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Network-enabled capability of logistics business groups

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Abstract: Logistics business group (LBG) is an effective organization forms to ease the inconsistency between supply and demand in logistics market as well as to improve the efficiency of collocating logistics resources. Since it's difficult to measure accurately the capability of LBG, the paper has concentrated on the capability of LBGs based on the idea of Network-Enabled Capability (NEC). NEC of LBG is a conception relative to traditional produce capability of enterprises, which roots in the network connectivity and network awareness. An idiographic model has been put forward to describe the NEC evolvement and some ratio to measure NEC of LBG has been employed. After analyzing two cases based on certain two models, we deem that the NEC of LBG is 1.5. That is, the potential capability produced by network urges LBG to have 1.5 times more capability than that of no network.

Keywords: Logistics Business Group, Network-Enabled Capability, Complex Network Model

1. Introduction

As one of the most typical productive services, logistics service constitutes a variety of subdivisions. In China, the levels of logistics socialization and logistics specialization are low. Most logistics enterprises can only provide some sub-segments of logistics services. After years of developing, China's logistics industry has shown the following two major contradictions: Firstly, individual logistics enterprises can realize highly organized and planned state, while the entire logistics industry production is still at disorderly state. Secondly, the absolute capability of logistics service supply is expanding rapidly, while the effective logistics demand and its structure from economic and social

development tend to disperse. Developing LBGs is an effective way to ease the present contradictions of China's logistics industry. LBG is one of the most effective organization forms so far to ease the inconsistency between supply and demand in logistics market, and to achieve synergetic development in the competition relationship among logistics enterprises.

Based on the literature review of business group (Manohar et al., 2007; Marianne et al., 2008; Raymond et al., 2004; Rejie et al., 2008; Robert et al., 2003; Stephen et al., 2003), we attain the following conclusions: ① the general principles for business groups provide professional support to our work on NEC of LBG. Such theoretical basis is essential. ② It is more mature to carry out empirical analysis on business groups by statistical method so far. However, there exist more subjective factors in course of selecting variables and acquiring data. Based on the literature review of LBG (Kee-hung et al., 2004; Panayiotis' et al., 2008; Scott et al., 2003), we attain the following conclusions: ① Following the evolvement principle of competition and cooperation among logistics enterprises, LBG is an effective way of synergetic development for logistics enterprises. ② Since modern logistics in China started late in practice, resources integration is essential to logistics industry. LBGs can help to solve the contradictions of logistics production structure and achieve effective integration of logistics resources. ③ The literature on logistics enterprises and logistics resources integration provides better base to study LBGs. Using network theory, it is expected to achieve innovation on quantitative methods of studying LBGs.

In the context of NEC (Lu L. et al., 2009), networking can be defined with regard to two aspects: network connectivity where every pair of distinct nodes is connected (without isolated sub-networks) and network awareness which enables each node to be aware of other nodes in the network. NEC requires Network Enabling by connectivity, information sharing and networking people, assets, procedures, and the Capability to integrate them to fulfill mission objectives. From the scientific point of view, we can give some theoretical expectations for the growth and development of LBGs by using some quantitative method. When thinking about capability-related issues of LBG from the perspective of NEC, we may employ the general characteristics of business groups (such as the boundary dynamics, frequent reorganization) as the basis and explore NEC of LBG which aims at allocating optimally resources and building overall capability.

2. Essence of Network-Enabled Capability of Logistics Business Group

2.1 Logistics Business Group

Set $Z(1), Z(2), \cdots, Z(n)$ as the transactions (enterprise buy or sell its specific logistics services) involved by a member enterprise of certain LBG (E).

