

Research on the Coupling of Information Industry and Building Industry

Hao Cheng and Dongtang Tao

School of Management, Qingdao Technological University, Qingdao, 266520, China

Abstract: With the increasing complexity interaction, the relationship between information industry and building industry shows the characterizations of nonlinear and coupling. Their coupling and coordination degrees decide the development path and industrial strategy of the present construction industry. Based on the coupling of information industry and building industry, we establish their coupling degree and coordination degree model. Meantime, a numerical example for information industry and building industry is given by using the given model. Empirical results show that the proposed model is an effective way to improve forecasting accuracy.

Key words: Building industry, coupling degree, coordination degree, information industry

INTRODUCTION

With the rapid development of network technology and extensive application of information technology and information system, information resources were quickly spread and shared on a global scale. Information has become the most important resource for the world economic and social development. The rapid development of informatization has created an opportunity for our country's construction industry and international standards. Informatization strategy is the inevitable choice for the China's construction industry, as a pillar industry of national economy, to adapt to the new "four modernizations" (economic globalization, capital liberalization, industrial informatization and information network) development.

The construction industry (Isard and Schooler, 1959; Osaka, 2002) belongs to traditional industries of national economy and the information industry (Li *et al.*, 2008) belongs to the strategic emerging industries. Due to its advantage of the broad demand prospect, low energy consumption, strong relevance, employment opportunities and good comprehensive benefits with other industries, information industry has been the emerging industry. During the period of "The Twelfth Five-Year Plan", the Chinese Government will vigorously promote the research and development and application of information technology in the construction field. On May 10, 2011 the Ministry of Housing and Urban-Rural Development issued the "2011-2015 construction industry informatization development outline", showing the importance of construction industry for Government Department informatization at the policy level. Applying information technology to transform and promote the traditional construction industry, applying informationization to lead forward industrialization and

applying industrialization to promote informationization will promote the upgrade of construction industrial structure and the cultivation of new economic growth point.

In the policy background of the world economic integration and the large-scale adjustment of national industrial structure, for the traditional industry, it is important how to optimize and upgrade and to couple with information industry. At the same time the relationship between information industry and construction industry showed some new features. Qiao and Fang (2005) studied the dynamic coupling model and applied it to urbanization and eco-environment problems. Wei *et al.* (2007) studied the grey-relation of traffic system and urbanization in Jilin Province of China. Zhang (2009) discussed the coupling development between urbanization and industrial ecologization. Xiong and Li (2010a, b) researched the coupling development of strategic emerging industry and traditional industry. More researches can be seen in Ran (2008), Hao and Yu (2008) and Qi and Ruan (2010).

In view of the increasing complexity interaction and the nonlinear and coupling of characteristics between information industry and building industry, the research on its coupling and coordination degree related to development path and industrial strategy decisions of the construction industry at the present stage. Therefore, we urgently need to further explore the coupling mechanism between information industry and the construction industry, revealing the inner technology path of the construction informationization.

The current related data is qualitative description on construction informationization, emphasizing the importance of construction informatization and lack of quantitative research, such as what extent is the China's construction informatization at the present? Only after

fully understanding the current situation, can we grasp the growing trends and the specific path in the future. Therefore, the authors apply industrial coupling theory and systems analyze methods to build relational model and research the trends of construction informationization by the method combining qualitative and quantitative. The industrial coupling degree reflects the degree of construction informationization. We attempt to benignantly explore coordinated development condition of information industry and construction industry under the new situation, so as to establish a coupling model on the coordinated development and virtuous circle between information industry and construction industry. This coupling model makes as a new exploration to rapidly develop China's construction industry.

THE COUPLING RELATIONSHIP OF INFORMATION INDUSTRY AND CONSTRUCTION INDUSTRY

Coupling refers to a phenomenon that the movement of two or more systems affects each other so as to unite together through various interactions and a dynamic interaction relationship under a benign interaction between the various subsystems of interdependence, mutual coordination and promote. This phenomenon, which respective coupling subsystem produces interactions and influences each other in different systems, called the coupling relationship.

