

## A Research on Evaluating the Integration of Supply Chain in Industrial Cluster

Liyang Tang<sup>\*</sup>, Wei Zhao, Guohong Wang  
 School of Management, Dalian University of Technology  
 No.2 Linggong Road, Ganjingzi District, Dalian, Liaoning, China  
<sup>\*</sup>EMAIL: tangly@dlut.edu.cn

**Abstract:** The influence on the supply chain integration is analyzed from industrial cluster environment at first, and the factors of the supply chain integrated development are sorted and summarized, including degree of information integration, capability for market rapid-response, cooperative synergy, process integration and the ability of innovation resources conformity. Then measure steps for integration degree are given based on the fuzzy integral method, providing a quantitative analysis method for evaluating the integration of supply chain from industrial cluster environment.

**Keywords:** Industrial cluster; Supply chain; Degree for integration; Fuzzy Integral

### I. Introduction

China is accelerating the process of integration into the global economic system in the background of industrial globalization and integration into the world economy. Different countries, regions and enterprises are looking for their breakthrough point to establish their own strategic position, making themselves embed into cooperated network relationship according to their respective resource endowment, production, technology and market, etc in the global value chain. The market competition is no longer at an enterprise-level, but at the supply chains-level [1]. The index that reflects the close relationship level between the core enterprise and other cooperative enterprise is Supply Chain Integration Industrial clusters, as one spatial industry organization based on specialization and networking, provide a high-quality of "eco-environment" to supply chain integrated development, and basically play a positive role in the healthy development of supply chain integration. Supply chain integrated development has become the end-result for many enterprises in industrial clusters environment, because it integrated specialization, integration of core competence based on comparative advantage and large-scale operating characteristics in the way of network organization [2]. Integrated organization development trend showed that high level of integration is inevitable direction of the integrated development. The higher the degree of integration, the greater the value of supply chain, the stronger of the radiated driving force in regional economy. So it is necessary to evaluate and measure the degree of integration in order that the core enterprises can know the situation of integration for supply chain. It can make better use of resources provided by industry cluster environment and

improve the overall competitiveness of the supply chain so as to enhance regional strategic position.

Although some literatures have concerned about the description and evaluation of the supply chain integration, the evaluation studies placed under the industrial cluster environment are not so many. It is not comprehensive for two questions. One is the environment in that industrial clusters provided to the development of supply chain integration, the other is quantitative evaluation studies on influential factors of supply chain integration in industrial cluster environment. In view of above, this paper analyses a sound developing environment which provides to the supply chain from the perspective of industrial cluster, gives factors that influence on supply chain integrated development. Based on the Fuzzy Integral Method, evaluation model is built. The paper will provide theoretical foundation to the government in formulating industrial policy and the corporate in making decision investment as reference.

### II. Connotation of Supply Chain Integration in The Cluster Environment

#### The Definition of Concept for Supply Chain Integration in The Cluster Environment

The explanation for the integration in English means fusion, synthesis, as a whole, unify etc. Some scholars summed it up as re-structure and re-configuration among integration elements according to certain integrated mode and pattern, aiming at enhancing the whole function of integration body in a greater extent and achieve the target of integration body more effectively [3]. To achieve the most optimal allocation and utilization of regional resources, supply chain integration is just one unified developing mode based on supply chain through resource integration and coordination of operations of cooperative enterprises. Supply chain integration is a key indicator to measure the degree of combination, namely the degree of integration.

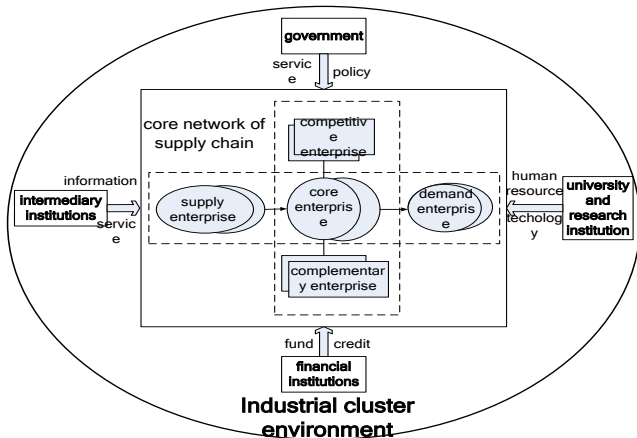


Figure 1 supply chain structure map in industrial cluster environment

Supply chain structure map in industrial cluster environment is shown in figure 1. As local concentration of supply chain spatially [4], industrial cluster collect some resources as human resources, information, technology, capital, and policy in the flexible way on a geographical basis. It provides broad foundation to the development of supply chain integration, completing resources integration in industrial chain and realizing the collaborative commerce for many enterprises. Based on this, the article gives the simple definition for supply chain integration as follows: cooperative companies in supply chain take advantage of essential factors, such as knowledge, technology, human resources, information provided by the main constitutions in clusters, reaching resource integration, coordination and collaboration of business operations to achieve the degree of integrated development in the industrial cluster environment.

