Competitive Evaluation Index of Chinese Fast-Food Enterprises Based on Feature Weighting Techniques

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Abstract. In recent years, China's fast-food industry has developed rapidly and is growing at a high rate. The number of fast-food enterprises is increasing rapidly, and the market is becoming increasingly competitive. To stand firm and succeed in the fierce market competition, enterprises must strive to improve their competitiveness. How to correctly measure and evaluate the competitiveness of Chinese fast-food enterprises has become an important research topic. Although many evaluation metrics have been proposed, most of the existing evaluation metrics are fused using uniform weights in the fusion stage. They lack the integration of domain knowledge into the metric construction process, which in turn leads to the problem of inaccurate evaluation. This paper proposed a competitiveness evaluation index based on feature weighting techniques for Chinese fast-food enterprises. Specifically, we first analyze the existing evaluation indexes statistically, then introduce an expert system to assign weights to the contribution of the indexes, and finally fuse the learned weights in a weighted manner to obtain our evaluation indexes.

Keywords: Chinese fast-food; Catering enterprises; Enterprise competitiveness; Expert system; Feature weighting techniques.

1 Introduction

A successful fast-food enterprise can bring great economic and social benefits to society. There is still a considerable gap between the Chinese fast-food market and the Western fast-food market, and there is huge room for development in the Chinese fast-food market. The healthy and rapid growth of Chinese fast-food enterprises can not only promote the essence of Chinese food culture, but also create more wealth for society. The development of Chinese fast-food enterprises has been less studied in the relevant literature, and the general information is limited to the discussion of the business strategies of Chinese fast-food enterprises. Domestic in-depth study of fast-food monographs includes only " Modern Chinese Fast Food ", " Modern Fast-Food Business and Management " and a few other books. The establishment of domestic fast food research professional courses is limited to a few colleges and universities such as the Harbin University of Commerce. Studying the competitiveness of Chinese fast-food

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enterprises and exploring the methods to cultivate the competitiveness of catering enterprises have not only a certain economic value, but also have certain theoretical significance.

There have been many studies on enterprise competitiveness, but the research on the competitiveness of Chinese fast-food enterprises is still in a fragmented stage. In this paper, by sorting out various index systems and conducting an in-depth analysis of the competitiveness system of Chinese fast-food enterprises, we construct a domain knowledge-driven and feature-weighted Chinese fast-food enterprise competitiveness evaluation index based on the competitiveness model of Chinese fast-food enterprises. Specifically, we first organize and statistically analyze the existing evaluation indexes, and then assign weights from the contribution of domain knowledge to the indexes based on the suggestions of experts in the field. Finally, we fuse the domain knowledge-based weights with the existing evaluation indexes to obtain our evaluation indexes.

The rest of the paper is organized as follows: We review the fundamentals of data-driven and knowledge-driven based approaches in Section 2 and provide a brief introduction to the feature weighting method. Details of the proposed method are shown in Section 3. The experimental results are presented in Section 4. Finally, the work of this paper is summarized and further work is indicated.

2 Related work

2.1 Knowledge-driven and data-driven

In the field of machine learning, intelligent decision-making is based on two main types of approaches: knowledge-driven and data-driven. The knowledge-driven approach [2] makes full utilization of existing knowledge, including existing knowledge of models and algorithms, empirical knowledge of rules, and domain-specific knowledge. The broad scope of knowledge facilitates the flexible integration of multidisciplinary knowledge. At the same time, many model-based knowledge-driven approaches have a complete theoretical support system and have natural advantages in analyzing algorithm stability, optimality and convergence. In addition, knowledge-driven models have better interpretability, and knowledge, as a highly condensed representation of data and information, often implies more efficient algorithm execution. Data-driven approaches such as deep reinforcement learning [3], which have emerged widely in recent years, are characterized by the no need for accurate modeling, the ability to achieve large coverage and exploration of the solution space, continuous learning and evolution from data, and the generality of the algorithms. It also has many open-source models and algorithm libraries and other tools to support. However, such approaches often have difficulties in theoretical characterization, and their typical "black box" characteristics also bring problems such as poor interpretability.

2.2 Feature weighting

The learning of feature weighting can be considered a generalization of the feature selection problem [4]. The feature selection process can be divided into two steps: feature

search and feature evaluation, where the feature evaluation method can be used to learn the feature weights. The existing feature evaluation approaches are the information gain approach, Re1ief approach, correlation approach, consistency approach and Wrapper subset approach, etc. The first two of these approaches are used to evaluate individual features, while the last three are used to evaluate feature subsets.