There is a natural coupling relationship between information industry and the construction industry. In the process of socio-economic operation, there exists the close coupling relation in information industry and the construction industry. Development of the construction industry is the basis for the development of information industry (these concept, such as intelligent building and green ecological building, needs the support of information technology). The changes of demand, such as information equipments, software products and information services needed by building industry, became the fundamental motion power of the development of information industry. The structure of construction industry affects the structure of the information industry and the scale and speed of development of information industry. The good and rapid development of construction industry can be able to promote the development of software industry, which is closely associated with the construction industry in the information industry. These will promote the information industry to continuously pursuit and take professional development courses. Information industry can promote the overall management of the construction to keep pace with the times and accelerate the reform of management organization and optimization and upgrading of industrial structure in the construction. Because of information technology possessing the characteristics such as permeability,

driven, doubled, network and system, the application of information technology will promote the construction industry to reform its management content, processes and ways and then will promote to restructure the original organization to adapt to the management of information society. The business reconstruction and management changes will directly contribute to promote the reform of management organization and optimization and upgrading of industrial structure in the construction.

DESIGN ON COUPLING MODEL OF INFORMATION INDUSTRY AND BUILDING INDUSTRY

Design on the coupling index system: The coupling relationship between information industry and construction industry is the complex system engineering. There are more elements of reflecting the relationship and the relationship is complex among these elements of the two systems. Each subsystem is also under the state network. Establishment of index system is the key element of coupling evaluation system. Currently, there are no uniform indexes at home. This paper ascertains corresponding index option according to the characteristics of each system combining information industry with construction industry.

Principles of designing the index system: Establishment of index system evaluated the coupling model of information industry and construction industry, must adhere to the following principles:

First of all, the index must be quantified. The meaning of the selected indexes must be explicit. We can directly obtain the data or indirectly obtain the data by calculated and deduced from the statistics. The method of index quantization must be consistent in the context. The quantification of index system is the basis for carrying out the data analysis finally.

Secondly, the index must be real and objective. The index selected must truly reflect the current situation of information industry and the construction industry. We should seek the index from the current realities of the industry.

Again, the index should be suit for the features of industrial development. Information industry and construction industry all have its unique characteristics; the index should reflect the relationship of interdependences and mutual restrictions between information industry and construction industry.

Finally, the index should be focused on contribution value. When selecting the indexes, we should try one's best to select these indexes that can give more value than others. We make use of as few indexes as possible to reflect sufficient information. So, we can effectively avoid using excessively example index system to result in redundancy and reduce operability.

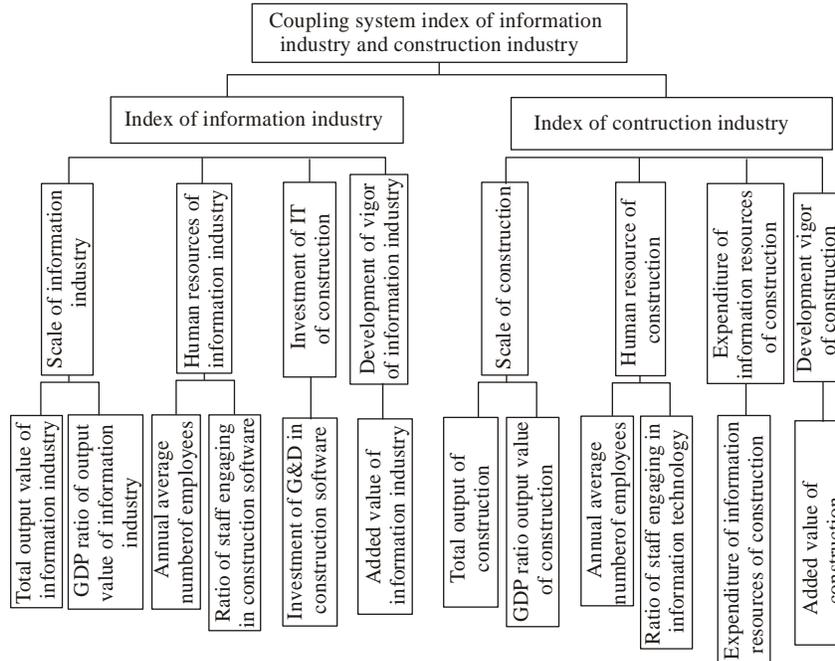


Fig. 1: Coupling system indexes of information industry and construction industry

