

## Design of Enterprise Innovation Resource Allocation Scheme Based on Multi-objective GERT Network

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**Abstract:** Firstly, the paper analyzes the common problems of goal setting in enterprise innovation resource allocation. It also clarifies the rationality of multi-objective planning to improve the utilization rate of enterprise innovation resources and optimize the allocation of innovation resources. Secondly, the GERT network model of enterprise innovation value flow is constructed by taking the basic process of enterprise technology innovation as the clue and GERT network method as the theoretical platform. Then, the implementation scheme is designed for the rational allocation of enterprise innovation resources. The study enriches the theoretical research on enterprise innovation resource allocation. In addition, it is another application of GERT network theory which has certain guiding significance for optimizing enterprise innovation resource allocation and making relevant policies.

### 1. Multi-objective nature of enterprise innovation.

In the process of enterprise innovation, due to different demands, there are many expected goals to be achieved. Through sorting out relevant literature and materials, it is found that these goals are generally intended to improve the economic benefits of enterprises, to enhance the core competence of enterprises, to improve the scientific, to technological literacy of employees and to create social values of enterprises.

The above four goals have important influences on the long-term development of enterprises from different perspectives and levels. During the process of enterprise innovation, the realization of each goal can be achieved through the allocation of resources. However, various objectives have diverse degrees of importance in the development of enterprises, and the same resource will have different degrees of influence on a variety of objectives. Because all objectives are in conflict with each other. How to allocate resources to maximize the comprehensive benefits of objectives has become an urgent problem for enterprises with multiple objectives. However the multi-objective programming satisfies the needs of the complex multi-objective optimal decision based on the linear programming.

### 2. Establishment of multi-objective planning decision-making model for enterprise innovation.

The mathematical model of multi-objective decision-making has multiple objective functions, which represent the main development indicators of various aspects in the process of technological innovation of enterprises. They are used to measure the optimal allocation of resources. The decision-making variables are composed of constraints such as the amount of resources of enterprises. The general mathematical model of multi-objective optimization decision-making problem is as follows:

$$\max(\min)[f_1(u), f_2(u), \dots, f_n(u)]$$

$$\text{s.t. } u \in U$$

$$\text{Among them: } u = (x_1, x_2, \dots, x_n), U = \{u | p_k(u) \leq 0, k = 1, 2, \dots, m\}.$$

In this paper, four indicators of enterprise economic benefit, enterprise core competence, enterprise employees' scientific and technological literacy and enterprise social value are selected as the decision-making objectives of the entire technological innovation system. Therefore, the multi-objective decision-making model of enterprise technological innovation can be obtained by combining the above models as follows:

$$\begin{aligned} & \max(\min)[f_1(u), f_2(u), f_3(u), f_4(u)] \\ & \text{s. t. } P(u) \leq 0, u \geq 0 \end{aligned}$$

Where,  $u$  is the decision variable  $f_1(u), f_2(u), f_3(u), f_4(u)$  are the decision-making function of four indicators: economic efficiency, core competence, scientific and technological literacy of enterprise staff, and social value of enterprise.  $P(u)$  as the constraint condition set.

### 3. Implementation plan of enterprise innovation resource allocation.

Resource allocation refers to the selection of relatively scarce resources for different purposes. Enterprise innovation resource refers to the sum of human, material and financial resources involved in the process of enterprise innovation, which is the basic condition for enterprises to carry out innovation activities. In a certain stage of enterprise development, relative to the development needs of enterprises, resources are relatively scarce. Therefore, to consume the least resources, enterprises are required to make reasonable allocation of limited resources that can produce the most suitable commodities and obtain the best benefits. When an enterprise sets multiple goals, it can maximize the limited and scarce resources to achieve the goals and obtain the highest comprehensive benefits, so that the enterprise can achieve long-term development. The rationality of resource allocation is more important. Although it has been known by scholars that multi-objective planning can be applied to realize rational allocation of enterprise innovation resources, how to apply multi-objective planning to enterprise innovation process and how to apply planning theory to enterprise innovation practice is still a difficult problem for enterprises. Therefore, the following will explore and elaborate the specific implementation scheme of enterprise innovation resource allocation under multi-objective planning.

(1) Configure the targets.

1) To maximize the realization of enterprise economic benefits, enterprise core competence, enterprise staff scientific and technological literacy and enterprise social value four goals;

2) To maximize the comprehensive benefits of enterprise innovation.

(2) Goals and objectives.

1) Increasing economic benefits of enterprises.

2) Enhancing the core competence of the enterprise.

3) Improving enterprise staff scientific and technological literacy.

4) Improving the social value.

(3) Configuration methods

GERT network value flow, building enterprise innovation in the key nodes (refers to has the value in the GERT network transfer efficiency is high, the promoting effect to the value flow is strong, have strong ability of value-added at the same time, greater influence on the innovation of the enterprise success or failure of nodes) and applying different degrees of control measures to the way of resources configuration, such as enterprise to implement their own economic benefit maximum. Those will increase the product publicity, advertising, endorsements or promotion, etc. The article calls these controls, the corresponding control measures for the goals of the forces, In order to achieve different development goals, enterprises will impose different degrees of control measures at key nodes, namely, resource allocation.