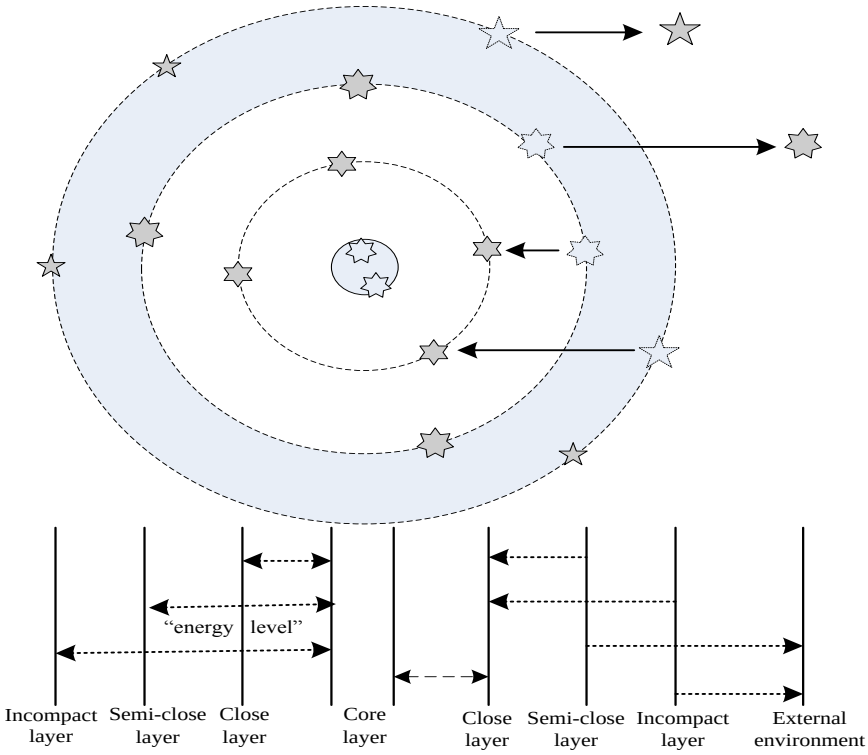
Define:

$U(Z(i)) = 0$ when transaction $Z(i)$ is realized in market; $U(Z(i)) = 1$ when transaction $Z(i)$ is realized among member enterprises.

Then $E = \{Z(i) \mid U(Z(i)) = 1\}$

Set as one logistics enterprise in economic and social system (U). Suppose that the set of transactions carried out by logistics enterprises can be involved in the set of all transactions carried out by LBG. By defining the lower approximation set as $Z_*(e) = \{e \in U : Z(e) \subseteq E\}$ and the upper approximation set as $Z^*(e) = \{e \in U : Z(e) \cap E \neq \phi\}$, we attain the boundary domain: $Z^*(e) - Z_*(e)$.

When the boundary domain of is empty, becomes an enterprise. When the boundary domain of is not empty, is a LBG.



Note: ① In this figure, dashed circles denote different arrangements on which enterprises lie. The five-pointed star, hexagonal and heptagonal denote respectively single enterprise.
② In this figure, four types of boundaries of LBG are displayed. Meanwhile, hiberarchy and transition movements are shown.

Figure 1: Homophile nucleus model of LBG

The boundaries of LBGs show the following main features: Firstly, when enterprises which are in outer boundary become more and more important to the core company, the core company may strengthen the control on these enterprises by increasing stake. As a result, these enterprises will transfer to inside boundary of LBG. Similar to nucleus model (Figure 1), enterprises in different boundaries have various "energy level" and the transition course will inevitably accompanied by energy changes. Secondly, LBGs dynamically adjust according to the logistics service capabilities of member enterprises. Such adjustment is exhibited by transition on the one hand and by "absorption/release" on the other hand. In order to absorb or release enterprises conveniently, LBG should let the outer boundary open.

2.2 Formal Description off LBG's Capabilities

The basic capabilities of LBGs include two aspects: basic logistics service

capabilities and profitability capabilities. The capabilities of LBGs can be divided as follows: transportation capability, storage capability, packing capability, loading/unloading and handing/carrying capability, distribution capability, distribution processing capability, information processing capabilities, and profitability capability.

