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Dynamic Coordinated Management Model of Programme in Large-Scale Construction Company

Abstract Large-scale construction companies develop rapidly when facing more and more opportunities and challenges of programme contracting. However, project management technology, not meeting the requirements of firm growth, still stands proud, while relevant programme management methods have not been well studied. Therefore, this paper commences innovative application of coordinated management theory to programme management according to the need of changing the existing management mode in large-scale construction companies, then puts forward the dynamic coordinated management model composed of the dynamic coordination of function module, interface module, support module and evaluation module. Besides, coordination degree was introduced to make auxiliary analysis, so that companies can utilize internal and external resources more effectively to realize the goals of programme management as well as enterprise strategy.

Keywords: large-scale construction company, programme, dynamic coordinated management, model

1 Introduction

Many projects recently have appeared in the form of a programme, such as the Beijing Olympic Games projects, urban subway projects, high-speed railway projects, etc. Large-scale construction companies could deal with several projects that serve for enterprise strategy and consume enterprise resources in the same period, thus becoming the new management object. Large-scale construction companies face the trend of being giant and clustering projects. How to manage a programme effectively in order to achieve continuous firm growth is a major task.

However, programme management is a relatively new

concept. Programme management has been applied in all kinds of companies such as large-scale mining companies, communication engineering companies, power construction corporations, real estate corporations, geological exploration enterprises and so on. Although the relative research went on, the definition of programme management, project selection and management content as well as methods have not been reached consensus. In this paper, programme management approach is taken as the focus point, while one of the key points to obtain management benefits depends on the choice of management model. Looking back on the existing literature, Sergio (2011), Wang (2004) and Liu (2011) studied programme management models from different perspectives, Shi (2010) came up with a synergetic management model of programme management, Miao (2009) studied integrated management in programme environment, Gao (2012) applied the WSR system methodology to programme management, and critical chain project management (CCPM) technology was used to manage programme by Sun (2011) who also proposed the critical chain programme management model. In a word, the different management approaches have their focus and shortcomings and leave space for this paper to apply coordinated management theory to programme management. And from the definitions of programme of the PMI (2000) and Turner (1999), programme is those groups of projects which are interrelated and linked with each other, and which are needing coordinated management as a whole. Only in this way could strategic objectives be better achieved. Therefore, this paper has a profound theoretical basis and practical significance.

2 Comparison of program management model

2.1 Connotation of programme and programme management

Programme as the extension of project concept, its meaning is not widely agreed upon. Ferns (1991) deemed that programme was a group of related projects managed in

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coordinated manner and that the structures and processes of projects were well organized in order to obtain greater benefits than managing single project. On this basis, Pellegrinell (1997) thought programme was a organizational framework composed of existing and future projects, which were managed in a coordinated approach so as to achieve the interests beyond the sum of individual project management. On the foundation of programme definitions of PMI, Turner, Ferns. and Pellegrinell, programme is guided by the organizational strategy objectives, included existing and future new projects that make up a interconnected and organic framework. It is linked to the internal and external environment and supervised through a coordinated manner to create greater overall profits than managing a single project. In this paper, programme, an organic combination of numerous projects belonged to the same enterprise, is from the position of large-scale construction companies, which can be divided into homogeneous programme and heterogeneous projects.

Similarly, programme management as the extension of project management is also different among scholars. Burke (2013) and Ferns (1991) defined programme management from different angles, but they both believed it can get benefits that can't be obtained by running projects separately. Programme management is to control and coordinate multiple projects in general (Wang, 2004), though it is rooted in project management—regardless of strategic height, management scope or management connotations—it is far beyond the project management (Lu and Zhao, 2004). Of course, programme management and project management are still relevant. The differences are those that programme management will be more focused on the control and coordination as a whole, and that goals of programme management are closer to corporate strategic objectives. In general, programme management is more open, strategic and uncertain than project management.

2.2 Programme management model

The previous paragraphs confirm that many scholars have studied the programme management model. To sum up, there are mainly four kinds of circumstances, with models on the basis of synergetic theory, integrated management, WSR system methodology and CCPM approach respectively. Table 1 shows the difference in detail.

