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Building the brand competitiveness model of sports industry based on PLS-SEM

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ABSTRACT

Brand is the largest commercial property; its birth is closely related to competition. National sports brand competitiveness is the embodiment of the rise and fall of the sports industry. In order to make up the deficiency of previous empirical research, using the calculation method of PLS-SEM as the machine learning method, mining the sports brand data, and combined with the characteristics of sports industry, to construct the model of sports brand competitiveness, and to promote the development of the sports brand.

Key words: PLS-SEM, Sports brand competitiveness, Data mining

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INTRODUCTION

The concept of brand had been born from the nomadic tribe time of Spain, the competition and marks are closely related to its origin. By the sixteenth Century, with the maturity of the guild system, brand has become an indispensable part of business activity. In order to protect the trademark, the copycats will be sentenced to capital punishment [1, 2]. In modern times, the brand has been the largest commercial property [3].

For consumers, the brand is the shortcut to purchase decision. It can reduce the risk of decision making. Brand for the business enterprise also helps to obtain self-identification and social identification, convey certain characteristics of the product to the consumer, transfer the sales and service of security information; to the state, a competitive brand has benefit to achieved national image, as USA Coca-Cola, Japan Toyota, Honda [4, 5].

National "sports development twelfth-five year "planning" clearly pointed out that "Speed up the implementation of brand strategy of sports products; promote the sports enterprises to carry out the construction of independent brands to create a sports brand in the world and to set up our country's sports brand". The main goal of the guidance of accelerating the development the sports industry mentioned: "By 2020, format a number of influential international sports brands with Chinese characteristics".

The creation of national sports brand is the key content of the future 40 years development of Chinese sports, is the principal measure to realize the goal of being a sports powerful nation.

However, since the accession to the WTO, Chinese economic globalization initiative is more and more strong, that is to say in the enormous commercial convenience, the economic globalization competition pressure is introduced and the competition is increasingly fierce. As the inevitable emerging industry, sports industry has also been affected. Although the domestic sports brands have made considerable progress since the 2008 Beijing Olympic Games, but with the international sports brands run into the Chinese sports market, domestic competition is more incandescent. At the same time, regardless the facts that the domestic sports brands have crowded, but lacking of a component brand. So we must take effective action, to evaluate the sports brand competitiveness, and to ensure the advantage in the market competition. At the same time, the research of sports industry and sports industry brand has become a hot topic of the domestic and foreign scholars:

Domestic and foreign has not been clearly defined in the sports brand. Generally the sports brand is equal to sports industry brand [6].

Mary A Hums thought, sports industry including: Occupation sports industry, University intercollegiate sports, entertainment and leisure sports, fitness and health sports and sports facilities management [7].

Research on sports brand strategy is mainly about the strategic role and connotation. Sun Kecheng, Yu Desheng, et al. thought: brand is the market boundary is the commanding heights of competition; the brand strategy is important support to the core competitiveness of sport enterprises [8-11].

Zhao Jian and others studied from the following several aspects to create sports brand:
(1) Comparative Study of domestic and international brand;
(2) The research on brand competitiveness;
(3) Research on countermeasure of sports products brand building in china;
(4) Lining and Anta brands case study.

These studies found that the principal factors affecting brand building are: the enterprise brand awareness is weak; positioning is not accurate, lack of brand strategy management and professional talents. Tong Xiaoling et al proposed relevant strategies [12-16].

ShaYanfei, Jin Long have conducted the research on the brand planning; proposed brand planning is to let consumers have rich, unique, positive association of brand, to form a good relationship. Brand planning includes the core value of brand positioning, brand identity and brand recognition. Liu Ping thought that the key to advertising planning is accurate positioning [17-19].

