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Partner Choice of Supply Chain Based on 3d Printing and Big Data

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Abstract: To solve the problem of partnership choice of Supply Chain in the context of 3D Printing and Big Data, a method to choose cooperative partners based on Analytic Hierarchy Process and Fuzzy Synthetic Evaluation was proposed. Analytic Hierarchy Process was used to construct the hierarchical structure of partner evaluating indicator and determine the corresponding weight. Fuzzy Synthetic Evaluation was adopted to assess and choose partners. For verifying the method, a logistics company was analyzed as an example. The results show that this method may reduce the influence of subjective factors on the partner choice, enhance the accuracy and reliability of partner choice and strengthen the competitiveness of supply chain enterprises.

Key words: Supply chain, partner choice, 3D printing, big data, analytic hierarchy process, fuzzy synthetic evaluation

INTRODUCTION

3D printing, known as one of the important indicators of the third industrial revolution, is a process of making a three-dimensional solid object of virtually any shape from a digital model (D'Aveni, 2013; Sachs, 2001). 3D printer can print in plastic, metal, nylon and over a hundred other materials (Burnett *et al*., 2012; Karim *et al*., 2012). With the development of 3D printing its cost is dropping which will be more accessible. 3D printing has changed the traditional supply chain business processes, such as procurement, manufacturing, logistics and sales and so on. The traditional vertical chain structure will become more short and efficient. Challenges faced by the manufacturing and logistics industry will become more prominent. Traditional variety, less volume, multi-batch delivery of raw materials by JIT (Just in time) mode will replaced by new less variety, high-volume, low batch 3D printing materials logistics supply. Procurement business processes will become simpler; a lot of complicated procurement of raw materials will become purchase mere 3D printing materials only. Imagine how easy we bought a box of toner! Sales business processes will also be affected. Customers and consumers will be more dependent on the network. They design by themselves or buy 3D printing source files from the designer there. They may also get the design supports and even get free 3D printing source files from Chkee Union. After that, what have to do for them is to start 3D printer's button to begin printing their own goods at home or 3D printing shop which were get before from a shopping mall or the E-commerce website, such as Amazon, Taobao Mall and so on. People can easily get their ideas "printed".

Big data usually includes data sets with sizes beyond the ability of commonly used software tools to capture, curate, manage and process the data within a tolerable elapsed time (Snijders *et al*., 2012). Big data will also have a significant impact on the supply chain. The new methods of acquiring, processing and applying data will make the supply chain more transparent and efficient. Rapid response strategy of supply chain (Jin *et al*., 2010) will be better realized, the traditional supply chain processes will be restructured.

Obviously, both 3D Printing and Big Data have generated the significant impacts on the traditional supply chain processes which are facing new restructuring changes. However, there are only a few scientific researches in this area. For example, Zage *et al*. (2013) pointed out that supply chain security can be improved using Big Data. In fact, supply chain control tower theory (Accenture, 2012; Miles, 2011) has the potential to solve these problems which turn raw data feeds into real-time information in a central location that monitors the flow of orders, inventory and consumption across the network.

The scholars mainly concentrated on "the influencing factor" and "the assessment method" of the partner choice problem before (Dai *et al*., 2011). Brouthers *et al*. (1995) found that companies should take four factors:

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Complementarity, cooperation culture, cooperation goal and risk share into consideration when choosing their partners. Wang *et al.* (2008) set up the evaluating indicator system from five aspects which are property prestige, management capacity, resource competence, technical conditions and compatibility, applied the Theil Imbalanced Index to calculate index weight value and set up multi-level preferential model of cooperative partner appraisal. Li *et al.* (2004)applied the Fuzzy Group Decision method to study the cooperative partner choice. Others also studied the Supply Chain partner selection model based on AHP and fuzzy synthetic evaluation (Brouthers *et al.*, 1995; Cao *et al.*, 2011; Ding, 2009; Luo *et al.*, 2008).