Configuration on the index system: According to the relevant literature material and above principles selected, combining with the coupling characteristics of information industry and the construction industry, we respectively choose the indexes closely affecting the coupling degree of information industry and construction industry. The indexes of construction industry include the scale of construction, the human resource of construction (mostly containing personnel engaging in information technology in the construction industry), expenditure of information resources of construction and development vigor of construction and so on four aspects; the indexes of information industry include the scale of information industry, the human resource of information industry, investment of science and technology in the construction industry (specifically referring to the investment of research and development engaging in construction software in information industry) and development vigor of information industry and so on four aspects. The coupling system indexes of information industry and construction industry are shown in Fig. 1.

Coupling degree model:

Assign index: The

$$U_i = \begin{cases} (X_i - X_{\min}) / (X_{\max} - X_{\min}) \\ (X_{\max} - X_i) / (X_{\max} - X_{\min}) \end{cases} \quad i = 1, 2, \dots, n$$

In the formula above, U_i reflects the level of efficacy of the variable X_i , it means most dissatisfactory when U_i

tends to 0, most satisfactory when U_i tends to 1, so there is $0 \leq U_i \leq 1$. Because information industry and construction industry is in two different subsystem, the whole efficacy of the various parameters of the subsystems can be expressed with linear weighting method.

The comprehensive evaluation function of information industry can be expressed by:

$$f(x) = \sum_{i=1}^n a_i x_i$$

In the formula above, i reflects the number of the characteristics of information industry system, a_i are the weights of the various indexes, x_i are the standardized values of the various indexes of the characteristics of information industry system. The comprehensive index of information industry calculated with the function is bigger, meaning that in the better status. The comprehensive index is smaller, meaning that the information industry is in the worse dimensional units of different indexes are not the same, so the indexes are carried out corresponding standardization. This positive index is the bigger, the better; the negative index is the smaller, the better. X_i ($i = 1, 2, 3, \dots, n$) is the variable of index, X_{\min} is the minimum of index and X_{\max} is the maximum of index. Therefore, the efficacy function of information industry and construction the information industry can be expressed by status.

Table 1: Judging standard of coupling development of information industry and construction industry

Coupling degree	Level classification	Evaluation description
(0, 0.4)	Embryonic stage	The relationship of information industry and construction industry is not close
(0.4, 0.6)	Starting stage	The information industry gradually influences construction industry
(0.6, 0.8)	Stable stage	The information industry promotes the development of construction industry
(0.8, 1)	Mature stage	The information industry and construction industry are mutual promotion and common development

The comprehensive evaluation function of construction industry can be expressed by:

$$g(y) = \sum_{i=1}^n b_i y_i .$$

In the formula above, i reflects the number of the characteristics of construction industry system, b_i are the weights of the various indexes, y_i are the standardized values of the various indexes of the characteristics of construction industry system. The comprehensive index of construction industry calculated with the function is bigger, meaning that the construction industry is in the better status. The comprehensive index is smaller, meaning that the construction industry is in the worse status.

Coupling degree function: Using the concepts and coefficient model of capacitive coupling in the Physics for reference, the coupling degree function of information industry and construction industry can be expressed by:

$$C = \frac{f(x)g(y)}{\sqrt{[f(x) + g(y)]^2}}$$

Clearly, the value of the coupling degree C is between 0 and 1. When C tends to 1, the coupling degree tends to maximum, the relationship tends to be benign resonance coupling between systems or internal elements of the system and system will tend to the new orderly structure. When C tends to 0, the coupling degree tends to minimum, the relationship is at unrelated stage between systems or internal elements of the system and the system will tend to the disorderly structure.