Table 1 shows that, the program collaborative management model shares the resources and information by collaboration of function modules, dimension modules and support modules, so that it can obtain synergistic effect and exceeded profits. Program integrated management can be divided into program level and subprojects level, and the former is on the basis of the latter. The major idea of WSR program management is through the integration of material resources (MR), time resources (TR) and human resources (HR) and the integration of quantitative and qualitative

analysis, requiring coordination throughout the process of project management. The program management model based on the Critical Chain Method would make sure that project planned under the certain environment can be implemented in dynamic environment. A project and resource input buffering mechanism will eliminate the effect of uncertainties of program implementation. The model is mainly applied to schedule control and can resolve resource conflicts more effectively. There no scholars clearly proposed to make use of coordinated management theory. The above methods are mixed. Their research results of the above methods will provide important references for this study.

3 Interpretation of coordinated management and application motivation

3.1 Interpretation of coordinated management theory

Fayol was the first to coordinate the management function in parallel with planning, organizing, directing and controlling, which should be regarded as the beginning of coordination being management function. Zhou and Zhang (2007) investigated the development of management theory and thought that the content of coordination became wealthier in social and economic activities: coordination was a greater integration with management, therefore, coordination function and coordinated management should be studied systematically. But research did not go further. So in 2008, coordinated management was proposed to be studied as a stand-alone branch of management science (Guo, 2008). In the following year the coordinated management theory system of construction project was attempted to build in monograph *Project Coordination and Management* (Guo, 2009). After that, *Coordinated Management and System Design*, published in 2013, has given a further interpretation (Guo, 2013).

From the existing research results, coordinated management is a management idea or management model that is human-centered and regards the management and coordination of human creativity as the core. All relevant parties participate, sharing characteristics of knowledge, team and network. Coordinated management theory (thought) is not only more popular, but applies in more domains. Taking coordinated management as the keyword to search literature from 2011 to 2015 will show that all kinds of articles, only titles containing coordinated management, go up to more than 180. The wide range of application can't be described in details in this brief journal article.

3.2 Application motivation of coordinated management

Programs undertaken by large-scale construction companies are mostly with features such as large amount investment, difficult techniques, lots of participating

Table 1*Comparison of Programme Management Model*

Programme management model (methods)	Theoretical basis	Management objectives	Management content	Key point
Collaborative management model	Synergetics, programme theory	Generating synergistic symbiotic effect, coevolution effect, collaborative innovation effect and synergistic economies effects in scale in order to obtain exceeded profits	Controlling and organizing programme structure, process, elements, functions and relations well	Strengthening synergies among multiple projects
Integrated management method	Systems theory, information theory, cybernetics	Maximize the overall interests of programme	In programme level, doing integrated management of subprojects; in sub-project level, doing the integrated management of quality, cost, schedule, and other elements	Taking the programme as a system
WSR method	WSR systems theory, coordinated management	Combining all kinds of knowledge and parties' interests to find the satisfactory solution, ensuring the integrity of programme management	Integration of MR, TR and HR, making coordination throughout the process of project management	Emphasis on the integrity of thing as well as linkage between the whole and the part
CCPM model	Critical chain method, theory of constraints	Making business benefits maximized, and making the most use of resources and the shortest time	Determining the relationship and distributing resources well among multiple projects; coordinate the competition for limited resources within the enterprise	Complying with the overall optimization rather than local optimization absolutely

units, giant implementation risk, complex relationship among sub-projects, more management interface etc. It requires more attention to allocate resources dynamically and deal with the complex relationship between the parties in a coordinated way. Coordinated management can meet those demands. Large-scale construction companies should consider coordinated management methods when managing programs with the following probable motivation.

(1) Influenced by the characteristics of the program. Compared with single project, a program is with more subjects, more interest conflicts and stronger self-organization. The rapidly changing external environment will bring more uncertainty and higher probability of risk. All of this makes coordination among different work or projects or internal relationship of some projects more difficult. The core function of coordinated management is dynamic coordination, so it can ensure that the material flow, information flow and energy flow of the system would be coordinated and controlled more effectively. Then, finally, programme objectives can be achieved smoothly.

