

# The Innovation Types Evaluation of Small Business<sup>\*</sup>

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The technology innovation and technology innovation capability plays an important role in management study of small business's growth and development. In this paper, the types of innovation in small business are discussed. Then, a hierarchy comprehensive fuzzy index system evaluating the types of small businesses is proposed. Because of the fuzziness of 15 factors used to analyze the small business, L-R fuzzy number is applied to describe the basic fuzzy state index. Furthermore, the corresponding fuzzy evaluation algorithm is designed. An application example indicated the effects of the methods.

*Keywords*: innovation, fuzzy identification, small business.

## Introduction

The 21st century makes the changes in market and technology which the small business faced faster and faster. And also, the life cycle of the product becomes shorter and shorter. With the speedy development of information technology, global market is seeking value and speed competition. In such case, small business should discover new industry and product in frontier and high-tech field and take corresponding technology innovation strategy and tactics to get position in global market.

In this paper, the importance of technology innovation and technology innovation capability in which the core competence concerned with innovation strategy in small business are discussed. Furthermore, the comprehensive evaluation and identification to innovation types of small business are studied.

## Importance of Innovation in Small Business

Science and technology are the first productivity. To stand in the global market and keep its sustainable development, small business should develop high-tech product by advanced technology.

However, resulting from past planning economy, small businesses in China have very weak innovation capability. Their weakness mainly include four categories, lacking of high-level research department and low research investment, overlooking new

product development, lacking of knowledge on technology innovation and low efficiency, and deficiency on department cooperation between departments in the firm.

## Innovation Capability of Small Business

Innovation capability depends on resources investment and transfer ability. And also, how to protect innovation property by patent is very important for technology innovation capability. Moreover, core capability, high-level ability concerned with innovation strategy, merits the sustainable capability for a small business.

### 1 Innovation resources investment and transfer ability<sup>[1]</sup>

The innovation resources investment and transfer ability mainly come in: (1) resources investment ability, that is research development investment, non-research development investment and personnel investment; (2) research development ability, that is market requirement grasping, problem finding, project determination and personnel and material arrangement; (3) manufacturing ability; (4) marketing ability; (5) management and decision ability; (6) innovation productivity.

### 2 Patent and technology innovation ability

The innovation work in process (WIP) product and finished product can't assure the innovation success. The patent is necessary in profit obtain from innovation product. The detail ways include: (1) patent consciousness, timely patent application and registration; (2) creating innovation basis by others patents; (3) choosing the proper development field from present patents; (4) patent transferring when the patent product development can not be implemented further; (5) patent validity and final owner; (6) patent product development.

### 3 The core competence

The core competence related to technology closely is in response of competition based on resources. It comes in: (1) the core competence, a special competition ability, can bring special values and benefits for the consumers, and it is presented by the firm's products and services; (2) the core competence which can involve a series of products instead of individual product; (3) the

core competence can not be imitated by other firms.

It is strengthened that the core competence of small business is obtained through the forecasting to related technologies and market development trend.

### Small Business Innovation Types and Comprehensive Evaluation and Identification

Innovation is being emphasized and plays important role in management study for its particular significance in small business's growth and development.

#### 1 Innovation types

Based on the comprehensive survey data analyzing of various firms innovation performance characteristics all over the world, professor Ronald M. Mitchell proposed 14 firm innovation types<sup>[2]</sup>, that is: (1) hobby; (2) charity; (3) research project; (4) low competence; (5) buy-a-job small business; (6) life style; (7) high potential; (8) model venture; (9) struggling proprietary; (10) competence based troubled; (11) hostage; (12) competence based success; (13) technology; (14) fad. Analysis by scoring the firm by 15 factors can determine the innovation type of a firm.

#### 2 Comprehensive fuzzy evaluation index system

Scores of 15 factors, such as new combination, product/market match etc., are obtained from the firm operation situation synthesis. How to evaluate the firm's innovation based on these 15 factors? Considering the small business innovation reality, the hierarchy comprehensive fuzzy evaluation index system<sup>[3,4]</sup> is designed.

Because of the fuzziness of these factors which is hard to describe by precise value, L-R fuzzy number is used as basic fuzzy state index. Hierarchy structure is divided into three levels, fuzzy state target level, fuzzy state criteria level and fuzzy state index level. According to the two targets of small business innovation, "Business" and "Keep It", two hierarchy systems are designed as follows.