The implementation of control measures involves the allocation of resources. At each key node, different allocation of resources will lead to different realization of goals and ultimately affect the comprehensive income of enterprises. The transition probability of nodes with control measures will change correspondingly due to the allocation of corresponding resources. The analytic hierarchy process was used to calculate the ratio of the importance of various control measures

under multi-objective planning, so as to calculate the transfer probability of each node after the control measures were applied.

Analytic hierarchy process is a common method to solve multi-objective problems. This paper uses the function of analytic hierarchy process to calculate the ratio of the importance of various control measures under multi-objective planning. Fig. 1 hierarchical structure chart of optimal allocation of technological innovation resources under multi-objective decision-making.

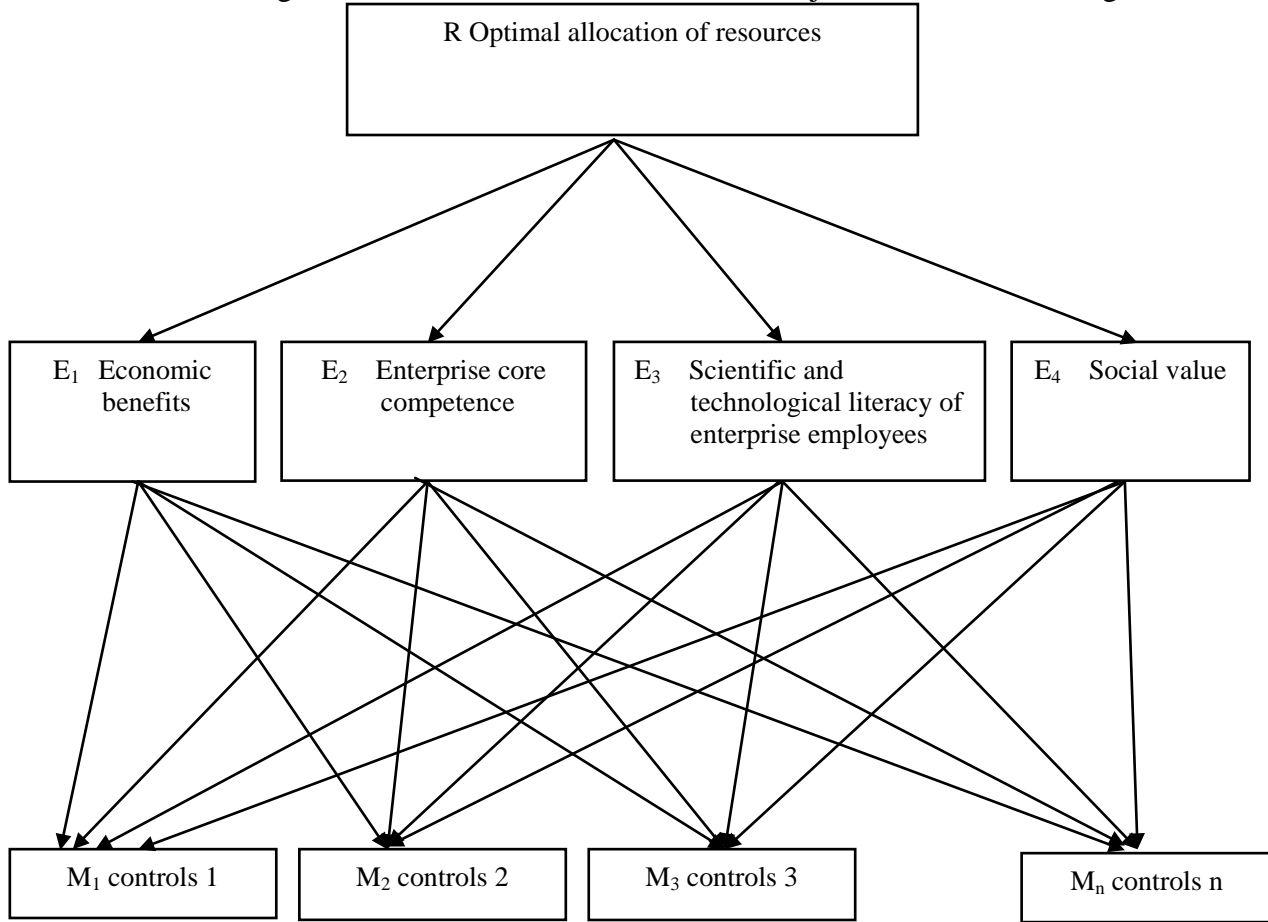


Fig. 1. Hierarchical structure chart of optimal allocation of technological innovation resources under multi-objective decision-making

#### (4) The configuration steps.

1) Constructing the basic network of enterprise innovation value flow;

2) The value transfer probability, value increment amount and value increment coefficient from each node to the final node are calculated by GERT network model, and the key nodes of the network are identified by these indicators.