The feature weighting approach is a typical data-driven intelligent decision-making algorithm whose value has been proven in real-world problems. However, it is still a challenge to incorporate domain knowledge into the feature weighting approach in the existing studies, especially in the study of the competitiveness of Chinese fast-food companies.

3 Approach

The main steps of the proposed approach are as follows: firstly, the collected data are analyzed qualitatively and quantitatively according to the existing evaluation indexes, then different weights are assigned to different evaluation indexes based on domain knowledge, and eventually, the features are fused based on the feature weighting approach to obtain our evaluation indexes, as shown in Figure 1.

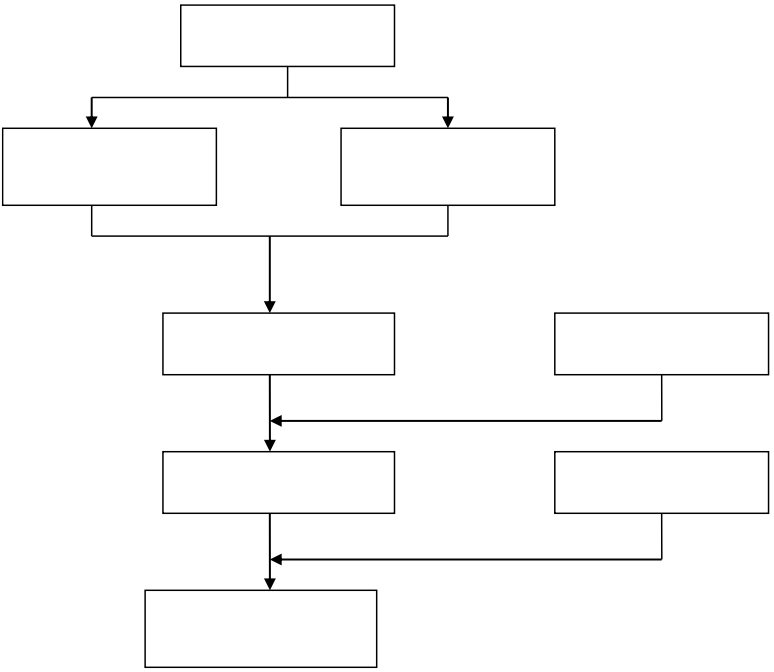

Fig. 1. Flow chart of data processing for the evaluation of the competitiveness of Chinese fast-food enterprises

3.1 Construction of evaluation index system

In this paper, based on the analysis of the internal and external environment of Chinese fast-food enterprises, according to the design principles of the index system, the enterprise competitiveness evaluation index system is studied in conjunction with relevant literature [1]. It constitutes a Chinese fast-food enterprise competitiveness evaluation index system, as shown in Table 1, which can roughly assess Chinese fast-food enterprises initially from both qualitative and quantitative aspects.

Table 1. Evaluation index system of Chinese fast-food enterprises' competitiveness

Competitiveness (A1)	Production Process (B1)	Degree of specialization (C1)
		Degree of mechanization (C2)
		Degree of standardization (C3)
		Uniformity (C4)
	Branding and Marketing Power (B2)	Brand recognition (C5)
		Brand reputation (C6)
		Brand loyalty (C7)
		Marketing efforts (C8)
	System Power (B3)	Ownership form (C9)
		Business model (C10)
		Corporate rules and regulations (C11)
	Service Power (B4)	Product categories (C12)
		Product quality (C13)
		Service speed (C14)
		Dining environment (C15)
		Service quality (C16)
		Response speed (C17)
	Expansion Power (B5)	Enterprise size (C18)
		Experience in expansion operations (C19)
	Innovation Power (B6)	Product innovation ability (C20)
		Service innovation ability (C21)
		Institutional innovation ability (C22)

Factors affecting the competitiveness of Chinese fast-food enterprises include production process, brand and marketing power, institutional power, service power, expansion power, and innovation power [5].Due to the limitation of the information, the profit amount, although quite reflective, is not included, and these indexes are chosen more from the perspective of Chinese fast food. These six primary indexes are critical to the competitiveness of Chinese fast-food enterprises. To summarize, the competitiveness of Chinese fast-food enterprises is measured from four aspects: cuisine, brand, scale and service.

3.2 Weight assignment based on domain knowledge

In the construction of decision indexes based on domain knowledge, our construction process is as follows.