Lu Yinzhi thought that the brand promotion includes rational brand extension and authorization, a reasonable brand portfolio. Brand updating and brand internationalization. Wang Shangen thought brand internationalization strategies include: strengthening international brand awareness, establish enterprises` long-term strategic planning, brand positioning, and internationalization of media selection, brand image, brand culture, enterprise team, product development and product standards. Shi Li believes that the risk of brand extension is mainly the dilution effect, unqualified products, from high-end to low-end extension; implicate effect caused by "seesaw”. Wang Peng`s study noted that the brand expansion strategy is the brand positioning; expand the scale of enterprises, cultivating core competitiveness; focus on brand quality; and improve the brand marketing system [20-28].

Through above study, it is not difficult to see that, although the domestic and foreign research put forward many suggestions from the theoretical and policy level, but insufficient in the positive, the most proposals are in the macro level, difficult to have instant results. To improve the competitiveness of sports brand in China, a pressing matter of the moment is the sports brand competitiveness evaluation. So, in this paper, on the basis of previous research results, references the PLS-SEM algorithm as the machine learning method, and mining sports brand data. We using the decision software to reduce the complexity of the algorithm, to construct the sports brand competitiveness model, to help sports brand promotion.

This paper is structured as follows: The first section, the foreign and domestic research on sports brand briefly introduced, and analyzes the necessity of the research. The second section, the relevant theory and application SEM.The third section, the relevant theory and application PLS-SEM. The fourth section, use PLS-SEM to create the sports brand competitiveness model and empirical research, put forward problems and suggestions for improvement.

SEM ALGORITHM

2.1 SEM Algorithm overview

Many social, psychological variables cannot be accurate or direct measure, such as job autonomy, job satisfaction. These variables are known as hidden variables, at this time, only can measure these latent variables with some explicit indicators. The traditional method of statistical analysis cannot properly handle these hidden variables, while the SEM model can cope with both hidden variables and indicators.

The SEM model is a booming branch of statistical field, mainly contains the causal model, path diagram, partial least squares method. SEM is commonly used in psychology, sociology etc, especially the customer satisfaction index (CSl) analysis model. There have been a lot of progresses on SEM algorithm, including the use of ML algorithm, EM algorithm. The practical application of PLS algorithm is still the most effective.

The advantages of the SEM model are able to deal with multiple dependent variables; variable and dependent variable with measurement error is admissible; estimate the relationship and structure of factors; can estimate the model fitting degree. This research will involve a large number of variables and the dependent variable, and get the existing error in the process of getting data; SEM model can solve these problems very well.

Structural equation model is divided into: the measurement equation and the structural equation model.
(1) The measurement equation model
The measurement equation describes in the relationship between the latent variables and parameters. Such as the relationship between enterprise's market position indicators and corporate image; the relationship between indicators and latent variable, usually written as the following measurement equation:

$$x = \Lambda_x \xi + \partial$$
$$y = \Lambda_y \eta + \varepsilon$$

Among them:
x is the exogenous vector index;
y --endogenous (endogenous) vector index;
vector ξ exogenous latent variable composition;
vector η -- consisting endogenous of latent variable;
Λ_x -- relationship between exogenous parameters and exogenous variables,
Λ_y is the matrix in the exogenous latent variables on load factor exogenous indicator.

(2) The structural equation model
Structural equation model provides a description of the relationship between the latent variables, such as the relationship between satisfaction and loyalty. The structure model is defined in the assumption of exogenous and endogenous a potential indicators of potential causal relationship between variables. On the relationship between hidden variables, usually written as a structural equation:

$$\eta = B\eta + \Gamma \xi + \zeta$$

Among them:
B -- Endogenous latent variable relationship; effects of Γ exogenous latent variables -- on the endogenous latent variables; ζ --structural equation residuals, reflected could not be explained parts of the equation. In the structural equation model needs to satisfy the following conditions:
The hidden variables of η, ξ and residuals ζ are uncorrelated
The measurement error of the hidden variable η and its corresponding ε uncorrelated, measurement errors hidden variables ξ and its corresponding δ not related