The previous studies rarely mentioned how to select partners based on 3D Printing and Big Data. Therefore, the article will evaluate the corporations comprehensively by integrating use of the AHP and fuzzy synthetic evaluation in supply chain. It will start at how to establish the Index-evaluation system, judge the matrix and finally make clarified presentations and introductions of the synthetic corporation quality evaluations. The aim is to enhance supply chain competitive power in the context of 3D Printing and Big Data.

ESTABLISHING THE STRUCTURAL MODEL OF EVALUATION INDEX

In the context of 3D Printing and Big Data, 3D Printing Capacity and Big Data processing Capacity are of utmost importance. Besides, For the core companies of supply chain who are selecting cooperation partners, they should also consider the potential companies' ability of financial situation, Credibility and Quality of service. Therefore, based on the features of 3D Printing and Big Data, the article summarized the evaluated index into five parts: 3D Printing Capacity, Big Data processing Capacity, credibility, financial service and quality of service to investigate their potential for cooperation. The purpose of this paper is to evaluate the competitiveness of partners and measure their comprehensive qualities as objective as possible.

3D printing capacity: The 3D Printing Capacity is the most important requirement to establish supply chain partnership. 3D Printing Capacity reflects the companies' ability to control change which is the ability to survive and develop in the unpredictable, sustainable and fast-changing competitive environment. 3D Printing Capacity is composed by 3D design capacity, 3D printer Capacity and time flexibility.

Big data processing capacity: The Big Data processing Capacity can evaluate whether an enterprise can adapt to the future challenges from big data. It will be appraised from Data gathering capability, Data analysis capability and Data decision capability.

Credibility: Credibility not only concerns a company's sustainable development ability but also is a very important factor to be considered when selecting cooperation partners. It will be appraised from reputation, customer quantity and the number of co operations.

Financial situation: To measure the corporations' competitive ability from financial situation is the most direct-viewing way to reflect its value. It will be appraised from asset-liability ratio,currency ratio and the capital return ratio.

Quality of service: Quality of service for any business is of great concern. It will be appraised from customer complaint ratio,safe serve ratio and accuracy ratio. From the analysis above, we can see the comprehensive evaluating index system on cooperation partners as shown in Fig. 1.

ESTABLISHING MATRICES AND SOLVE

Establishing judgment matrix: According to the Index-Evaluation System and based on the Delphi method, we may establish judgment matrix A-Babout elements of B horizon relative to overall goal, as shown in Table 1. In the same way we may establish the judgment matrix about elements of C horizon relative to B horizon.

Solving the largest eigenvalue and eigenvectors of the judgment matrix: We solved the largest eigenvalue λ_{max} and corresponding eigenvectors of the judgment matrix by the square-root method.

Through the unitary processing, we can obtain the evaluation indicator weight set W.

According to:

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(A - B_i W)_i}{nW_I}$$

we may figure out λ_{max} = 5.2998 and the weight set W = {0.3896,0,2847,0.1255,0.1329,0.673}. The weight set W is namely the weight of each appraisal factor which asks.

Consistency check: According to:

