision-making stages, in order to weigh “complete the R&D task efficiently now” and “maintain the competitive advantage of technology products in the medium and long term” (low project value in the short term can reduce the difficulty of R&D; high project value in the medium and long term needs to increase the difficulty of R&D), so the R&D of the offshore wind power unveiling team can be regarded as weak. Therefore, the R&D consensus aggregation process of this offshore wind power unveiling team can be regarded as a dynamic integration problem of decision preferences across time for a large group of weakly related people. An overview of the decision analysis background for the simulation case is shown in Figure 2.

5.2. Initial State Main Parameter Setting. In the above decision, most of the 35 people who constitute this weakly related group had a medium level of decision expectation (with expected investment set at 75 million dollars) in a decentralized distribution, most of the individuals’ decision execution periods were short term and few were medium term, and most of the individuals’ decision cognition was low and the remaining part was of medium level. Two experts familiar with the characteristics of offshore wind power project construction, operation, and
5.3. Main Simulation Process. Based on the underlying decision data given in Table 1, the cross-fusion process of decision preferences across periods for the weak relationship large group shown in Figure 1 is implemented. Based on Definition 1, i.e., (3), the integrated expectation level $V\tau$ of each decision-maker in period 1 can be solved. Based on Definitions 3 and 4 and (4), the expert group sets $\varepsilon_1$ to 1 and $\varepsilon_2$ to 5 and specifies the individual preference interaction domain of subgroups. Based on Hypotheses 1–7, set $m$ to 10 and $(k_i, \bar{k}_n)$ to $(0.3, 0.9)$; i.e., when $k_{ij} \in (0.3, 0.9)$, $K_{ij}^t = 1 - k_{ij} - (\varepsilon_i - 1) / 10k_{ij} - (\varepsilon_j - 1)$, if $k_{ij} \leq 0.3$, then $k_{ij}$ will increase by 0.02 in the next period. The decision-makers in period 1 will update their decision perceptions in period 2 based on (2). Then, the decision-makers in period 1 in the interaction neighborhood will complete the preference learning in the subgroup based on Definitions 5–7 and (5) and (6) (the expert group defines the learning efficiency $\lambda$ as 0.8). Finally, all decision-makers will form the expectation value and
execution cycle judgment information of the decision in period 2 based on the solution of (7). Accordingly, the results of the interaction adjustment of the preference in period 1 and the distribution of the decision information in period 2 are shown in Table 2.

According to Definition 9, the decision expert defines the maximum acceptable time of decision as \( t_0 = 3 \), the limit of magnetization rate as \( \omega_1 = 0.8 \), and the limit of integrated expectation difference sum as \( \omega_2 = 1 \). Analyzing Table 2, we can see that the number of stable views of the group (i.e., the number of participants whose \( v_t \) difference sum is 0) in the preference interaction process of the first period of the group decision is 6. Due to the magnetization rate \( \rho = 6/35 = 0.17 < \omega_1 = 0.8 \), the integrated expected difference sum \( \gamma = 1.5 > \omega_2 = 1 \) of all individuals, and the decision time of the current period \( 1 < t_0 = 3 \), the preference interaction process of the group has not reached the criteria for determining the stability of the overall view, will continue the preference interaction in the second and third periods, and reach the stability of the overall view (as shown in Table 3).

Analysis of Table 3 shows that, in the preference interaction process of the third phase of group decision-making, the number of group stable opinions is 33; due to the magnetization rate \( \rho = 33/35 = 0.94 > \omega_1 = 0.8 \), the integrated expected difference of all individuals and \( \gamma = 0.71 < \omega_2 = 1 \), and the current decision time \( 3 \leq t_0 = 3 \), so the preference interaction process of this group has reached the standard of overall view stability, and the group preference interaction process is over.