(2) Influenced by the nature of construction companies. The construction company is a typical project organization from the view of the current operation mode, project management is still the dominant mode of construction projects, but the traditional project management mode has within it many problems. For example, the whole process of construction project is clearly divided into some phases and lack of coordination among teams makes it difficult to harmonize the interests of involved parties. Under the new situation, the construction enterprises need to accelerate to

change the program management approach. Coordinated management seems to be the reasonable choice.

(3) Influenced by the advantages of coordinated management. As mentioned above, the program has a high degree of complexity, uncertainty and dynamic and fuzzy target, coordinated management, applied to program management is to create a coordinated and ordered environment, and to build a system structure with close connections, convergent objectives and resource integration in the organization, what's more, which is also able to connect the various departments or persons and integrate the knowledge resources to make the target clear and organization coordinated. In the end, various work can operate on the way of maximizing the overall profits of program. In addition, program management methods mentioned previously have some shortcomings. For example, collaborative management mode doesn't further study the relationship between program objectives and corporate strategy, while integrated management model is difficult to deal with the high degree of complexity and uncertainty of program itself.

4 Constructing dynamic coordinated management model of program

4.1 Dynamic coordinated management model

By researching fifteen strategy programme, David and Sergio (2005) established a analysis framework of

programme management competitiveness based on seventeen properties over four competitive levels, which is specifically from three aspects, namely the project itself, the project and other projects, as well as the project and the environment. Also worthy of study, Zhang (2008) built a collaborative management programme model from the perspective of maximizing use of internal resources. In view of these, dynamic coordinated management model of programme in large-scale construction company is constructed as *Figure 1* combined with earlier comparative analysis of programme management modes and analysis of application motivation of coordinated management. The dynamic model can be divided into four modules, namely dynamic coordination function module, dynamic coordination interface module, dynamic coordination support module and dynamic coordination evaluation module.

(1) Coordination function module. This module shows the contents of program coordinated management, including knowledge dynamic coordination, resources dynamic coordination, objectives dynamic coordination, risk dynamic coordination, organization dynamic coordination, innovation dynamic coordination and system dynamic

coordination. When in practice, it will also have to analyze the main measures that every function might take the probable coordinated effects, and to analyze that conflicts and cost may arise during the process of dynamic coordination. It should be noted that objectives dynamic module is of great importance, because all of functions are for program objective.

(2) Coordination interface module. It includes four aspects, namely longitudinal dynamic coordinated management of program itself, lateral dynamic coordination between the project and the other one, dynamic coordination between programmes, dynamic coordinated management between programme objectives and corporate strategy. To make it clear, coordination among single projects is mainly on resource such as labor, finance, material and knowledge, while coordination among programmes is mainly on organization, the elements such as objectives, risks, innovation and systems.

(3) Coordination support module. Programme management is a complex system for that management elements link with each other more closely, and the management interface becomes more diverse, and even it is possible to