Judging standard: Information industry can bring fresh vigor to the development of construction industry. The present development situation of construction industry shows that the construction industries have a larger impact on the development of information industry in the more developed regions of construction. The development of software industry, which is associated with the construction industry, promotes to accelerate informatization process and plays a positive role to the

construction industry. In order to more accurately reflect the coupling relationship and development level between two systems, we propose the evaluation standards and basic types of coupling development between information industry and construction industry using the related data for reference, as shown in Table 1. During the development process, possibly, because of the influence of policies and regulations and other mutations factors, information industry and construction industry are possible to degenerate to a previous coupling stage.

Coupling coordination degree function: The coupling degree C is the important index reflecting the coupling level of information industry and construction industry, playing an important significance in judging the strength and time sequence of coupling role between information industry and construction industry. However, the coupling degree is difficult to reflect the overall “efficacy” and “synergistic” effects of the information industry and construction industry development in some situations, especially on multiple areas, the upper and lower limit values calculating coupling degrees are generally derived from reference annual values and development planning values of each area. The judgment is possible to cause the misleading result merely relying on the coupling degrees, because information industry and construction industry of each area have the staggered, dynamic and imbalance characteristics. Therefore, in order to judge the interaction coupling coordination level of information industry and construction industry, we propose the coupling coordination degree function of information industry and construction industry. Its mathematical model can be expressed by:

$$D = (C \times T)^{1/2}, T = af(x) + bg(y)$$

In the formulas above, D is coupling coordination degree. T is comprehensive coordination index of information industry and construction industry system, which reflects overall synergistic effects or efficacy a and b are undetermined coefficients, moreover $a + b = 1$, which respectively represent efficacy coefficients of information industry and construction industry (we take 0.5 for convenient calculation). In practice, we had better ensure $T \in (0, 1)$, so we can ensure $D \in (0, 1)$ in order to use it. The classification of coupling coordination degree of information industry and construction industry is as shown in Table 2.

Table 2: Judging standard of coupling coordination degree of information industry and construction industry

Coupling coordination degree	Level classification
(0, 0.4)	Low-grade coordination coupling
(0.4, 0.5)	Moderate coordination coupling
(0.5, 0.8)	High coordination coupling
(0.8, 1)	Extreme coordination coupling

Table 3: Comprehensive evaluation value of information industry and construction industry

Year	2008	2009	2010
Comprehensive evaluation value of information industry	0.2105	0.3452	0.5551
Comprehensive evaluation value of construction industry	0.2444	0.3928	0.4554
Coupling degree	0.4986	0.4990	0.4976
Coupling coordination degree	0.3368	0.4291	0.5014

EMPIRICAL ANALYSIS ON THE COUPLING RELATIONSHIP OF INFORMATION INDUSTRY AND CONSTRUCTION INDUSTRY IN CERTAIN CITY OF CHINA

This study collects the related index data from “the Statistical Yearbook in certain city of China” in 2008-2010, finally carrying out to analyze and process these data. Firstly, because the dimensional unit of information industry and construction industry indexes is not the same, the indexes are carried out by corresponding standardization. Because the maximum and minimum values of each index are undetermined, the data is possible to be outliers beyond the range. We choose the mean and standard deviation, based on the original data, to carry out corresponding standardization. Secondly, we set the weight value of each index after applying the factor analysis and Delphi method to carry out comprehensive analysis.

After the data has been standardized, we calculate the comprehensive evaluation value of information industry, the comprehensive evaluation value of construction industry, the value of coupling degree and coupling coordination degree of information industry and construction industry from 2008 to 2010, as shown in Table 3.

Analysis indicated that the comprehensive evaluation value information industry and construction industry increased year by year, indicating that the city's information industry and the construction industry integrally have good coupling.

The coupling degree overall value, calculated by the model, is in the intervals of (0.4, 0.6). There is no great change and a slight increase of coupling degree and in the past three years the coupling degree has been close to about 0.5 and is more stable, which indicates that this city's information industry gradually affects the construction industry. According to the coupling law, the

city should energetically develop the information industry basis of the development of construction industry and relying on information demand. Developing comparative advantage of the city industry can effectively improve the developing of the pattern that the development between the information industry and construction industry are mutually promoted, virtuous circled and high-effected.