| Table 1: Distribution status of decision information in period 1. |
| --- | --- | --- | --- |
|  | \( g \) | \( v_t \) | \( t_1 \) | \( k_1 \) |
| Q₁ | 1 | 90 | 6 | 0.40 |
|  | 2 | 65 | 6 | 0.40 |
|  | 3 | 45 | 3 | 0.20 |
|  | 4 | 50 | 4 | 0.30 |
|  | 5 | 80 | 5 | 0.40 |
|  | 6 | 75 | 6 | 0.40 |
|  | 7 | 90 | 6 | 0.60 |
| Q₂ | 8 | 60 | 4 | 0.30 |
|  | 9 | 55 | 4 | 0.30 |
|  | 10 | 55 | 3 | 0.30 |
|  | 11 | 65 | 5 | 0.40 |
|  | 12 | 55 | 3 | 0.20 |
|  | 13 | 40 | 2 | 0.30 |
|  | 14 | 55 | 4 | 0.30 |
| Q₃ | 15 | 70 | 6 | 0.40 |
|  | 16 | 80 | 7 | 0.50 |
|  | 17 | 75 | 5 | 0.30 |
|  | 18 | 90 | 5 | 0.50 |
|  | 19 | 60 | 6 | 0.40 |
|  | 20 | 80 | 6 | 0.60 |
|  | 21 | 90 | 6 | 0.30 |
| Q₄ | 22 | 90 | 5 | 0.50 |
|  | 23 | 95 | 7 | 0.40 |
|  | 24 | 85 | 6 | 0.50 |
|  | 25 | 90 | 7 | 0.50 |
|  | 26 | 100 | 9 | 0.60 |
|  | 27 | 90 | 6 | 0.40 |
|  | 28 | 85 | 6 | 0.50 |
| Q₅ | 29 | 90 | 6 | 0.30 |
|  | 30 | 40 | 3 | 0.20 |
|  | 31 | 90 | 5 | 0.60 |
|  | 32 | 70 | 5 | 0.50 |
|  | 33 | 45 | 3 | 0.20 |
|  | 34 | 50 | 3 | 0.30 |
|  | 35 | 55 | 4 | 0.40 |
| Arithmetic value | \( v_t \) | \( t_1 \) | \( k_1 \) |
| Q₁ | 70.71 | 5.14 | 0.39 |
| Q₂ | 55.00 | 3.57 | 0.30 |
| Q₃ | 77.86 | 5.86 | 0.43 |
| Q₄ | 90.71 | 6.57 | 0.49 |
| Q₅ | 62.86 | 4.14 | 0.36 |
| Total | 71.43 | 5.06 | 0.39 |
5.4. Contrast Analysis Results. Comparing the different decision results at the early stage of decision-making, previous models, and this study model, we can obtain the comparison of preference information fusion results as shown in Table 4 and Figures 3 and 4. In the case where the preference interaction trait of the weakly related large group is not considered, the initial decision state is the same as the data shown in Table 1. Without considering the differential growth of decision cognition in Definitions 6 and 7, it is assumed that individual decision cognition increases uniformly at a constant rate of 0.02 per period. Without considering the setting of preference learning rules in Definition 7, the arithmetic mean of all individuals within the confidence threshold in each period is taken as the learning result of the conventional HK model. The information is directly used as the learning result of the interaction object. The other parameters, such as the discounted composite expectation and the preference interaction neighborhood setting rules, continue to adopt the viewpoint of this study. The initial decision state in Table 4 is the direct arithmetic mean of the group decision information of period 1 in Table 1.

According to Definition 10, analysis of Table 4 and Figures 3 and 4 shows that, in the initial decision state, the views of the decision group at the beginning of period 1 are more dispersed ($\rho = 0.17$, $\gamma = 1.5$) and difficult to aggregate directly. If the information is forcibly aggregated and its arithmetic mean case is considered, it is easy to see that the

