Advance Journal of Food Science and Technology 9(6): 482-486, 2015
DOI: 10.19026/ajfst.9.1907
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: April 9, 2015 Accepted: April 28, 2015 Published: August 25, 2015

Research Article

Evaluation and Modeling of the Digestion and Absorption of Novel Manufacturing Technology in Food Enterprises

[1]Kerong Zhang and [2]Wuyi Liu
[1]Department of Business and Management,
[2]Department of Science and Technology, Fuyang Normal University, China

Abstract: The food industry is more and more in need of importing and absorption new technologies. Focusing on all the possible issues of contradiction and difficulty to improve the digestion and absorption of novel manufacturing technology, a set of customized dynamic quantitative evaluation models were put forward that made it easy to model and supervise the usages, digestion and absorption of novel manufacturing technology in food enterprises. According to the proposed set of evaluation models, anyone could comprehensively analyze the food enterprises' technology import, digestion and absorption and even re-innovation capabilities from many aspects. The models and strategy discussed here are highly operable and objectively profitable to insure the dynamic evaluation of the digestion and absorption of technology imported in food enterprises.

Keywords: Digestion and absorption, evaluation, modeling, novel manufacturing technology, similarity theory, technology import

INTRODUCTION

The food industry is as old as civilization and many of its process operations are thousands of years old, such as brewing developed in Sumeria and Babylon and baking developed in Egypt 8000 B.C., (Fryer and Versteeg, 2008). The modern food manufacturing industry evolved during and after the industry revolution and Thorne (1986) attributed the beginnings of the industry to the first heat sterilization plant developed by Appert in France in the early 1800s (Thorne, 1986; Vaclavik and Christian, 2008). Since then, the modern food industry becomes highly diverse and large. Actually, the food industry is more and more in need of importing and absorption new technologies (Matsuno, 1995; Silva, 1996; Norton *et al*., 2006; Bhaskaran, 2006; Fryer and Versteeg, 2008; Bhaskaran and Gligorovska, 2009), especially bio-technologies. The food industry is directing new product development towards the area of functional foods and functional food ingredients due to consumers' demand for healthier foods. Although their research staff and organizations can make much technical support and/or technical assistance in food production, food enterprises are badly seeking investment and funds in Research and Development (R and D) to import, digest and take absorption of advanced technologies. The R and D sections of many food companies are interested in new technologies such as super high pressure cooking, super critical CO_2 extraction and extrusion cooking and membrane separation to improve the quality of their production design (Matsuno, 1995; Silva, 1996; Bhaskaran and Gligorovska, 2009).

In the conventional technology innovation theory, there is a common assumption that most innovations are created in developed countries and no real innovations are produced in developing countries; the developing countries have to import new technologies with possible digestion and absorption and imitation. Economists usually focus on technology innovation in developed countries, since the most of the modern industrial technologies and relevant products were firstly developed and appeared in the markets of Western Europe and Northern America. Nevertheless, the technological innovation aims to obtain high economic efficiency and active economic activities and goods or products in the markets. It is necessary to make evaluation and design well-being strategies on the digestion and absorption of technology imported in food enterprises. Therefore, in the study, according to the previous analysis on the enterprises' technology import, digestion and absorption and re-innovation capabilities and the building principles of a evaluation model or system (Zhang, 2011), a set of evaluation models was proposed to evaluate the import, digestion and absorption and even re-innovation of novel manufacturing technology in food enterprises based on the bionic similarity theory, focusing on all the possible issues of contradiction and difficulty in the digestion

Corresponding Author: Wuyi Liu, Department of Science and Technology, Fuyang Normal University, Qing He West Road No. 100, Fuyang 236037, People's Republic of China, Tel.: +86-558-2596562; Fax: +86-558-2596561

and absorption of novel manufacturing technology in food enterprises.

MATERIALS AND METHODS

Origin of the similarity theory: Similarity presents the consistency of two phenomena or more in their apparent and inherent regularities. The similar phenomenon exists widely in nature and society. The similarity theory is of importance in various types of engineering and modeling issues, especially in bionic technical engineering, such as the genetic similarity theory, which incorporates the kin-selection theory of altruism. The genetic similarity theory states that a gene ensures its own survival by action so as to bring about the reproduction of any organism. Actually, the similarity theory referred in the study is a bionic theory used to illuminate the similarity principle of all kinds of similarity phenomena in nature and engineering projects, investigating the relationship between individuality and commonality, specialty or generality and inner contractions and outer conditions (Mansfield *et al*., 1981). This similarity theory was initially applied to instruct the model test to define the similarity degree among models and prototypes. Herein, with the escalation of the concept of similarity, the bionic similarity theory has a tendency to extend from the natural scientific fields to others, including economics, social sciences, cognitive sciences and the philosophy.