3) Control measures are applied at key nodes to achieve optimal allocation of resources, and the transfer probability of each key node after the application of control measures is obtained. The specific operations are as follows:

When the enterprise fails to take control measures, node 1,2,3... , n,... , the transfer probability at u is successively  $m_{11}, m_{12}, m_{13}, \dots, m_{1n}, \dots, m_{1u},$  and the enterprise will be at node 1,2,3... , n, n key nodes to impose control measures.

According to:

When enterprises allocate resources based on the plan without specific goals, they generally adopt the method of uniform distribution at all nodes, that is, they apply the same intensity of control measures at key nodes. Suppose that at this point, the transfer probability at the above n nodes becomes  $m_{21}, m_{22}, m_{23}, \dots, m_{2n},$  then we can get

$$\frac{m_{21} - m_{11}}{m_{11}} : \frac{m_{22} - m_{12}}{m_{12}} : \frac{m_{23} - m_{13}}{m_{13}} : \dots : \frac{m_{2n} - m_{1n}}{m_{1n}} = 1 : 1 : 1 : \dots : 1$$

Where the value of  $m_{21}, m_{22}, m_{23}, \dots, m_{2n};$

When an enterprise makes resource allocation based on single-objective planning, it will allocate as many resources as possible to the direction that can meet the set goal, that is, exert the strongest control measures in a certain place or several places. Suppose that at this point, the transfer probability at the above  $n$  nodes becomes  $m_{31}, m_{32}, m_{33}, \dots, m_{3n}$ , then,  $\frac{m_{31}-m_{11}}{m_{11}} : \frac{m_{32}-m_{12}}{m_{12}} : \frac{m_{33}-m_{13}}{m_{13}} : \dots : \frac{m_{3n}-m_{1n}}{m_{1n}} = N:1:1:\dots:1$  (let node 1 be the important resource distribution location), and then the value are  $m_{31}, m_{32}, m_{33}, \dots, m_{3n}$ ;

It can be known that when the enterprise makes resource allocation based on multi-objective planning, it will make comprehensive decisions according to the importance of multiple goals set by the enterprise, coordinate the realization of each goal, and select and allocate the resource allocation scheme that maximizes the goal of all aspects of the enterprise. Suppose that at this point, the transfer probability at the above  $n$  nodes become  $m_{41}, m_{42}, m_{43}, \dots, m_{4n}$ .

And  $\frac{m_{41}-m_{11}}{m_{11}} : \frac{m_{42}-m_{12}}{m_{12}} : \frac{m_{43}-m_{13}}{m_{13}} : \dots : \frac{m_{4n}-m_{1n}}{m_{1n}} = q_1:q_2:q_3:\dots:q_n$ ,

Thus, we can get  $m_{41}, m_{42}, m_{43}, \dots, m_{4n}$ . The analytic hierarchy process is used to calculate the ratio of the importance of various control measures under multi-objective planning, that is, to obtain  $q_1:q_2:q_3:\dots:q_n$ , and finally determine  $m_{41}, m_{42}, m_{43}, \dots, m_{4n}$ .

According to the above allocation methods and steps, the rational allocation of enterprise innovation resources under multi-objective planning can be achieved. However, the allocation effect of innovation resources and the realization of each goal need to be determined through further evaluation and testing.

#### 4. Conclusion

Combined with the knowledge of multi-objective planning and GERT network theory, this paper makes an in-depth study on the basic process and elements of enterprise technological innovation, multi-objective planning in enterprise innovation, implementation plan of enterprise innovation resource allocation under multi-objective and evaluation of program effect.

(1) Enterprise innovation resources allocation are analyzed in detail, the main problem of goal setting, the goal of a single, too pursuit of short-term interests, not build a coordinated target system is the enterprise the rational allocation of innovation resources, improve the efficiency of resource utilization and innovation of the reality, reflecting the development goal and set up multiple application of multi-objective programming to optimize the allocation of resources to the enterprise, the importance of that the enterprise innovation from the Angle of multiple objective research the rationality of the resource allocation problem.

(2) On the basis of detailed analysis of the basic process and elements of enterprise technological innovation, the value flow network model of enterprise innovation is constructed. According to the development goal set by the enterprise, combined with multi-objective planning, the implementation scheme design of enterprise innovation resource allocation is carried out. An evaluation model was set up to evaluate the effect of enterprise innovation resource allocation scheme under multi-objective planning by comparing the equivalent transfer probability and comprehensive income of innovation under single objective planning and primary and secondary unclear objective planning. Finally, it was found that the effect of enterprise innovation resource allocation under multi-objective planning was better. It provides a theoretical basis and practical reference for the application of multi-objective programming in the optimal allocation of enterprise innovation resources.

This paper is an attempt of GERT network theory on enterprise innovation resource allocation from multi-objective perspective, and constructs GERT network model of enterprise technology innovation. This model presents a general picture of the technological innovation process of the enterprise as a whole, but the technological innovation process is very complex. It is a future direction to refine the technological innovation link and use the GERT network to represent it.

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