| g | $v_{g1}$ | $\gamma_{g1}$ | $v_{g2}$ | $t_{g2}$ | $k_{g2}$ |
|---|---|---|---|---|---|
| 1 | 0.37 | 0.45 | 0.73 | 87.07 | 8 | 0.55 |
| 2 | 0.27 | 0.55 | 0.71 | 84.63 | 8 | 0.55 |
| 3 | 0.36 | 0.46 | 0.73 | 68.31 | 3 | 0.22 |
| Q1 | 4 | 0.41 | 0.41 | 0.74 | 59.99 | 7 | 0.53 |
| 5 | 0.82 | 3.38 | 3.52 | 70.00 | 5 | 0.55 |
| 6 | 0.31 | 0.51 | 0.72 | 85.60 | 8 | 0.55 |
| 7 | 4.20 | 0.00 | 4.20 | 71.74 | 7 | 0.67 |
| 8 | 0.49 | 1.00 | 1.29 | 55.84 | 6 | 0.53 |
| 9 | 0.45 | 1.04 | 1.28 | 55.49 | 6 | 0.53 |
| 10 | 1.49 | 2.12 | 3.18 | 73.62 | 5 | 0.53 |
| 11 | 0.67 | 3.75 | 2.17 | 78.29 | 6 | 0.55 |
| 12 | 0.44 | 1.05 | 1.28 | 26.36 | 2 | 0.22 |
| 13 | 3.60 | 0.00 | 3.60 | 44.49 | 4 | 0.53 |
| 14 | 0.45 | 1.04 | 1.28 | 55.49 | 6 | 0.53 |
| Q2 | 15 | 0.29 | 0.34 | 0.56 | 66.56 | 8 | 0.55 |
| 16 | 0.63 | 5.29 | 2.74 | 97.99 | 7 | 0.60 |
| 17 | 0.18 | 0.44 | 0.54 | 81.95 | 8 | 0.53 |
| 18 | 2.81 | 0.00 | 2.81 | 100.47 | 7 | 0.60 |
| 19 | 0.25 | 0.38 | 0.55 | 65.58 | 8 | 0.55 |
| 20 | 3.73 | 0.00 | 3.73 | 95.66 | 8 | 0.67 |
| 21 | 0.07 | 0.40 | 0.23 | 121.43 | 10 | 0.53 |
| Q3 | 22 | 2.81 | 0.00 | 2.81 | 100.47 | 7 | 0.60 |
| 23 | 0.16 | 0.76 | 0.46 | 99.85 | 9 | 0.55 |
| 24 | 1.33 | 1.48 | 2.52 | 89.86 | 7 | 0.60 |
| 25 | 0.70 | 2.11 | 2.39 | 85.40 | 7 | 0.60 |
| 26 | 1.01 | 1.80 | 2.45 | 94.25 | 9 | 0.67 |
| 27 | 0.37 | 1.60 | 1.01 | 120.39 | 8 | 0.55 |
| 28 | 1.33 | 1.48 | 2.52 | 89.86 | 7 | 0.60 |
| Q4 | 29 | 0.07 | 0.29 | 0.30 | 86.25 | 9 | 0.53 |
| 30 | 0.32 | 2.12 | 1.17 | 109.62 | 3 | 0.22 |
| 31 | 7.00 | 0.00 | 7.00 | 79.72 | 6 | 0.67 |
| Q5 | 32 | 2.19 | 4.81 | 6.04 | 77.63 | 5 | 0.60 |
| 33 | 0.36 | 2.04 | 1.18 | 24.28 | 2 | 0.22 |
| 34 | 1.35 | 5.65 | 5.87 | 72.54 | 4 | 0.53 |
| 35 | 1.41 | 5.59 | 5.88 | 64.26 | 4 | 0.55 |