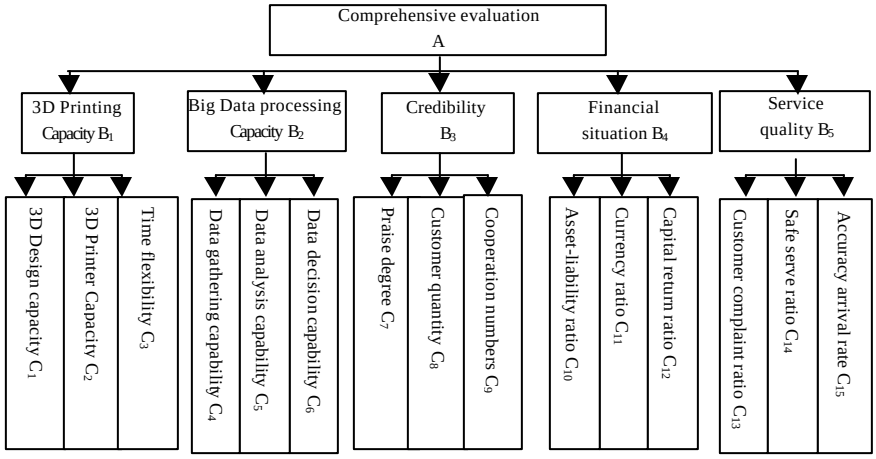

Fig. 1: Indicator system of comprehensive evaluation

Table 1: Judgment matrix

$A\text{-}B_j$	B_1	B_2	B_3	B_4	B_5
B_1	1	2	3	4	3
B_2	2-Jan	1	2	3	5
B_3	3-Jan	2-Jan	1	2-Jan	3
B_4	4-Jan	3-Jan	2	1	2
B_5	3-Jan	5-Jan	3-Jan	2-Jan	1

$$\frac{\lambda_{max} - n}{n - 1}$$

we may calculate: consistency index: CI = 0.07495.

According to the table we can find: RI = 1.12, according to:

$$CR = \frac{CI}{RI}$$

the computation may result in: stochastic consistency ratio CR = 0.0669.

Because CR<0.10, the judgment matrix has satisfaction consistency. In the same way, we may also calculate the weight of each element in C horizon relative to its related element in B horizon. We can see the results in the following Table 2. We carried on the examination using the same method and the results have all passed consistency check.

CARRYING ON FUZZY SYNTHETIC EVALUATION

Because it is hard to measure the precise index data of supply chain enterprises in the context of 3D Printing and Big Data, we establish fuzzy matrix and carry on the analysis. Fuzzy evaluation method is the use of fuzzy math which give the possibility of things to get a comment according to certain criteria for the subject affected by a number of factors (Cheng, 2011; Cheng *et al*., 2013; Koulouriotis and Ketipi, 2011; Zhang *et al*., 2009).

Establishing target collection and evaluation collection: Target collections are as follows.

$A = \{B_1, B_2, B_3, B_4, B_5\}$, $= B_1 = \{C_1, C_2, C_3\}$, $B_2 = \{C_4, C_5, C_6\}$, $B_3 = \{C_7, C_8, C_9\}$, $B_4 = \{C_{10}, C_{11}, C_{12}\}$,

$B_5 = \{C_{13}, C_{14}, C_{15}\}$

According to the evaluation indicator system, we established the evaluation collection and this research divides the partner overall quality's appraisal into excellent, good, medium, bad four levels, recorded as:

$$V = \{v_1, v_2, v_3, v_4\} = \{4, 3, 2, 1\}$$

Carrying on the single factor appraisal and establishing fuzzy relationship matrix: When establishing the fuzzy evaluation model, various factors' degree of membership is gotten by evaluation from valuers. The degree of membership refers to the evaluation indicator subordinates evaluation level in the opinion rating degree, so we must use the fuzzy statistics.

First we need to make the survey form which the valuer marks. Each target of each concrete appraisal object is identified according to valuers' experience and their personal views. They should hit "¡Ì"in the correspond rank place of the marking form. After that, collect valuers' survey forms, obtain each factor's frequency of correspond levels, undergo unitary processing, obtain each factor's degree of membership to correspond levels and thus obtain the single factor judgment matrix R_j but use R_j as the expression in the second-level target.