There is an obvious upward trend in coupling coordination degree, from a low-grade coordination coupling degree at the year of 2008 and a moderate coordination coupling degree at 2009 gradually increasing to over 0.5 into the high coordination coupling stage at the year of 2010.

In summary, the relationship between the information industry and construction industry is now in the starting stage, the development between the two systems is more coordinated, which is in accord with the present status of the city's industry.

CONCLUSION

We came to the conclusion that there is a coupling relationship between information industry and construction industry applying the industrial coupling theory and system science theory to analyze the information industry and construction industry. Meanwhile, according to the output of the mathematical model, we came to the following conclusions:

- There is an interactive coupling relationship between information industry and construction industry. The information industry can promote the management of the construction to keep pace with the times and accelerate the reform of management organization and optimization and upgrading of industrial structure in the construction. The optimization and upgrading of the construction structure conversely affects the structure of the information industry and the scale and speed of development of information industry. The coordinate development between them is the foundation of the overall benign development.
- The coupling degree of information industry and construction industry reflects the synergistic level between variables in the interaction of the two kinds of industries, so that the system development is from disorder to order and effective. Meanwhile, the choice of coupling degree index has played a crucial role in establishing the model.
- This study follows the scientific, logical and applicable principle and also refers to the related index used to calculate the development of information industry and construction industry by the country and refers to the coupling degree particularity in establishment of index system.
- The coupling degree can effectively reflect the coupling level of information industry and

construction industry, but it is difficult to reflect the synergistic effect. Therefore, on the basis of research on the coupling degree of information industry and construction industry, this paper introduces the coupling coordination degree to judge its interaction coupling coordination level.

- We also make an empirical analysis on comparative study in multiple areas between information industry and construction industry. Observing the change trend in the coupling coordination development of information industry and building industry among the cities, analyzing the interlaced, dynamic and unbalance characteristics on the development of information industry and construction industry in each area, which is used to guide the technical path of industrial structure optimization and upgrading.

REFERENCES

- Hao, S.B. and B. Yu, 2008. Research on Coupling Degree Model and Application of the Enterprise's Technology Capacity and Technology Management Capacity, Forecasting.
- Isard, W. and E.W. Schooler, 1959. Industrial complex analysis, agglomeration economies and regional development. *J. Regional Sci.*, 1(2): 51-53.
- Li, Q.X., Y. Su and Y.L. Pei, 2008. Proceedings of the International Conference on Information Management, Innovation Management and Industrial Engineering. N.W. Washington IEEE Computer Society pp: 172-175.
- Osaka, T., 2002. Regional economic development: Comparative case studies in the US and Finland. *IEEE I. E.M.C.*, pp: 635-642.
- Qi, Z.F. and Y.Y. Ruan, 2010. International Conference on Artificial Intelligence and Computational Intelligence. N.W. Washington IEEE Computer Society, pp: 458-462.
- Qiao, B. and C.L. Fang, 2005. The dynamic coupling model and its application of urbanization and eco-environment in Hexi Corridor. *J. Geogr. Sci.*, 15(4): 491-499.
- Ran, Q.G., 2008. Coupling model of industry cluster and industry chain. *Commer. Res.*, 379(11): 91-94. (in Chinese)
- Wei, X., Y. Wang, N. Li and Q.W. Zhu, 2007. Grey-relation analysis of traffic system and urbanization in Jilin Province of China. *Chinese Geogr. Sci.*, 17(3): 216-221.
- Xiong, Y.Q. and S.C. Li, 2010a. Research on the process and mechanism of coupling development of strategic emerging industry and traditional industry. *Sci. Sci. Manag. S.T.*, 31(11): 84-87 (in Chinese).
- Xiong, Y.Q. and S.C. Li, 2010b. Research on coupling development of strategic emerging industry and traditional industry. *Res. Finan. Econ. Issues*, 323(10): 38-44.
- Zhang, W.L., 2009. Study on the coupling development between urbanization and industrial ecologization. Ph.D. Thesis, Jinan University.