Note. $v_{g1}'$ is the result of solving according to (5) and (6) (the same as below).
When the weakly related large group preference interaction trait was not considered, the preference interaction was still not completed in period 3 (met in period 4); the decision group views were generally more fragmented ($\rho = 0.71$, $c = 2.88$); it was easy to see that the group tended to focus more on short- and medium-term ($t = 3.89$), lower direct values ($v = 51.25$); and at a moderately low level of cognition ($k = 0.45$), $v' = 2.94$ in the current period. On the other hand, considering the interactive qualities of weakly related large group preference interaction, the group prefers to focus on the medium-term ($t = 5.06$), moderate indirect value ($v = 71.43$), but at a low level of cognition ($k = 0.39$) condition, $v' = 1.22$ in the current period. When the weakly related large group preference interaction trait was not considered, the preference interaction was still not completed in period 3 (met in period 4); the decision group views were generally more fragmented ($\rho = 0.71$, $c = 2.88$); it was easy to see that the group tended to focus more on short- and medium-term ($t = 3.89$), lower direct values ($v = 51.25$); and at a moderately low level of cognition ($k = 0.45$), $v' = 2.94$ in the current period. On the other hand, considering the interactive qualities of weakly related large group preference interaction, the group prefers to focus on the medium-term ($t = 5.06$), moderate indirect value ($v = 71.43$), but at a low level of cognition ($k = 0.39$) condition, $v' = 1.22$ in the current period.

### Table 3: Results of preference interaction adjustment in period 3 and distribution status of final decision information.

| $Q_1$ | $g$ | $v'_{g1}$ | $v'_{g2}$ | $v'_{g3}$ | $v_{g}$ | $t_{g}$ | $k_{g}$ |
|-------|-----|-----------|-----------|-----------|--------|--------|--------|
| 1     | 1.00| 3.23      | 3.23      | 3.23      | 91.13  | 9      | 0.69   |
| 2     | 1.00| 3.23      | 3.23      | 3.23      | 91.02  | 9      | 0.69   |
| 3     | 1.00| 3.23      | 3.23      | 3.23      | 47.84  | 2      | 0.26   |
| 4     | 1.00| 3.24      | 3.24      | 3.24      | 101.51 | 9      | 0.68   |
| 5     | 1.00| 3.52      | 3.52      | 3.52      | 99.26  | 9      | 0.69   |
| 6     | 1.00| 3.23      | 3.23      | 3.23      | 91.06  | 9      | 0.69   |
| 7     | 1.00| 4.20      | 4.20      | 4.20      | 68.67  | 10     | 0.76   |
| 8     | 1.00| 2.97      | 2.97      | 2.97      | 93.09  | 9      | 0.68   |
| 9     | 1.00| 2.97      | 2.97      | 2.97      | 93.04  | 9      | 0.68   |
| 10    | 1.00| 3.18      | 3.18      | 3.18      | 99.65  | 9      | 0.68   |
| 11    | 1.00| 2.17      | 2.17      | 2.17      | 88.47  | 10     | 0.69   |
| 12    | 1.00| 2.97      | 2.97      | 2.97      | 43.88  | 2      | 0.26   |
| 13    | 1.00| 3.60      | 3.60      | 3.60      | 77.00  | 8      | 0.68   |
| 14    | 1.00| 2.97      | 2.97      | 2.97      | 93.04  | 9      | 0.68   |
| 15    | 1.00| 2.33      | 2.33      | 2.33      | 95.27  | 10     | 0.69   |
| 16    | 1.00| 2.74      | 2.74      | 2.74      | 107.09 | 11     | 0.72   |
| 17    | 1.00| 2.33      | 2.33      | 2.33      | 107.15 | 10     | 0.68   |
| 18    | 1.00| 2.81      | 2.81      | 2.81      | 109.80 | 11     | 0.72   |
| 19    | 1.00| 2.33      | 2.33      | 2.33      | 95.21  | 10     | 0.69   |
| 20    | 1.00| 3.73      | 3.73      | 3.73      | 106.74 | 12     | 0.76   |
| 21    | 1.00| 0.49      | 7.79      | 2.05      | 94.08  | 10     | 0.68   |
| 22    | 1.00| 5.45      | 0.00      | 2.81      | 109.80 | 11     | 0.72   |
| 23    | 1.00| 4.95      | 0.00      | 1.83      | 51.64  | 9      | 0.69   |
| 24    | 1.00| 6.50      | 0.00      | 2.52      | 98.21  | 11     | 0.72   |
| 25    | 1.00| 5.40      | 0.00      | 2.39      | 93.33  | 11     | 0.72   |
| 26    | 1.00| 5.51      | 0.00      | 2.45      | 92.72  | 13     | 0.76   |
| 27    | 1.00| 5.45      | 0.00      | 2.18      | 128.75 | 11     | 0.69   |
| 28    | 1.00| 6.50      | 0.00      | 2.52      | 98.21  | 11     | 0.72   |
| 29    | 1.00| 4.94      | 16.93     | 3.71      | 116.25 | 9      | 0.68   |
| 30    | 1.00| 4.95      | 0.00      | 4.98      | 73.61  | 2      | 0.26   |
| 31    | 1.00| 5.63      | 0.00      | 7.00      | 86.55  | 9      | 0.76   |
| 32    | 1.00| 6.00      | 0.00      | 6.04      | 86.74  | 8      | 0.72   |
| 33    | 1.00| 4.90      | 0.00      | 5.19      | 76.80  | 2      | 0.26   |
| 34    | 1.00| 4.92      | 0.00      | 5.87      | 85.60  | 7      | 0.68   |
| 35    | 1.00| 4.50      | 0.00      | 5.88      | 78.90  | 7      | 0.69   |
| Arithmetic value | $v'_{g1}$ | $v'_{g2}$ | $v'_{g3}$ | $v_{g}$ | $t_{g}$ | $k_{g}$ |
| $Q_1$ | 3.41 | 0.00 | 3.41 | 84.36 | 8.14 | 0.64 |
| $Q_2$ | 2.97 | 0.00 | 2.97 | 84.03 | 8.00 | 0.62 |
| $Q_3$ | 2.40 | 1.11 | 2.62 | 102.19 | 10.57 | 0.70 |
| $Q_4$ | 5.68 | 0.00 | 2.39 | 96.09 | 11.00 | 0.71 |
| $Q_5$ | 5.12 | 2.42 | 5.52 | 86.35 | 6.29 | 0.58 |
| Total | 3.92 | 0.71 | 3.38 | 90.60 | 8.80 | 0.65 |