##### (1) "Business" state index system

Representing comprehensive "Business" state, this three-level index system includes three fuzzy state criteria,  $\underline{X}_1, \underline{X}_2, \underline{X}_3$  and eight fuzzy state index  $\underline{x}_{ij}$  ( $i = 1, 2, 3; j = 1, 2, \dots, n_i; n_1 = 2, n_2 = 3, n_3 = 3$ ). The basic framework is as Fig. 1.

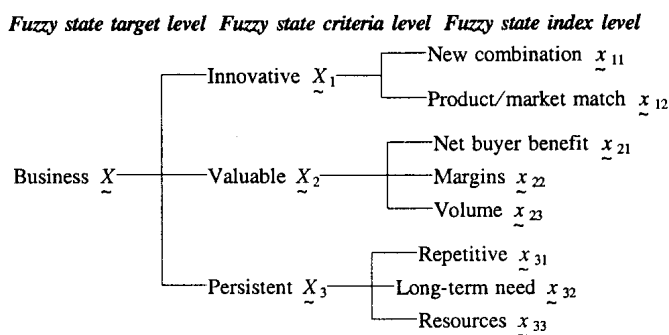


Fig. 1 Small business "Business" comprehensive evaluation index system

Fuzzy state target level Fuzzy state criteria level Fuzzy state index level

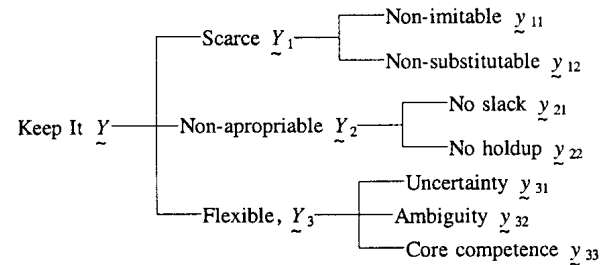


Fig. 2 Small business "Keep It" state comprehensive evaluation index system

##### (2) "Keep It" state index system

Representing comprehensive "Keep It" state, this three-level index system includes three fuzzy state criteria,  $\underline{Y}_1, \underline{Y}_2, \underline{Y}_3$ , and seven fuzzy state index  $\underline{y}_{pq}$  ( $p = 1, 2, 3; q = 1, \dots, m_p; m_1 = 2, m_2 = 2, m_3 = 3$ ). The basic framework is as Fig. 2.

#### 3 Quantifying the fuzzy state index

In general, the fuzzy state indexes are needed to be quantified in application. L-R fuzzy number is applied to represent the index as follows:

$$x_{ij} = (x_{ij}, \underline{x}_{ij}, \bar{x}_{ij}) \quad i = 1, 2, 3; j = 1, \dots, n_i$$

$$y_{pq} = (y_{pq}, \underline{y}_{pq}, \bar{y}_{pq}) \quad p = 1, 2, 3; q = 1, \dots, m_p$$

where,  $x_{ij}$  and  $y_{ij}$  are center values ( or main values) of the fuzzy state index;  $\underline{x}_{ij}$  and  $\underline{y}_{pq}$  are left extensions;  $\bar{x}_{ij}$  and  $\bar{y}_{pq}$  are right extensions; both extensions indicate the left or right degree its value deviate.

In application, the fuzzy evaluation standard (values sit from 1 to 9) is determined to realistic meaning of different state index. And then, comprehensive expert grading is used to decide the center values (1 ~ 9) and left or right extensions (0 ~ 0.99).

#### 4 Weight coefficient determination

Before comprehensive fuzzy evaluation, it is needed to decide following coefficients first.

(1) the weight coefficients  $w_i$  and  $v_p$  of the fuzzy state criteria  $\underline{X}_i$  and  $\underline{Y}_p$  on  $\underline{X}$  and  $\underline{Y}$  ( $i = 1, 2, 3; p = 1, 2, 3$ ).

(2) the weight coefficients  $w_{ij}$  and  $v_{pq}$  of the fuzzy state criteria  $\underline{X}_{ij}$  and  $\underline{Y}_{pq}$  on  $\underline{X}_i$  and  $\underline{Y}_p$  ( $i = 1, 2, 3; j = 1, \dots, n_i; p = 1, 2, 3; q = 1, \dots, m_p$ ).

Here, the judging matrix method in AHP is taken in coefficient determination. The two-to-two factor comparisons are taken to various factors in each level. The judging matrix is obtained from the judge quantifying on a certain ratios. At the end, relating weight coefficients are got on the calculation of maximum characteristic eigenvalues and eigenvectors.