Development of the similarity theory: Presently, the similarity theory mainly consists of the three similarity theorems that undergo a process of gradual development and improvement. In 1686, Newton studied the similarity between two objects and proposed Newton Criterion which defines the similarity criterion between two mechanical systems. In 1782, Fourier advanced the conditions to judge the similarity of the temperature field of two cooling spheres. In 1848, Bertrand, a French scientist, based on the mechanics formula, ascertained the first similarity theorem. Between 1911 and 1914, Friedman from Russia and Buchigham from America, deduced the second similarity theorem. Afanasyev (1980) proved the correctness of the first and second similarity theorems in the most stringent conditions. Similarity theory was basically established, accordingly.

The first and subsequent similarity theorems are primarily deduced in the hypothesis that two phenomena are similar. However, it is unknown how to judge whether two phenomena are similar or not, from former Soviet Union explored the third similarity theorem to answer the question. Therefore, a more integrate similarity theory system was derived and finally formed.

RESULTS AND DISCUSSION

The derivation of quantitative evaluation models: The similarity systems, which indicate the systems have similar elements and characters, are ubiquitous in nature and simply differing in similarity degree. From the definition of the digestion and absorption, mentioned in the preliminaries, one could infer that the result of digestion means the “production”, simulated to design or produce by itself after analyzing the imported technology’s modules. Thus, the existing result of digestion and the imported technology can form a pair of similarity system. Furthermore, the quantitative evaluation to this similarity system is designed to calculate how much the company understands the imported technology and how about the simulating capability up to a certain manufacturing time. After clearing the objectives, one must consider some important factors, including technical structure, unit function and time (Chen, 2006; Bhaskaran and Gligorovska, 2009).

In the system of existing result of digestion and absorption, technical structure is the module making up the technology and function is the attribute and character of the module. Time must be considered in the evaluation, because without time limitation, the two similarity systems would be almost completely similar with each other, which would make the evaluation meaningless. Form the analysis on the market risk of the digestion and absorption, one can find that the time for the imported country to digest the technology is very short comparing with the product’s life cycle. Therefore, time is a crucial factor to assess the result of digestion. As the imported technology, the result of digestion can be treated as the similarity system, then, it’s feasible to use the bionic similarity theory to build a quantitative evaluation model. Next, based on the predecessor’s mathematics model of the similarity system, the model was built in Fig. 1.

Figure 1, one can infer that the similarity degree of the similarity system is a multivariational function which can be simply represented by the following formula:

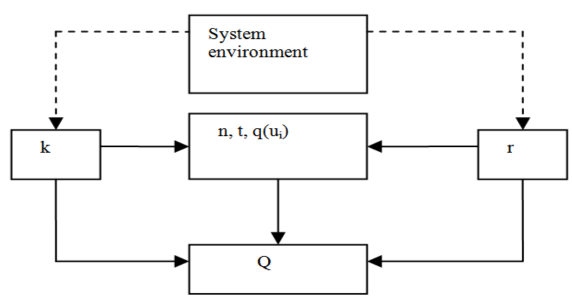

Fig. 1: The similarity system of digesting the technology
The marker k: The element number of imported technology; r: The element number of the result of digesting the technology; n: The number of the similar elements; t: The time between the beginning of the digestion and absorption and the evaluation; q (ui): The value of the similar elements, which means the value of the character number similarity of the similar elements