Industrial cluster provides a high-quality “eco-environment” to the sound development of supply chain integration, achieving the integration for main talents which possess the necessary knowledge and capacity. At the same time, it lays the foundation for core technology, ability enhancement and value realization of supply chain integration with a platform for industry and product, providing a stage for supply chain integrated operation.

### The Constituent Elements of Supply Chain Integration in Cluster Environment

The key roles of industry cluster environment in identifying the constituent elements for supply chain integration must be highlighted. It means that industrial cluster environment is the carrying capacity and foothold for supply chain integrated development. In recent years, some scholars are also concerned on the symbiotic relationship between industry clusters and supply chain. Lijizi, Liuchunlin (2006) illustrated the concept of the supply chain in the cluster mode, providing a feasible method in discussing supply chain from the industry clusters perspective [5]. Starting from the industrial cluster environment, Yangjin, Youjianxin,

Caiyiping (2007) analyzed and summarized the evaluation factors influencing on rapid response capability of supply chain. Four major factors were given as follows: cooperation and coordination ability, process integration, information integration levels and customer demand-oriented.

Based on conceptual refinement, and relevant literature [6][7][8] and expert interviews, the constituent elements of supply chain integration in industrial cluster environment include as the follows:

#### 1. Information integrated degree

Information integration refers to the use of modern information technology, database technology and multimedia technology to realize information of collecting, integrating, analyzing and processing in the whole supply chain nodes. It can reduce costs and improve efficiency of supply chain management by forecasting and supporting decision case and by monitoring and controlling timely towards supply chain. Information integrated degree is mainly reflected on the information construction, mainly refers to the ability to use information technology, the breadth and depth of virtual network connections, the level of information sharing with customers and suppliers.

#### 2. Rapid response capacity in the market

In order to adapt the market “on demand” mentality, market rapid response can make the supply chain response to customer demand fast with high efficiency, mainly refers to the ability to adapt the market conditions, forecasting ability and responding ability. The diversity of technical resources makes the rapid reaction capability possible in industrial clusters through supply chain on the market.

#### 3. The ability of cooperative synergy

Under the cluster conditions, cooperated partners join the supply chain system, not only bringing manufacturing information and manufacturing resources, but also bringing knowledge of management technology, patented technology, market development, product development and technological innovation. Clusters provide a fast and convenient way for knowledge dissemination and utilization so that partners can integrate into the supply chain and coordinated development, including capacity for handling relationship between suppliers and customers; the ability to adapt industrial cluster environment; the capacity for coordinating with the government, intermediary agencies and other stakeholder groups.

#### 4. Degree of process integration

Degree of process integration reflects integrated level in the supply chain business processes especially the R&D, manufacturing and marketing. And it also reflects the tacit level in the main interaction for the supply chain in industry clusters environment. The objective is to maximize the value of each cooperative enterprise in the supply chain, mainly including degree of vertical integration, capacity of quick decision-making, the level of customized products and services etc.

#### 5. Ability of integrating innovation resources

Innovative resources integration means consolidation and

utilization to key elements of innovative resources in clusters Resource integration process is a large-scale optimization process. It can access to a variety of resources in timely at lower cost, higher quality and faster speed in industry clusters, including social services and human resources. Through innovative resources integration, resources utilization of supply chain may more rational, achieving integrated high-performance in supply chain.

### III. The Evaluation System for Supply Chain Integration Based on Fuzzy Integral

#### Construction of Evaluation Index System

In this paper, the evaluation of integration is the influence on the supply chain integrated development based on industrial cluster environment, so the filter for evaluation indicators also based on resource elements in industrial cluster as a foothold. After experts' inspection, discussion and analysis to the above five elements, the evaluation system for supply chain in integration industrial cluster environment is confirmed based on basic principles of objectivity, comprehensiveness, maneuverability in index construction, its hierarchical structure as shown in Table I.