2.2 The basic idea of the SEM algorithm:
SEM algorithm is a generalization of the parameters of EM algorithm. It applies the EM algorithm to incomplete data sets of learning Bayesian networks. The basic idea is: from an initial Bayesian network $B_o = (G_o, \theta_o)$ to start the iteration, on the t iteration to get the optimal network $B_t = (G_t, \theta_t)$

The $t+1$ iteration consists of the following two steps:

1, based on the current best network $B_t = (G_t, \theta_t)$ using the EM algorithm to complete data set D ,get the data set D_t;
2, based on the D_t data set for the further optimization of the model, get $B_{t+1} = (G_{t+1}, \theta_{t+1})$

2.3 The execution process of the SEM algorithm
SEM algorithm is divided into the structure searchand parameter learning two steps. The specific implementation of the process is as follows:
1 set the initial value of a variable;
2 from an initial Bayesian network to start the iteration;
3 calls the join tree algorithm for Bayesian network inference operation, obtain the best network;

4 based on the current best network using EM algorithm to complete data set, get a complete data set in order to realize the maximization of the parameters;
5 calculate the sum of the number of all the nodes in the network.
6 create different network structures; take the structure as a candidate network structure.
7 use BIC scoring functions to score the candidate network structure, selected the maximum score parameters.
8, network structuresof output and data sets fit best.

2.4 learning structure of SEM

$engine = jtree\ \inf\ engine(bnet)$

Input parameters: $bnet$ refers to the initial network structure

Output parameters: $engine$ is a structure

Main functions: The Bias network joint into the tree, then by definition in the combined tree message transfer process is used to compute the probability, complete reasoning operations on the Bias network.

$$[engine.jtree, engine.preorder, engine.postorder] = mk\_rooted\_tree(engine.jtree, engine.root\_clq);$$

Input parameters: $engine.jree$ refers to the joint tree; $engine.root\_clq$ refers to the group with the node.

Output parameter: $engine.jtree$ refers to the joint tree output; $engine.preorder$ refers to redraw the node sequence of united tree; $engine.postorder$ to draw the joint tree node ranking.

Main functions: draw a tree with nodes from the start

$engine = init\_fields()$

Main functions: the initial definition of engine

$[bnet, LOGLIKE] = learn\_params\_em(engine, samplesM, 10)$ (EM algorithm)

Input parameters: $engine$ is a structure;

$samplesM$ represents the network parameter learning sample number; 10 refers to the maximum number of EM algorithm cycles.

Output parameter: $bnet$ refers to a network; $LOGLIKE$ represents the estimated maximum log likelihood function parameters.

Main functions: Bayesian network parameter completes learning of defaultdata.

$BNET = bnet\_from\_engine(engine);$

Input parameters: $engine$ is a structure

Output parameter: $bnet$ refers to the network

Main functions: return network structure in internal-combustion engines

$[engine.\log lik] = EM\_step(engine, evidence);$

Input parameters: $engine$ is a structure; $evidence$ refers to the evidence

Output parameters: $engine$ is a structure; the log likelihood $\log lik$ returns theevidence

Main functions: the implementation process of EM algorithm

$[D, d] = compute\_bnet\_nparams(BNET)$

Input parameters: $BNET$ represents the EM algorithm after the generation of the network.

Output parameter: D refers to the sum of all the parameters of the nodes in the network; d is the number of values of each node

Main functions: parameter was calculated as the sum of all the nodes in the network.

$[nbrs, ops, nodes, orders] = mk\_nbrs\_of\_dag\_topo(bnet.dag);$

Input parameters: $bnet.dag$ is a network diagram

Output parameter: $nbrs$ represents a node in figure bnet.dag neighbor nodes; OPS refers to the neighbor nodes by adding, reducing, edge turning to create I; $nodes$ refers to the node $(new\_nodes(I,1:2))$ are the head and tail of theoperated-on arc; $orders$ refers to the topological order neighbor node list

Main functions: all DAG create different in figure bnet.dag.
$[nbrs, OPS, nodes] = mk\_nbrs\_of\_digraph(DAG)$
Input parameters: DAG is a Bayesian network
Output parameter: $nbrs$ represents a node in Figure DAG neighbor nodes; OPS refers to the neighbor nodes by adding, reducing, edge turning to creating i ; $nodes$ refers to the node name;