### Table 4: Comparison of results of large group decision-making information fusion ($v'$ and $v$).

| $\rho$ | $\gamma$ | Note |
|--------|----------|------|
| Primary decision-making status (denoted as $A_0$) | 1.22 | 1.5 | Comparison at the beginning of period 1 |
| Weakly related group preference interaction traits were not considered (denoted as $A_1$) | 2.94 | 2.88 | Period 2 has not met the standard |
| Weakly related group preference interaction traits were considered (denoted as $A_2$) | 3.92 | 0.71 | Period 3 has met the standard |

Note. The signs of $A_0$, $A_1$, and $A_2$ are the same as below.
related large group preferences, the fusion of views of the decision group was completed at the end of period 3, with more concentrated preference information after the fusion ($\rho = 0.94, \gamma = 0.71$); it is easy to see that the group prefers to focus on the long-term ($t=8.8$), higher indirect values ($\nu = 90.6$); and at a higher moderate level of cognition ($k=0.65$) condition, current period $\nu^* = 3.92$, the highest level in the comparison state.

The above comparative analysis results indicate that the preference dynamic fusion method constructed in this study can effectively cope with the characteristics of the weakly related groups such as large size of decision participants, complex preference information, and narrow preference interaction range and improve the final group decision performance based on the relatively rational interaction learning process. With the general improvement of participants’ decision-making cognitive level, participants gradually paid more attention to the medium- and long-term higher value in the later decision-making, compared with the initial situation of mainly focusing on the short-term higher value. The 35 R&D representatives who participated in the decision-making more rationally achieved a combined short-term and long-term value understanding trade-off for the specific decision of the R&D of smart operation and maintenance technology for the smart offshore wind power project and successfully reached a high level of preference agreement in period 3 (considering $\rho$ and $\gamma$). The validity and credibility of the information fusion are significantly improved. Considering the complexity of group interterm decision-related problems in terms of group structure, preference connotation, and interaction conditions similar to the above simulation situation, the theory and method constructed in this study can provide some reference for dealing with the dynamic fusion of interterm decision preferences of weakly related large groups in an approximate situation.