Table I. evaluation index system for supply chain integration in industrial cluster environment

The first index	The second index
information integrated degree	breadth and depth of the virtual network connections the level of information sharing with customers and suppliers difficulty of information transmission
rapid response capacity in the market	adaptability in the market predictability in the market response capacity in the market
the ability of cooperative synergy	capacity for handling relationship between suppliers and customers the ability to adapt industrial cluster environment the capacity for coordinate with the government and intermediary agencies
degree of process integration	the level of customized products and services capacity of quick decision-making degree of vertical integration
ability of integrating innovation resources	acquisition capacity for Human resource acquisition capacity for social services utilization for scientific research and technology

#### Methodology of Evaluation

#### 1. Fuzzy measure

In 1974,the Japanese scholar named Sugeno proposed a class of set functions which can replace relatively weak monotonicity to additivity, namely fuzzy measure Relative to the classical additive measure, fuzzy measure is a kind of non-additive measure in the condition of unavoidable measurement error Regular fuzzy measure of finite set is used in the practical application. The definition is given as follows [9]:

Suppose  $X$  is a finite set,  $P(X)$  is set of  $X$  subset,if the function  $g : P(X) \rightarrow [0,1]$  satisfy the following conditions:

$$g(\phi)=0,g(X)=1 \tag{1}$$

$$A,B \in P(X), \text{ and } A \subset B, \text{ then } g(A) \leq g(B) \tag{2}$$

Then  $g$  is regular fuzzy measure defined in  $P(X)$ .

When  $|X| = n$ , just determine the fuzzy measure value in  $n$  positive single-point set, the measure of all subsets is confirmed overall. There are totally  $2n$  parameters' value to be determined, if the value of  $n$  is large, determination of the fuzzy measure is very difficult. Fuzzy measure which meets  $\lambda$  rule becomes  $g_\lambda$  fuzzy measure. At the moment, just confirm fuzzy measure value in certain single point set,  $g_\lambda$  fuzzy measure can be constructed.

$\lambda$  rule:

There are  $\lambda \in \left(-\frac{1}{\sup g}, \infty\right)$ , here  $\sup g = \sup_{A \in P(X)} g(A)$ ,

for arbitrary  $A, B \in P(X)$ , and  $A \cup B \in P(X), A \cap B \in \phi$ , equality holds when  $g(A \cup B) = g(A) + g(B) + \lambda g(A)g(B)$ .

When  $g_\lambda(X) = 1$ , and for arbitrary  $A \in P(X)$ ,  $g_\lambda(A) \in [0, 1]$  can be defined regular  $g_\lambda$  fuzzy measure.

Obviously in regular  $g_\lambda$  fuzzy measure, there is  $\lambda \in (-1, \infty)$ . Besides, according to the  $\lambda$  rule, there are:

In regard to arbitrary  $A, B \in P(X)$ , and  $A \cup B \in P(X), A \cap B \in \phi$ , there is  $g_\lambda(A \cup B) = g_\lambda(A) + g_\lambda(B) + \lambda g_\lambda(A)g_\lambda(B)$

When  $A, B$  are single-point set,  $g_\lambda(X_i)$  can be called measure density, named  $g_i$ .

So, for any finite set of  $X = \{x_1, x_2, \dots, x_n\}$ , there is

$$g_\lambda(X) = \frac{1}{\lambda} \left[ \prod_{i=1}^n (1 + \lambda g_i) - 1 \right] \tag{3}$$

there is

$$\lambda + 1 = \prod_{i=1}^n (1 + \lambda g_i) \tag{4}$$

for regular  $g_\lambda$  fuzzy measure and  $g_\lambda(X)=1$

2. Fuzzy Integral

Fuzzy Integral is a nonlinear integral based on Fuzzy measure. Choquet Fuzzy Integral is used in this paper, the definition is given as:  $X=\{x_1,x_2,L,x_i,L,x_n\}$  is finite set, function  $f(x) = x$  is defined as discrete-valued function, function value respectively is  $\{a_1,a_2,L,a_n\}$  Suppose  $a_1 \leq a_2 \leq L \leq a_n$ ,  $g_\lambda$  is regular fuzzy measure defined in  $X$ .

There is

$$(c) \int fdg = \sum_{i=1}^n (a_i - a_{i-1}) g_\lambda(A_i) \tag{5}$$

Order  $(c) \int fdg = F$ , then  $F$  is the overall value of assessment for supply chain integration.