Main functions: to create the different figure DAG graphics
$A = init\_ancestor\_matrix(DAG)$
Input parameters: DAG refers to the Bayesian network
Output parameters: A is a matrix

Main functions: the first ancestor matrix network
$[ec, EC1, LL] = compute\_approx\_ess(BNET, samplesM, OPS, nodes)$
Input parameters: $BNET$ refers to a network; $samplesM$ refers to the number of samples of network; OPS refers to create I neighbor nodes by adding or reducing of the edge turning; $nodes$ refers to the node name.
Output parameters: approximate expected neighbor node ec to save the factor changes of the sufficient statistics $EC1$ approximation; expected to savethe removed node edge sufficient statistical factor; LL refers to the estimated log likelihood values of nodes.

Main functions: the network computing approximate expected to all neighbor nodes based on sufficient statistics factor
$parents = mysetdiff(parents, head)$
Input parameters: $parents$ refers to a parent node to a node in the network; $head$ is the starting point of one side
Output parameter: $parents$ refers to a node set

Main functions: $parents$ and $head$ two different sets
$index = find\_same\_domain(EC, domain, length)$
Input parameters: approximate expected neighbor node ec to save thechanges of the sufficient statistics factor; $domain$ refers to the range of node; $length$ refers to the number of nodes containing
Output parameter: $index$ refers to the node label
Main functions: returns the node with the same label value range. [29]

PLS-SEM ALGORITHM
PLS-SEM model is a new method proposed by Wood based on PLS regression in the last century eighty's. Measure function and the method of structure equation is similar to SEM,But the idea of modeling is different,PLS-SEM model is iteratively through a series of a univariate or multivariate linear regression, using partial least squares regression method, so when the other variables correlation is high, this method is more effective and reliable. The model does not exist some problems which cannot be recognition, and the sample capacity requirements are relatively loose.

Partial least squares estimation is mainly estimated to the hidden variables by an iterative method, can be carried out from two aspects;one is to calculate the hidden variables based on the relationship between the significant variables and latent variables,Hidden variables ξ_j estimate by linear combination of significant variables of $x_{jh}(j=1,2,\cdots j, h=1,2,\cdots p_j)$,Remember the estimator is Y_j, for the above model assumptions hidden variable ζ_j is the standard, therefore, there are: $Y_j = (\sum_{h=1}^{p_j} w_{jh}x_{jh})^* = (X_j w_j)^*$ w_j as a weight vector,the asterisk indicates that estimator of model standardization processing.On the other hand, the relationship between the latent variables are calculatedmainly is the estimation of hidden variables of ξ_j and other hidden variables.

The calculation of e_{ij} internal weights:

$$e_{ij} = sign(r(Y_j, Y_i)) = \begin{cases} 1 \ (r(Y_j, Y_i) > 0 \\ 0 \ (r(Y_j, Y_i) = 0 \\ -1 \ (r(Y_j, Y_i) < 0 \end{cases}$$

Where $sign$ is the symbolic function; $(r(Y_j, Y_i)$ represents the amount of coefficient of external estimate Y_j, Y_i,the weight of the w_j can use the following two kinds of model to estimate.Mode A the specific calculation formula is as follows:

$$w_j = \frac{1}{n} X_j^T Z_j$$

The weight vector of w_j is correlation coefficients or variance of variables X_j and Z_j for standardized variables, w_j is partial least squares regression weights of the first components for variables Z_j to X_j.
Mode B the specific calculation formula is as follows:

$$w_j = (X_j^T X_j)^{-1} X_j^T Z_j$$

This time weight vector of w_j represents variable Z_j to X_j ordinary least squares regression equation coefficient.When a significant relationship between the variables and latent variables to reflect the way, we generally select model of A to calculate the weight. When a significant relationship between the variables and hidden variables to constitute the way, we generally select model of B to calculate the weight.At the same time, because each observable variable exists highmulticollinearity, the model B will exists big estimation error, and the choice of model A using partial least squares method for calculation, set condition is more suitable for PLS-SEM model.