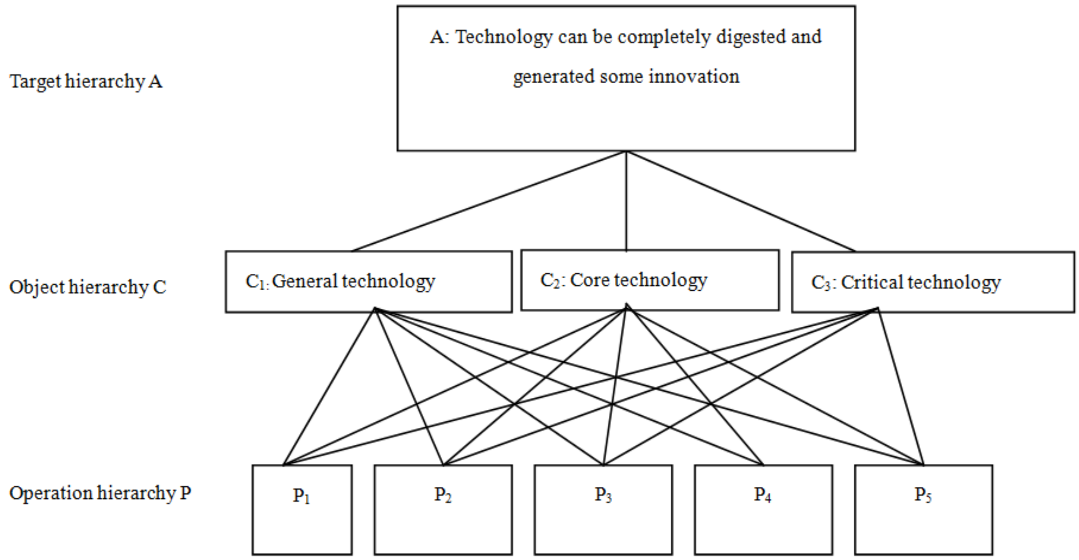

Fig. 2: The AHP structure of the digestion and absorption and re-innovation of technology

$$Q = f(k, r, n, t, q(u_i)) \tag{1}$$

In which,

$$i = 1,2,\cdots,n; 1 \le n \le \min(k,r), k = 1,2.\cdots,N, r = 1,2,\cdots,N$$

According to the mathematical description of the similarity above, the value of the static similarity can be considered from the perspective of the element value similarity degree and the similarity fixed by the similar element value.

The element value similarity degree can be calculated by Q_n:

$$Q_n = \frac{n}{k + r - n} \tag{2}$$

Considering that each similar element value may have different effect on the system similarity, thus one can give different weight coefficient to each of them. Using Q_u to denote the similarity fixed by the similar element value:

$$Q_u = \sum_{i=1}^{n} (\beta_1 q(u_1) + \beta_2 q(u_2) + \cdots + \beta_n q(u_n)) = \sum_{i=1}^{n} \beta_i q(u_i) \tag{3}$$

The weight coefficient contained in (3) can be calculated by AHP. Then, the technology was divided into three categories as following: general technology, core technology and critical technology. In order to study the result of digesting the technology, the following five facets are to be focused on, i.e., P_1 (whether the amount of the function module is complete or not), P_2 (whether every indicator, including accuracy indicator, energy consumption indicator, environmental protection indicator, intensity indicator, longevity indicator and so on, reaches or exceeds the standard, P_3 (whether the appearance and/or volume and/or the size of machinery parts are aesthetic or not), P_4 (whether the visualization degree is favorable or not), P_5 (whether the operability is favorable or not). The overall aim of the study is whether the manufacturing technology could be completely digested and taken into absorption and later can generated some innovation (re-innovation). The AHP structure is shown in Fig. 2.

After building the AHP framework, the judgment matrixes should be constructed. The values of the judgment matrix elements, which reflect the relative importance of each element, usually defined by 1-9 scaling method. First, the judgment matrix (A-C) are defined, which reflects the relative importance between the three objects (C_1, C_2 and C_3) under the target (A). The concrete values of the matrix elements should be specified by experts investigating. Second, the judgment matrixes (C-P) are defined by the same method above. After defining the judgment matrixes, one can calculate the matrixes' Eigenvalues and Eigenvectors, which denotes the weights from the lower hierarchy to the upper one. Last, the order of each hierarchy should be sorted according to the Eigenvalues and Eigenvectors and deduce the sequence of the total structure. Notability, the values of (β_1, β_2, …, β_n) must be done consistency test before substitute into (3).

To the similarity system, there are some similar elements among systems and each similar element has certain similarity degree. So, combining the formula (2) and (3), then, the formula (4) is obtained to calculate the similarity of the static system:

$$Q_x = Q_n Q_u = \frac{n}{k+r-n} \sum_{i=1}^{n} \beta_i q(u_i) \tag{4}$$

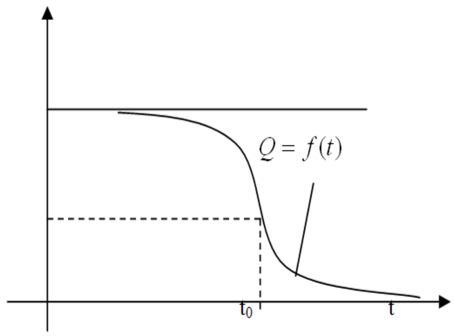

Fig. 3: The correlation between the similarity of the dynamic system and time

Next, time factors should be considered to research the similarity of the dynamic system. Usually, t_0 is used, which is the ending time of T, as the dividing line. T is the time for the imported country to digest the technology in the product's life cycle. Supposed t is the time of evaluation, if t is far from the left side of t_0, which means the time of digestion is a little short, the final evaluation should be active if there are some similarities. On the contrary, if t is far from the right side of t_0, which means the time for digestion is too long. In this condition, even though the static evaluation is very similar, yet the final evaluation would be affected. The correlation between Q, the similarity of the dynamic system and t is showed in Fig. 3, which represents the dynamic change of Q in condition that Q_x is fixed at a certain value.