(1) It is assumed that the number of experts involved in the decision to assign index weights is *m* and the number of evaluation indexes to be assigned weights is *n*. Next, we let each expert independently make a two-by-two comparison of the importance of the indexes and construct an individual judgment matrix *Ae* based on the experts' judgment.

$$\boldsymbol{A_e} = \begin{bmatrix} \boldsymbol{a_{11}^e} & \cdots & \boldsymbol{a_{1n}^e} \\ \vdots & \ddots & \vdots \\ \boldsymbol{a_{n1}^e} & \cdots & \boldsymbol{a_{nn}^e} \end{bmatrix} \tag{1}$$

Where $\boldsymbol{a_{ij}^e}$ denotes the relevance judgment value of expert *e* for indicator *i* and indicator *j*.

(2) Construct the judgment matrix Am of m experts,

$$\boldsymbol{A_m} = \begin{bmatrix} \sqrt[m]{\boldsymbol{a_{11}^1} \times \boldsymbol{a_{11}^2} \times \boldsymbol{a_{11}^m}} \cdots & \cdots & \sqrt[m]{\boldsymbol{a_{12}^1} \times \boldsymbol{a_{12}^2} \times \boldsymbol{a_{12}^m}} \\ \vdots & \ddots & \vdots \\ \sqrt[m]{\boldsymbol{a_{n1}^1} \times \boldsymbol{a_{n1}^2} \times \boldsymbol{a_{n1}^m}} & \cdots & \sqrt[m]{\boldsymbol{a_{nn}^1} \times \boldsymbol{a_{nn}^2} \times \boldsymbol{a_{nn}^m}} \end{bmatrix} \tag{2}$$

(3) The eigenvector V_a=(v_{a1},v_{a2}...,v_{an}) corresponding to the largest eigenvalue λ_a of the judgment matrix A_m is calculated.

$$\boldsymbol{\lambda_a} = \max_{\boldsymbol{1 \le i \le m}} \boldsymbol{\lambda_i} \qquad \text{s.t. } \boldsymbol{A_m x} = \boldsymbol{\lambda_i x} \tag{3}$$

(4) V_a is used as the evaluation weight of experts for *n* indexes.

3.3 Feature weighting fusion

For feature fusion, we use a two-level fusion mechanism to calculate the final index. It is assumed that the composite index is composed of k1 primary indexes and there are k2 secondary indexes under each primary evaluation index. For example, the competitiveness index in Table 1 consists of six primary indexes, and there are four secondary indexes under B1 index. Then the final fusion index value s is calculated as follows.

$$\boldsymbol{s} = \sum_{\boldsymbol{i=1}}^{\boldsymbol{k1}} \widehat{\boldsymbol{v}}_{\boldsymbol{i}} \sum_{\boldsymbol{j=1}}^{\boldsymbol{k2}} \boldsymbol{v_{ij} s_{ij}}. \tag{4}$$

Where s_{ij} denotes the value of the j-th evaluation index, and $\widehat{\boldsymbol{v}}_{\boldsymbol{i}}$ denotes the weight under the i-th primary index obtained by using Eqs. (1)-(3).

4 Experiment

In the experimental evaluation, we conducted a random survey of customers of Chinese fast-food enterprises, such as Pastry King and McDonald's, and asked them to rate the weights of indexes affecting the competitiveness of Chinese fast-food enterprises. In the experiment, we distributed 120 questionnaires, of which, 105 were valid. After data processing, the weights of the Chinese fast-food enterprise competitiveness evaluation model were obtained by using the weight calculation in Section 3, and the Chinese fast-food enterprise competitiveness evaluation model was concluded.

Then this paper takes two fast-food enterprises (Pastry King and McDonald's) as examples and fills the values of each index and the corresponding weights into the evaluation model of the competitiveness of the fast-food industry, and the calculation results are as follows (Table 2 and Table 3):

Table 2. Pastry King's competitive evaluation score

Competitive-ness A	B-level indexes and weights	B-level index scores	C-level indexes and weights	C-level index scores
0.631	(B1) 0.241	0.644	(C1) 0.448	0.638
			(C2) 0.212	0.584
			(C3) 0.194	0.676
			(C4) 0.146	0.708
	(B2) 0.215	0.634	(C5) 0.367	0.695
			(C6) 0.255	0.632
			(C7) 0.254	0.584
			(C8) 0.124	0.562
	(B3) 0.099	0.598	(C9) 0.410	0.568
			(C10) 0.391	0.632
			(C11) 0.199	0.595
	(B4) 0.150	0.686	(C12) 0.226	0.670
			(C13) 0.273	0.708
			(C14) 0.139	0.643