Table 2: Weight of each evaluating indicator

Elements of B horizon	Weight	Elements of C horizon	Weight
3D Printing capacity	0.3896	3D design capacity	0.5396
		3D printer Capacity	0.2970
		Time flexibility	0.1634
Big Data processing capacity	0.2847	Data gathering capability	0.5396
		Data analysis capability	0.2970
		Data decision capability	0.1634
Credibility	0.1255	Praise degree	0.5584
		Customer quantity	0.3196
		Cooperation numbers	0.1220
Financial situation	0.1329	Asset-liability ratio	0.4434
		Currency ratio	0.3874
		Capital return ratio	0.1692
Service quality	0.0673	Customer complaint rate	0.5842
		Safe serve ratio	0.1840
		Accuracy arrival rate	0.2318

We adopt the following appraisal matrix (Jin *et al*., 2012) which is the previous research result of our team' another paper one year ago. This matrix evaluated the data of a logistics enterprise carried on by 50 logistics experts:

$$R_1' = \begin{pmatrix} 0.2 & 0.7 & 0.1 & 0 \\ 0.4 & 0.4 & 0.1 & 0.1 \\ 0.5 & 0.4 & 0.1 & 0 \end{pmatrix}; R_2' = \begin{pmatrix} 0.2 & 0.6 & 0.2 & 0 \\ 0.3 & 0.5 & 0.2 & 0 \\ 0.3 & 0.7 & 0 & 0 \end{pmatrix}$$

$$R_3' = \begin{pmatrix} 0.5 & 0.3 & 0.2 & 0 \\ 0.2 & 0.6 & 0.1 & 0.1 \\ 0.2 & 0.7 & 0.1 & 0 \end{pmatrix}; R_4' = \begin{pmatrix} 0.2 & 0.6 & 0.1 & 0.1 \\ 0.2 & 0.5 & 0.2 & 0.1 \\ 0.4 & 0.4 & 0.2 & 0 \end{pmatrix}$$

$$R_5' = \begin{pmatrix} 0.5 & 0.4 & 0.1 & 0 \\ 0.2 & 0.7 & 0.1 & 0 \\ 0.2 & 0.6 & 0.2 & 0 \end{pmatrix}$$

Carrying on fuzzy synthetic evaluation: We carried on the blurring operation with each kind of factor weight matrix and the fuzzy appraisal matrix and fuzzy synthetic evaluation's effect is:

$$Q = W \times R = (q1, q2, ..., qm)$$

Firstly, we calculated the second-level target B_1 (3D Printing Capacity).

$$R_1 = W_1 \times R_1 = (0.3, 0,6, 0.1, 1.0)$$

Likewise, we may calculate other targets value:

$$R_2 = (0.2, 0.6, 0.2, 0)$$

$$R_3 = (0.4, 0.4, 0.2, 0)$$

$$R_4 = (0.2, 0.5, 0.2, 0.1)$$

$$R_5 = (0.4, 0.5, 0.1, 0)$$

Then we calculated the first-level target. through factor's appraisal of 3D Printing Capacity, Big Data processing Capacity, credibility, financial situation and service quality. We may obtain the appraisal matrix of the criterion level, combine the weighting coefficient of criterion level and make further appraisal to the partner.

$$\begin{aligned} Q &= W \times (R_1 R_2 R_3 R_4 R_5)^T \\ &= (0.2775, 0.5549, 0.1543, 0.0133) \end{aligned}$$

The comprehensive evaluation result indicated that this partner appraisal in four appraisal centralized degrees of membership, respectively is 27.75, 55.49, 15.43% and 1.33%. We can obtain the value of this enterprise G = 3.097 according to $G = Q \times V^T$. The result show the comprehensive evaluation conclusion of this enterprise is excellent.

CONCLUSION

Supply chain partner selection method based on 3D Printing and Big Data with analytic hierarchy process and the fuzzy judgment method was proposed in this paper. Evaluation system has considered the impact from 3D printing and big data on Supply chain partner selection innovatively which well reflect future changes in market competition during the partner selection. The paper carried on the appraisal by comprehensive quality of partners, combined qualitative research method with quantitative method, subjective estimate, synthesized each kind of factor from the standpoint of system, enhanced appraisal accuracy and the reliability.

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