6. Conclusion

Focusing on the three core dimensions of time-oriented preferences, expectation-oriented preferences, and cognitively oriented preferences that are of concern to weakly related large groups, this study systematically proposes a theory and method for dynamic fusion of interperiod decision preferences of large groups in weak relationships that simultaneously considers the different attributes of decision preferences of decision individuals and the degree of asymmetric influence among individuals. Compared with the existing large group decision preference fusion models based on hard constraints, this study complements the theory and method of the dynamic fusion of intertemporal decision preferences of weakly related groups under soft constraints, with the following innovations.

Firstly, it integrates the results of decision participants' size, preference heterogeneity attributes, and dynamic characteristics in open contexts; inductively proposes the features of larger-scale individuals' common expression of dispersed preferences for weakly related large group decision-making; and combines the hyperbolic discounting model's judgment of the decision cycle accompanied by immediate base utility adjustment, and the discount utility model's exploration of the multidimensional discount factor and individual discount rate dynamic growth law. The structure and corresponding attributes of the intertemporal decision preferences of the weakly related large group are sorted out from three aspects: expectation, decision execution cycle, and decision perception, and the initial preference state of the intertemporal decision of the weakly related large group is portrayed more systematically.

Secondly, in view of the narrow interaction information scope of the weakly related large group; the hyperbolic discounting model is improved based on the difference between decision association and individual time preference in each period; the common role comparison method of the three types of preferences of the weakly related large group in interperiod decision-making and the objective comparison criteria of interindividual preferences are defined; the analysis dimension of the interperiod decision preferences of large group in weak relationships from subjective random distribution to objective strategy stability is explored; then the HK model in the analysis of public opinion evolution process and dynamics mechanism is improved; the
characteristic of “individuals only interact with some neighbors” of the weakly related large group is clarified; and the basic scheme of interaction mode selection and interaction neighborhood threshold setting of the bounded trust model is constructed.

Thirdly, considering the indirect influence of learning mode and efficiency loss to improve the original preference adjustment rules of HK model, the basic scheme of decision-maker’s own scheme and learning content convergence in the adjacent stage is constructed; the general process of cyclic interaction of group viewpoints until stabilization or reaching the decision demand is faced; and the convergence level (magnetization rate, difference of comprehensive expectation between individuals in the neighborhood), the convergence time, the comprehensive expectation of decision, and the “decision performance” measure of such dynamic group decision problems are proposed in terms of convergence level (magnetization rate, sum of combined expectations among individuals in the neighborhood), convergence time, mixed expectations, and decision perception.

It is foreseeable that with the continuous development of the openness of technology application scenarios and the social sharing paradigm, the decision-making process of large groups dominated by weak relationships will receive more attention in the future. Therefore, an effective preference fusion method will help improve the effectiveness and scientificity of large group decision-making and promote the standardized construction of relevant decision-making systems, which has important research prospects. Based on this paper, follow-up research can focus on four important directions. Firstly, for a wide range of application scenarios of participating groups such as enterprise digital transformation, industrial integration development, innovation, and entrepreneurship, carry out case application and comparative research in combination with specific decision-making issues, improve the practical guiding value of theoretical methods, and improve the initial preference setting rules for weak relation decision-making. Secondly, expand the potential impact and mechanism of factors such as social cognitive tendency and knowledge level orientation, combine stratified sampling technology and more scientific group difference analysis methods, and further improve the preference aggregation rules and adjustments for weak relation group decision-making in different situations strategy. Thirdly, in view of the uncertainty, inaccuracy, and asymmetry of decision-making information expression, further investigate the influence mechanism of language preference relationship in the decision-making of large groups of weak relation, improve the accuracy of consensus information acquisition and consistency judgment, and continuously enrich the applicable scenarios of decision-making. Finally, further discuss the consensus level identification mechanism of large groups of weak relation, aiming at the possible consensus stratification situation and adjustment cost of group decision-making, clarify the legitimacy of consensus and the boundary conditions of maintaining cost, and study noncooperative behavior management methods.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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