The general PLS-SEM model uses the iterative method to calculate thehidden variables, to calculate the measurement model and the structural model according to the estimation of hidden variables. The specific steps are as follows:

The first step, the initial orientation of Y_j equals x_{j1}

The second step, calculate Z_i estimation;

The third step, according to a Z_i estimate, calculate weight vector w_i

The fourth step, using w_i, calculate Y_i, and then back to the second step until convergence, finally got Y_i as a hidden variable ξ_i estimates ξ_i^*;

The fifth step, according to the implicit variables ξ_i^* toestimate ξ_i, estimate the coefficient measurement model and the structural model of the λ_{jh} and β_{ji} using ordinary least squares linear additive model. [30]

BUILDING THE BRAND COMPETITIVENESS MODEL OF SPORTS INDUSTRY BASED ON PLS-SEM

4.1 The evaluation index and data acquisition

This paper selects the evaluation index system of brand competitiveness which was put forward by Professor Han Furong, as the basis of research on brand competitiveness of sports,

According to the quantitative evaluation principles, evaluation indicators are at table 1and table 2:

Table 1. Evaluation indicators

The core competitiveness classification	first level index	second level index	Index code
Explicit competitiveness	Awareness	Operation time	e_{11}
		Advertising	e_{12}
		Expand the customer quantity	e_{13}
	Popularity	The well-known state	e_{21}
		Source way	e_{22}
		Mode of transmission	e_{23}
		Communication evaluation	e_{24}
	Reputation	The credibility of the state	e_{31}
		Sales promotion	e_{32}
		Product life improvement	e_{33}
		Customer	e_{34}
Implicit competitiveness	Loyalty	New Member quantity	e_{41}
		The difference value	e_{42}
		After-sale service	e_{43}
		Means of communication	e_{44}
		Source condition	e_{45}
	Associate degree	Association state	e_{51}
		Product coverage	e_{52}

Table 2.10 representative sports brand competitiveness data

e_{11}	e_{12}	e_{13}	e_{21}	e_{22}	e_{23}
5	1065	98	37	63	0.85
6	937	75	47	54	0.92
5	945	84	62	60	0.96
8	990	67	43	53	0.89
12	9248	55	69	45	0.99
13	8864	46	65	70	0.71
8	1010	73	57	68	0.71
9	8573	65	42	71	0.66
10	1037	71	61	79	0.97
7	9976	80	40	60	0.73
e_{24}	e_{31}	e_{32}	e_{33}	e_{34}	e_{41}
0.84	64	478	0.4	3901	221
0.85	71	539	0.1	5702	391
0.92	59	543	0.3	9493	949
0.78	57	583	0.2	945	31
0.93	67	302	0.4	8931	473
0.77	73	43	0.3	9488	1021
0.81	80	988	0.5	10332	3004
0.67	55	440	0.1	4949	199
0.84	70	30	0.1	9492	881
0.91	47	491	0.1	9958	339
e_{42}	e_{43}	e_{44}	e_{46}	e_{51}	e_{52}
13	210	80	76	83	31
23	123	87	70	84	23
15	136	84	73	78	21
34	39	79	77	67	30
12	140	77	81	71	40
20	192	83	60	72	38
23	89	86	74	56	12
12	112	91	69	48	19
33	88	84	76	31	11
20	111	84	70	80	20

4.2 Determine the weights of evaluation indexes

According to the related research results of scholars at home and abroad about sports brand competitiveness, put forward the following hypothesis:

H 1 Brand Popularity has positive effect on brand reputation and loyalty;

H 2 Brand loyalty has a positive impact on the brand reputation;

H 3 The brand association has a positive effect on brand awareness;

H 4 Brand reputation has a positive impact on the relationship between Brand Association;

Based on the assumption to establish the PLS model, as showed in figure 1.