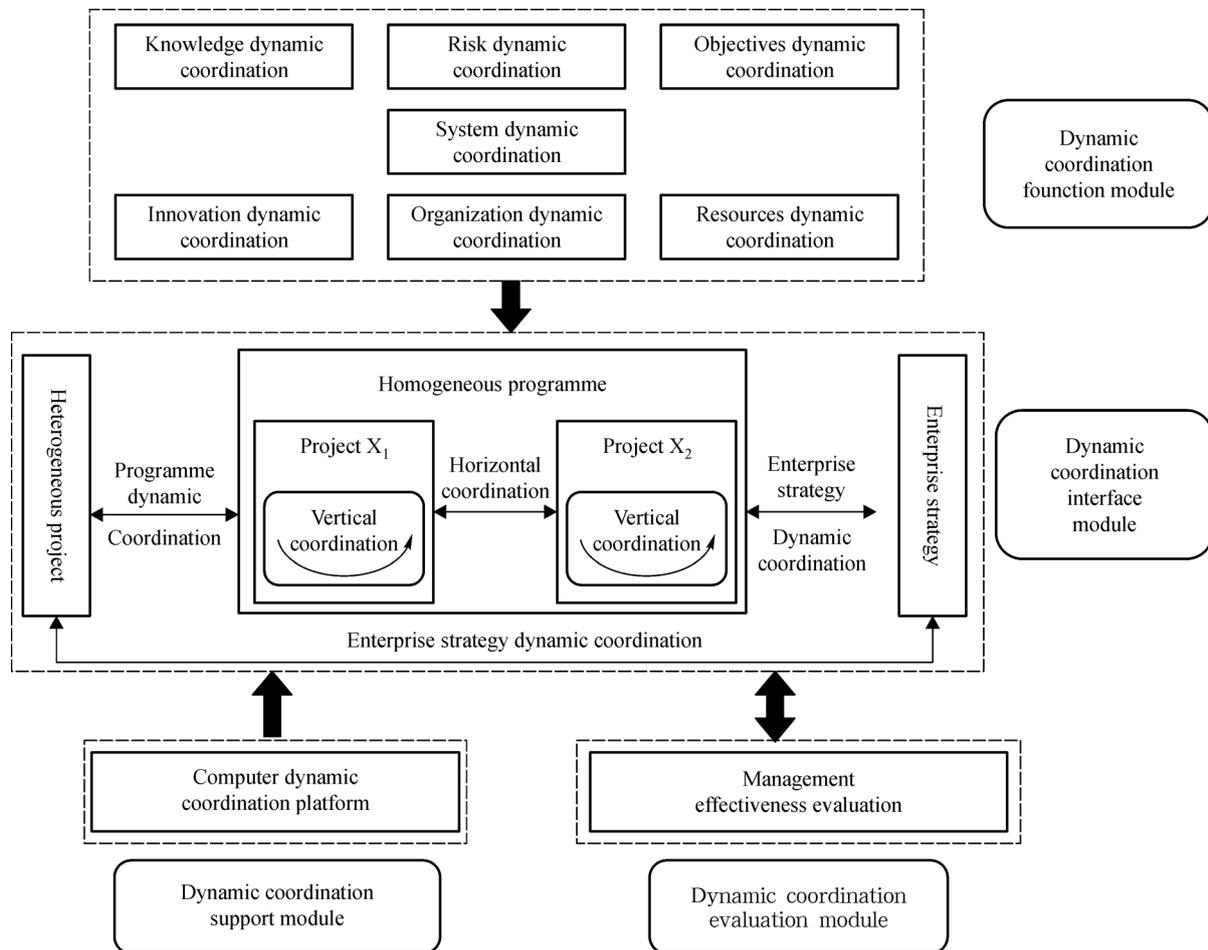


Figure 1. Dynamic coordinated management model of program.

appear virtual organizations or virtual teams, the system will generate a huge amount of information. With the increasing maturity and escalation of the computer technology and big data technology, the huge amount of information can be analyzed rapidly and timely, and the optimal allocation of resources and precise management can be achieved, so dynamic coordinated management could realize effectively.

(4) Coordination evaluation module. Effectiveness of management approach must be evaluated to test its feasibility. By evaluating programme coordinated management effectiveness and delivering feedback to programme management system through a certain transmission mechanism, so that it can promptly correct the deviation, or take other measures to adjust the internal structure. As a result, the programme system would be operated more effectively to achieve management objectives.

4.2 Analysis on coordination degree

The process of programme coordinated management must be with lots of uncertainties and the internal and external environment shows a high degree of complexity, so coordination degree is introduced to explain sufficiently in this paper. Coordination degree is the degree of harmonization with each other during the development process of the elements within system. Coordination degree is greater, which indicates that the collaboration of system elements is close, and that the system operates better, and that is more conducive to achieving the system goals.

This paper argues that the success of the programme coordinated management can be showed by the coordination degree of the external environment and internal environment. Internal environment is defined by the organizational structure, organizational systems, corporate culture, management level of leaders, innovation, organizational efficiency, etc. And external environment is defined by the natural environment, policy and legal factors, economic and social factors, technical factors, suppliers, customers, competitors etc.