			(C15) 0.149	0.638
			(C16) 0.139	0.665
			(C17) 0.094	0.676
	(B5) 0.150	0.606	(C18) 0.596	0.632
			(C19) 0.404	0.568
	(B6) 0.145	0.593	(C20) 0.559	0.589
			(C21) 0.306	0.611
			(C22) 0.135	0.568

Table 3. McDonald's competitive evaluation score

Competitiveness A	B-level indexes and weights	B-level index scores	C-level indexes and weights	C-level index scores
0.828	(B1) 0.241	0.852	(C1) 0.448	0.854
			(C2) 0.212	0.832
			(C3) 0.194	0.865
			(C4) 0.146	0.859
	(B2) 0.215	0.876	(C5) 0.367	0.930
			(C6) 0.255	0.870
			(C7) 0.254	0.805
			(C8) 0.124	0.870
	(B3) 0.099	0.804	(C9) 0.410	0.789
			(C10) 0.391	0.816
			(C11) 0.199	0.811
	(B4) 0.150	0.809	(C12) 0.226	0.778
			(C13) 0.273	0.762
			(C14) 0.139	0.838
			(C15) 0.149	0.805

			(C16) 0.139	0.827
			(C17) 0.094	0.773
	(B5) 0.150	0.772	(C18) 0.596	0.768
			(C19) 0.404	0.778
	(B6) 0.145	0.810	(C20) 0.559	0.800
			(C21) 0.306	0.876
			(C22) 0.135	0.703

The calculations allow us to derive the evaluation scores of the competitiveness of the two fast-food enterprises, as well as the competitiveness of the two enterprises in terms of different operational elements. The evaluation scores of these two enterprises in terms of enterprise competitiveness are 0.631 and 0.828, respectively. We can see the performance of the two Chinese fast-food enterprises in terms of their ultimate competitiveness, with McDonald's outperforming Pastry King in terms of competitiveness overall.

In terms of the composite index level (Level B), there are six indexes, which are production process (B1), brand and marketing power (B2), institutional power (B3), service power (B4), expansion power (B5) and innovation power (B6). From Figure 2, we can clearly see that there is a large gap between the scores of the two fast-food companies in the composite index level in terms of the production process, branding and marketing power, and institutional power.

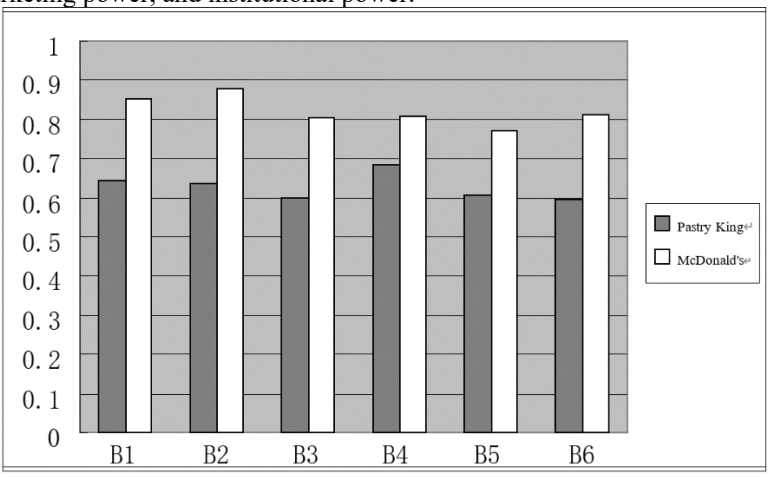

Fig. 2. Pastry King and McDonald's enterprise competitiveness evaluation composite index level score chart

5 Conclusion

In this paper, an evaluation index of the competitiveness of Chinese fast-food enterprises based on the feature weighting technique is proposed to address the problem that the current evaluation index of the competitiveness of Chinese fast-food enterprises is not perfect. The evaluation index incorporates the domain knowledge of the experts into the evaluation index and uses hierarchical weight fusion to obtain the experts' weights on the evaluation index. Finally, based on the obtained weights and evaluation indexes, the characteristics are weighted to obtain the final evaluation value. In addition, we applied the evaluation index to the competitiveness evaluation of Pastry King and McDonald's, and conducted a comparative analysis of Pastry King and McDonald's, and the experimental results verified the validity of the proposed index.

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