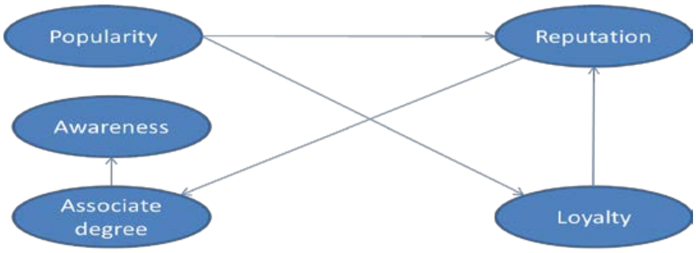

Figure 1.PLS model

Chin thought, the recommended sample number for PLS method is 30 ~ 100.This study utilized 40 famous sports brands` yearbook data as samples. Significant test, the coefficient of determination R2 all greater than 0.8,More than the minimum requirements, shows that the model has strong ability to explain;Reliability test, Krone Baha alpha values are greater than 0.65,composite reliability are more than 0.6 minimum requirement;Convergent validity test, all the average extraction variance value reached the minimum requirement of 0.5.

The test results as showed in the table 3.

Table 3. Test results

Latent variable	Kroner Bah alpha value	Composite reliability	The average extraction variance	The coefficient of determination
Awareness	0.843912	0.974392	0.904951	0.731
Popularity	0.858867	0.975872	0.890011	0.939
Reputation	0.950852	0.925489	0.715222	0.859
Loyalty	0.948091	0.937466	0.818492	0.839
Associate degree	0.905409	0.971035	0.725795	0.868

The standardized weights as shown in the table 4:

Table 4. Standardized weights

first level index	second level index	Standard weight	The accumulated weight
Awareness	Operation time	0.31	0.31
	Advertising	0.35	0.66
	Expand the customer quantity	0.34	1
Popularity	The well-known state	0.4	0.4
	Source way	0.21	0.61
	Mode of transmission	0.15	0.76
	Communication evaluation	0.24	1
Reputation	The credibility of the state	0.23	0.23
	Sales promotion	0.19	0.42
	Product life improvement	0.27	0.69
	Customer	0.31	1
Loyalty	New Member quantity	0.21	0.21
	The difference value	0.19	0.4
	After-sale service	0.17	0.57
	Means of communication	0.23	0.8
	Source condition	0.2	1
Associate degree	Association state	0.5	0.5
	Product coverage	0.5	1

Based on the above assumptions, there is mutual influence between the brand competitiveness evaluation factors, play the role of the brand competitiveness. In order to simplify the calculation, assume that all the influence factors only affect sports brand competitiveness through the maximum coefficient path. To calculate the weight on the basis of this, the standard weight as showed in table 5.

Table 5. The accumulated weights

Route	Standard weights	The accumulated weights
Popularity－reputation-loyalty	0.2	0.2
loyalty-reputation	0.43	0.63
associate degree-awareness	0.17	0.8
reputation-associate degree	0.2	1

According to the model and the table 5 data, the brand competitiveness is showed in table 6:

Table 6.Brandcompetitiveness

brands	competitiveness	
brand 1	2.13	medium
brand 2	1.97	weak
brand 3	3.49	medium
brand 4	4.31	strong
brand 5	3.21	medium
brand 6	1.29	weak
brand 7	2.57	medium
brand 8	4.11	strong
brand 9	3.12	medium
brand 10	1.92	weak

CONCLUSION

This paper uses PLS-SEM algorithm to obtain the competitiveness of 10 representative domestic brands, and revised the index weight evaluation model of brand competitiveness, which put forward by Professor Han Furong. However, there are some shortcomings in this study:

1, this paper selects the data of international representative brand as training data, based on the results to evaluate the domestic brand,Due to different environment,the results may lack of impartiality;

2, some of the data got by expert scoring method, therefore, the result of the study has some man-made factors.

These problems will be improved in the uocoming research.

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