Then it proceeds to introduce the order parameter, because the basis of calculating coordination degree is to set the order parameter, which is used to describe the macroscopic order degree or macroscopic model in a

system. More specifically, it is designed to describe what an orderly state or ordered structures the system will get in the course of time and in what kind of mode the system runs. Here to make the following description, programme coordinated management system $S = \{S_1, S_2\}$, S_1 indicates the internal environment subsystems, S_2 represents the external environment subsystem, and S_1, S_2 can be described by a set of state variables, namely order parameter S_{1k}, S_{2k} ($k = 1, 2, 3, \dots, k$), where $S_1 = \{S_{11}, S_{12}, \dots, S_{1k}\}$, $S_2 = \{S_{21}, S_{22}, \dots, S_{2k}\}$, S_{1k} refers to various elements that constitute the internal environment, S_{2k} represents opportunities proportion of key factors of external environment, the higher they are, the more ordered of internal and external environment is. The multi-level fuzzy comprehensive evaluation method is used to measure the value of S_1 and S_2 , the final assessment of the value is the order degree between order parameter S_1 and order parameter S_2 , represented respectively by $U_1(S_1)$ and $U_2(S_2)$, at the same time, $U_1(S_1)$ and $U_2(S_2)$ vary from zero to one. The system order degree of the internal environment subsystems order parameter at the initial time (or in a specific time period) t_0 is expressed as $U_1^0(S_1)$, while the external environment subsystems $U_2^0(S_2)$, and at the time t_1 , which is respectively expressed as $U_1^1(S_1)$ and $U_2^1(S_2)$, attentively $U_1^1(S_1) - U_1^0(S_1) \geq 0$ and $U_2^1(S_2) - U_2^0(S_2) \geq 0$. Or these two equations are simultaneously less than zero (if the two formulas, one is greater than zero while the other less than zero, the situation is inconsistent state), coordination degree C of the large-scale construction enterprise programme management system can be showed as the following equation (1).

$$C = \sqrt{[U_1^1(S_1) - U_1^0(S_1)] \times [U_2^1(S_2) - U_2^0(S_2)]} \quad (1)$$

$C \in [0, 1]$, the larger it is, the higher the degree of system coordination is, otherwise the lower is, Table 2 shows the coordination level.

Equation (1) tests the coordinated situation of the whole system from the changes of order parameters of the internal and external environment subsystem. Through the material, energy, information exchange, that different subsystems would influence and interact with each other leads to overall system effect with self-organizing feature. Besides, nonlinear interactions among various elements are the inherent motivation of the organizational evolution, while

Table 2

The Classification of Coordination

Coordination degree C	0-0.09	0.10-0.19	0.20-0.29	0.30-0.39	0.40-0.49
Coordination level	Extremely uncoordinated	Seriously uncoordinated	Moderately uncoordinated	Mildly uncoordinated	Nearly uncoordinated
Coordination degree C	0.50-0.59	0.60-0.69	0.70-0.79	0.80-0.89	0.90-1.00
Coordination level	Barely uncoordinated	Primarily coordinated	Intermediately coordinated	Fine coordinated	Wonderfully coordinated

coordination is the form and means of self-organization. Coordinated management is to take the program management activities as a complicated system, and apparently key factor affecting the operation and development of the system is more than one, which makes the system has the feature of dominating by order parameter. Order parameter can reflect the status of each subsystem and play the dominant role of subsystems and benign coordination of constituent elements of the system. Coordination and optimization of the internal order parameters play a dominant role in turning the system from disorder state to order state and making the objectives of dynamic coordinated management of program come true. After calculating the value of the coordination degree C and comparing to the numerical value in Table 2, we will obtain the coordination degree and then infer the level of program management benefits. Of course, that references based on the calculated results is partly reasonable but relatively ideal, some qualitative factors will also be converted in fact, in general, the coordination degree plays the role of perfecting the dynamic coordinated management of program.

5 Conclusions

Needless to say, large-scale construction companies will face more situation of program contracting, it must accelerate the transformation of project management model in order to realize the innovation of management model and strategic growth of firms. This article gains the following cognition by making use of coordinated management theory in program management.

(1) Large-scale construction enterprises are facing the problems of project management model innovation and growth strategy selecting in the new situation, there is demand for changing the management model of construction projects.

(2) Coordinated management has a big advantage of applying it to program management in large-scale construction enterprises and it is worthy being further studied and widely applied.

(3) This paper presents the dynamic model of program management and introduces the coordination degree, which provides a new idea for large-scale construction companies to manage program but needs further empirical research.

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