Define the following parameters: A_j ——the basic capabilities of logistics enterprises $j = 1,2,\cdots,8$ (denote respectively transportation capability, storage capability, packing capability, loading/unloading and handing/carrying capability, distribution capability, distribution processing capability, information processing capabilities, and profitability capability); B_i ——the compositive capability of logistics enterprise i （ $i = 1,2,\cdots$）; a_{ij} ——weight of logistics capability in logistics enterprise ; a_j ——weight of logistics capability in LBG; B ——the basic capabilities of LBG; η ——a relativity parameter between the basic capabilities of LBG and the total capabilities of logistics enterprises included in LBG.

The capability of a logistics enterprise can be expressed as $B_i = \sum_{j=1}^{8} a_{ij} A_j$; The basic capabilities of LBG can be expressed as $\mathrm{B} = \sum_{j=1}^{8} a_j A_j$ If the growth process of LBG is considered as a reversible reaction process (since the boundary is dynamic, LBG absorbs or releases enterprises from time to time), the formation and development of basic capabilities of LBG can be expressed as $\{B_1, B_2, \cdots, B_i, \cdots, B_n\} \Leftrightarrow \mathrm{B}$ (where is variable)

$$\{B_1, B_2, \cdots, B_i, \cdots, B_n\} = \begin{pmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} & a_{17} & a_{18} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} & a_{26} & a_{27} & a_{28} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{i1} & a_{i2} & a_{i3} & a_{i4} & a_{i5} & a_{i6} & a_{i7} & a_{i8} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & a_{n3} & a_{n4} & a_{n5} & a_{n6} & a_{n7} & a_{n8} \end{pmatrix} \begin{pmatrix} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \\ A_8 \end{pmatrix}$$

Simplified as $\{B_1, B_2, \cdots, B_i, \cdots, B_n\} = \alpha \mathrm{A}$

$$\mathrm{B} = \sum_{j=1}^{8} a_j A_j \Rightarrow \begin{pmatrix} a_1 & a_2 & a_3 & a_4 & a_5 & a_6 & a_7 & a_8 \end{pmatrix} \begin{pmatrix} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \\ A_8 \end{pmatrix}$$

Simplified as $\mathrm{B} = \beta \mathrm{A}$

Where $\beta = (a_1 \quad a_2 \quad a_3 \quad a_4 \quad a_5 \quad a_6 \quad a_7 \quad a_8)$ In this way, the evolution relationship between the basic capabilities of LBG and the total capabilities of logistics enterprises included in LBG can be expressed as $\alpha \mathrm{A} \approx \beta \mathrm{A}$. With the significance of η, we attain $\beta \mathrm{A} = \eta \cdot \alpha \mathrm{A}$.

2.3 NEC of LBG

From a practical perspective, it is very difficult to measure the capabilities of LBGs because of their dynamic boundaries and integrated logistics service form. In expression $\alpha \mathrm{A} \approx \beta \mathrm{A}$ and $\beta \mathrm{A} = \eta \cdot \alpha \mathrm{A}$, the "≈" and " = " show the uncertainty of such transformation. We try to employ "NEC of LBG" to measure the capability of LBGs.

In the context of "NEC of LBG", network can be divided into two aspects: the organizational structure network and logistics service business network.

In general, these two networks have connectivity feature. However, the network awareness which enables each node to be aware of other nodes in the network is evidently different due to partial-interests driving, information sharing and other comparable factors. Different network awareness limits the full use of synergies. Network-Enabled comes from the connectivity of networks and should be protected by LBG from the organization, management, institutional and other soft environment. Capabilities, which base on the potential of Network-Enabled, are synergetic integrated and at the level of the whole LBG.

3. Measure NEC of LBG: an Example

NEC of LBG is a conception relative to traditional produce capability of enterprises, which roots in the network connectivity and network awareness. It's natural that there are various expression forms of NEC of LBG. Here we try to put forward an idiographic model to describe the NEC evolvement and employ some ratio to measure NEC of LBG.

In China, there are two major operating modes employed by logistics enterprises so far: point-to-point transportation and network transportation. In the following, we explore the ratio between LBG founded by point-to-point transportation enterprises and LBG founded by network transportation enterprises.