#### 5 Comprehensive fuzzy evaluation algorithm

Because fuzzy state index is represented by L-R fuzzy number, this evaluation algorithm can be obtained according to the basic idea of comprehensive fuzzy evaluating.

(1) comprehensive evaluation algorithm of the fuzzy state criteria  $\underline{X}_i$  and  $\underline{Y}_p$

Based on the determination of weight coefficients  $w_{ij}$  and  $v_{pq}$ , there is:

$$\underline{X}_i = \sum_{j=1}^{n_i} w_{ij} \underline{x}_{ij} \quad i = 1, 2, 3$$

$$\underline{Y}_p = \sum_{q=1}^{m_p} v_{pq} \underline{y}_{pq} \quad p = 1, 2, 3$$

(2) comprehensive evaluating algorithm of the fuzzy state target  $\underline{X}$  and  $\underline{Y}$

Based on the determination of weight coefficients  $w_i$  and  $v_p$ , there is:

$$\underline{X} = \sum_{i=1}^3 w_i \underline{X}_i$$

$$\underline{Y} = \sum_{p=1}^3 v_p \underline{Y}_p$$

### 6 Innovation type identification based on the comprehensive fuzzy evaluation

Based on the comprehensive fuzzy evaluation of fuzzy state target  $\underline{X}$  and  $\underline{Y}$ , fuzzy identification of innovation type can be proceeded on above-mentioned "Business"  $\underline{X}$  and "Keep It"  $\underline{Y}$  definitions of 14 innovation types. The details will be discussed in another paper.

### Application

A cable factory was established in Wuxi, Jiangsu Province, in 1994 to provide consumers with electric wires and telecommunication cables. The innovation type of this small cable business can be evaluated with above-mentioned system and algorithm. First, the scores of 15 factors are given based on the practical business situation of this cable factory as follows.

$$\underline{x}_{ij} = ( \underline{4}, \underline{8}, \underline{6}, \underline{9}, \underline{7}, \underline{9}, \underline{9}, \underline{8} ) \quad j = 1, \dots, 8$$

$$\underline{y}_{pq} = ( \underline{4}, \underline{9}, \underline{6}, \underline{4}, \underline{5}, \underline{5}, \underline{8} ) \quad q = 1, \dots, 7$$

here,  $\underline{x}_{ij}$  are represented with L-R fuzzy number as,  $\underline{4} = (4, 0, 0)$ ,  $\underline{8} = (8, 0.5, 0)$ , ...etc..

Let weight coefficients are,

$$\begin{bmatrix} w_{1j} \\ w_{2j} \\ w_{3j} \end{bmatrix} = \begin{bmatrix} \frac{1}{2} \\ \frac{1}{3} \\ \frac{1}{3} \end{bmatrix} \quad \begin{bmatrix} v_{1q} \\ v_{2q} \\ v_{3q} \end{bmatrix} = \begin{bmatrix} \frac{1}{2} \\ \frac{1}{2} \\ \frac{1}{3} \end{bmatrix}$$

$$w_i = 1/3 \quad v_p = 1/3$$

Then, we can get state criteria  $\underline{X}_i$ ;

$$\underline{X}_1 = \sum_{j=1}^{n_1} w_{ij} \underline{x}_{ij} = \sum_{j=1}^2 w_{ij} \underline{x}_{ij} = \underline{6};$$

$$\underline{X}_2 = \underline{7.3}_i;$$

$$\underline{X}_3 = \underline{8.7}_i$$

And, state criteria  $\underline{Y}_p$ ;

$$\underline{Y}_1 = \sum_{q=1}^{m_1} v_{pq} \underline{y}_{pq} = \sum_{j=1}^2 v_{pq} \underline{y}_{pq} = \underline{6.5};$$

$$\underline{Y}_2 = \underline{5};$$

$$\underline{Y}_3 = \underline{6}_i$$

Furthermore, the state target can be obtained,

$$\underline{X} = \sum_{i=1}^3 w_i \underline{X}_i = \underline{7.3};$$

$$\underline{Y} = \sum_{p=1}^3 v_p \underline{Y}_p = \underline{5.8}$$

Based on above calculation, the innovation type can be identified. This cable factory is most likely a "High potential" business as the identification results.

The determination of a business's innovation type is very important. First of all, managers of business can review and study the overall recent conditions of their businesses during the type evaluation process. And also, it is the basis of further business direction adjustment and development decision of a firm.

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