According to logic analysis in Fig. 3, one can find that the similarity of the dynamic system is an exponential function of the similarity of the static system:

$$Q = \begin{cases} (Q_x)^{\frac{t}{t_0}} & , t < t_0 \\ Q_x & , t = t_0 \\ (Q_x)^{\frac{t}{t_0}} & , t > t_0 \end{cases} \tag{5}$$

secure

From the formula (5), in the range of Q<1, when $t<t_0$, the smaller the value of t is, the more the value of Q would be amplified; when $t = t_0$, system is static; when $t>t_0$, the bigger the value of t is, the more the value of Q would be minified.

Considering synthetically the structure, function and time of the similarity system, one can obtain the quantitative evaluation model of digesting the technology:

$$Q = \left[\frac{n}{k + r - n} \sum_{i=1}^{n} \beta_i q(u_i) \right]^{\frac{t}{t_0}} \tag{6}$$

In which the value of similarity is not more than 1, the closer it's to 1, the more the similar degree is, the better the result of digestion is. The dynamic quantitative evaluation model is helpful to encourage the digester (when t is far away from t_0), or spur them (when t is near to t_0) and give a reasonable dynamic evaluation to their work.

CONCLUSION

In the study, a set of evaluation models were proposed to evaluate the import, digestion and absorption and re-innovation of novel manufacturing technology in food enterprises based on the bionic similarity theory. The models and strategy discussed here are highly operable and objectively profitable to insure the dynamic evaluation of the digestion and absorption of technology imported in food enterprises utilizing this set of evaluation models.

ACKNOWLEDGMENT

The authors would like to thank the anonymous referees for constructive suggestions. This study is supported by the National Statistical Scientific Study Project (No. 2013LY051), Anhui Provincial Natural Soft Scientific Research Project (No. 1502052051) and Anhui Provincial Educational Commission's Key Projects (No. SK2014A069, 2014SK006 and 2014SK020, resectively), Fuyang City Social Scientific Project (FSK201413), and Fuyang Normal University's Educational Study Project (No. 2013JYXM24).

REFERENCES

Afanasyev, V., 1980. Science and Social Control for Development Purposes [J]. Science Technology and the Future, 1: 37-49.

Bhaskaran, S., 2006. Incremental innovation and business performance: Small and medium-size food enterprises in a concentrated industry environment [J]. J. Small Bus. Manage., 44(1): 64-80.

Bhaskaran, S. and E. Gligorovska, 2009. Information communication technology adoption by small-to-medium-sized food enterprises in Australia [J]. Int. J. Enterprise Network Manage., 4: 332-346.

Chen, E.K.Y., 2006. Multinational corporations and technology diffusion in Hong Kong manufacturing [J]. Appl. Econ., 15(3): 309-321.

Fryer, P.J. and C. Versteeg, 2008. Processing technology innovation in the food industry [J]. Innovation, 10(1): 74-90.

Mansfield, E., M. Schwartz and S. Wagner, 1981. Imitation costs and patents: An empirical study [J]. Econ. J., 364: 907-918.

Matsuno, R., 1995. The Japanese overview: Quality control and its supporting technology [J]. Food Control, 6(2): 115-120.

Norton, I., P. Fryer and S. Moore, 2006. Product/process integration in food manufacture: Engineering sustained health [J]. AIChE J., 52(5): 1632-1640.

Silva, J.L., 1996. Novel technologies and ingredients in food [J]. Trends Food Sci. Tech., 7: 26-28.

Thorne, S., 1986. The History of Food Preservation. Barnes and Noble, New York.

Vaclavik, V.A. and E.W. Christian, 2008. Food Preservation and Processing. In: Essentials of Food Science, Springer Science+Business Media, LLC., New York, pp: 425-446. Retrieved form: http://link.springer.com/chapter/10.1007%2F978-0-387-69940-0_17?LI=true.

Zhang, K.R., 2011. An empirical analysis of the regional enterprises technological innovation ability in Anhui province. Sci. Technol. Prog. Pol., 28: 50-54.