In our prevenient work (Hong, 2009); a complex network model was constructed to describe Regional Freight Transportation Network. We describe it briefly as follows:

Firstly, we'd better confirm the following rational presuppositions. Presupposition 1: The principle of cultivating and developing new logistics demand is as follows: "a little logistics demand → simple supply → inspiring potential logistics demand → supply on a large scale". Presupposition 2: When constructing complex network models, we refer to units of measurement in increasing logistics volume to score the time axis. Presupposition 3: The structure of the logistics network is similar to that of national transportation infrastructures. The working routes are set up according to national layout of transportation infrastructures.

Then, a complex network model was constructed: at the beginning, there are 2 ($N_0 = 2$) nodes which are connected with each other by links. The weight of every link is 1 ($w_0 = 1$). The total amount of links is M .

(1) Weight evolvement shows the appearance of new logistics demand on nodes. In every time-step, all links can update their weight by following coupling mechanism:

$$w_{ij} \to \begin{cases} w_{ij} + 1, & \textit{with probability} \quad Wp_{ij} \\ w_{ij}, & \textit{with probability} \quad 1 - Wp_{ij} \end{cases}$$

While $p_{ij} = \dfrac{s_i s_j}{\sum_{a<b} s_a s_b}$

The sum of follows $< \sum_{i<j} \Delta w_{ij} >= W$. Parameter reflects statistically the increasing extent of logistics volume.

(2) During the course of expanding, a partial selection mechanism is adopted. Let $s_i(t)$ be the node weight of node i in time t . $s_i(t)$ is restricted by: $\sum_j s_j = (2M + 2W)t$

Based on field theory, we can find $s_i(t) = M(t/t_i)^{\frac{M+2W}{2M+2W}}$

$P(s) \propto s^{-\beta}$ while $\beta = 2 + \frac{M}{M+2W}$

Based on the self-similar fractal characteristics of the national network, we attain $\beta \approx 2.5$ So $\frac{M}{M+2W} \approx 0.5$, $M = 2W$.

Considering two cases based on the above complex network model.

Case (1): Point-to-point transportation enterprise with the initial state $N_0 = 2$ and $w_0 = 1$ forms LBG. During the engendering course, point-to-point transportation enterprise adds liner at each time step. Case (2): Network transportation enterprise with initial state $N_0 > 2$ and $w_0 = 1$ forms LBG. During the engendering course, network transportation enterprise develops through such way as the above complex network model. Table 1 shows the evolvement of transportation capabilities of the two cases.

Table 1: The Evolvement of Transportation Capabilities.

Time	Case (1)		Case (2)	
	Node Amount	Capability	Node Amount	Capability
1	2	1	3	3
2	3	m+1	4	4+m
……	……	……	……	……
t-1	t	……	t+1	……
t	t+1	1+（t-1）m	t+2	3+（t-1）m+[3+（t-3）m]/2

It's obvious that the ratio between the two cases is when the time t tends to infinity

$$\lim_{t\to\infty} R = \lim_{t\to\infty} \frac{1.5mt - 2.5m + 4.5}{mt - m + 1} = 1.5$$

According to the above settings, we deem that the NEC of LBG is 1.5. That is, the potential energy produced by network urges LBG to have 1.5 times more capability than that of no network.

4. Conclusion

Logistics business group (LBG) is one of the most effective organization forms so far to ease the inconsistency in China's logistics industry, and to improve the efficiency of collocating logistics resources and achieve synergetic development. LBG has some network features and it's very difficult to accurately measure the service capability of LBG. In contrast to previous research, we concentrated on the capability of LBGs based on the idea of Network-Enabled Capability brought forward firstly by U.K. Ministry of Defense in 2003. Meanwhile, a complex network model is constructed to explore some idiographic form of NEC of LBG. Certain two complex network models have been put forward to describe the NEC evolvement while some ratio to measure NEC of LBG has been employed. We deem that the NEC of LBG is 1.5 under the condition of such models. That is, the potential capability produced by network urges LBG to have 1.5 times more capability than that of no network.

Since LBG is so complex, we can't immediately find all NEC indexes in any cases. More models put forward by industry and academe are expected to help understand LBG in depth.

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