**Steps for Calculation of Evaluation**

1. Semantic Transformation of evaluating indexes

After the discussion and modification finally, assessment Panel definite the semantic operator which used to evaluate the supply chain integration and semantic operator for weight measure indicators which used to measure the importance of indicators In addition, the Panel selected the semantic operator and the triangular fuzzy number corresponding to the weight of the importance, as shown in Table 2. The aim is to quantify the information expressed in language. The corresponding relationship in Pre-designed triangular fuzzy number and linguistic don't need the export care the choice of subordinate function.

Table 2 Performance of indicators and the semantic of indicators weight and its triangular fuzzy number

performance of indicators	weight of indicators	positive triangular fuzzy number
worse	the most not important	(0,0,0.25)
bad	not important	(0,0.25,0.5)
ordinary	ordinary	(0.25,0.5,0.75)
good	important	(0.5,0.75,1.0)
better	the most important	(0.75,1.0,1.0)

2. Steps for calculation

Suppose  $X=(X_1,X_2,X_3,X_4,X_5)$ ,  $X_1$  represents information integrated degree,  $X_2$  represents rapid response capacity in

the market,  $X_3$  represents the ability of cooperative synergy,  $X_4$  represents degree of process integration,  $X_5$  represents ability of integrating innovation resources.

Steps for calculation are as follows:

①Referring to the index in table 1, semantic operators of different indicators and relative importance of the first index and the second index are given by experts panel; it can not be changed after confirmation.

②Referring to the index in table 1,semantic evaluation of index performance is given by experts panel.

③After evaluating the importance of indicators for every supply chain integration degree, the fuzzy weight values of every elements are gotten, then use the relative distance formula for fuzzy number

$$\frac{\sqrt{1/3(a^2 + b^2 + c^2)}}{\sqrt{1/3(a^2 + b^2 + c^2)} + \sqrt{1/3[(1-a)^2 + (1-b)^2 + (1-c)^2]}}$$

Defuzzify fuzzy weight value  $\omega_i$  into a clear value  $\bar{\omega}_i$ .

④Represent Weights  $\bar{\omega}_i$  with  $g_i$  after defuzzification, substituted into(2), calculate the value of  $\lambda$ .

⑤Suppose  $x_{ij}$  is assessed value of supply chain degree in the factor  $i$ , indicator  $j$ .  $\bar{\omega}_{ij}$  is the assessed value of the weight. So the evaluated value of supply chain degree in factor  $i$  is  $x_i=(x_{i1} * \bar{\omega}_{i1} + x_{i2} * \bar{\omega}_{i2} + \dots + x_{ij} * \bar{\omega}_{ij})$ ,  $x_n$  represents index number under factor  $i$ . Defuzzify  $x_i$  into  $\bar{x}_i$  taking advantage of the relative distance of fuzzy number.

⑥Reorder the evaluation value from small to big after defuzzification of every factor.

⑦Calculate the value of  $\lambda$  and  $g_i$  in order, get the fuzzy measure  $g_\lambda$  of every factor.

⑧ Calculate the assessed value of the fuzzy integral of supply chain integration according to (3), represent as  $F$ , that is to say  $F$  is just the measured values of supply chain integration in industrial cluster.

After getting evaluated result above, we can compare the supply chain integration vertically and horizontally, and we can also find where the short slab for supply chain integration in certain industry during the calculation course, which take an important part in improving overall regional competitiveness.

**IV. Conclusion**

Supply chain integrated development in industrial cluster environment has important guiding significance for strengthening of the supply chain coordination and cooperation, optimizing the allocation of resources taking advantage of and reducing the production costs, thereby enhancing the overall competitiveness of the region. Based on defining the concept of supply chain integration in industrial cluster environment. We have studied the factors affecting supply chain integration, built an integrated degree evaluation index system and gave the evaluation steps based on fuzzy integral method. The paper provides theoretical support for supply chain integration at the level of industrial cluster and provide a pre-analytical decision-making support for government.

In general, this paper is just a small part of the supply chain integration research. A model of the empirical analysis has not been built up, a lot of work needs to be more in-depth and be detailed, and further analysis and examination have to be done. Further studies need to be focus on how to improve supply chain integration in the industrial cluster environment and the role that supply chain integration play to enhance the overall competitiveness of the region in the future.

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### Background of Authors

**Tang Liyan**(1963-), female, born in JiLin province, the city of JiLin, doctor degree, vice head of the technical economics institution in Dalian University of Technology, research on technical economics and management, project management.