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Construction of Evaluation System for Upgrading of Chinese Automobile Enterprises under the Intelligent Background

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Abstract

A simple analysis of the development status of the automobile industry under the background of intelligence, puts forward that the automobile industry urgently needs to transform and upgrade to improve its international competitiveness. Subsequently, an industrial upgrading evaluation index system including 5 criterion-level indicators and 16 program-level sub-indices including innovation capability, intelligent integration, coordinated development, green development, and industrial benefits was built, and the index weights were obtained by means of analytic hierarchy process and other methods. Put forward countermeasures and suggestions from the aspects of industrial policy, informatization and industrialization integration, and enterprise management methods.

Keywords

Industrial Upgrading; Smart Car; Analytic Hierarchy Process; Evaluation Index System.

1. Introduction

The manufacturing industry is a pillar industry of the national economy. As an important part of the manufacturing industry, the automobile industry has the characteristics of a long industrial chain, strong integration, and complex product structure and technology. With the advent of a new generation of technological revolution, intelligent and networked, Electrification and sharing have become a new direction for the development of the automobile industry. The car will become the next smart mobile terminal. The emergence of mobile Internet and big data has made the intelligent manufacturing of automobiles possible. With the changes in the consumption concepts of the new generation of consumers, the service experience of the automobile industry has received more and more attention. Affected by the domestic economic situation and the new crown epidemic, Chinese auto companies and suppliers are facing a liquidity crisis, generally experiencing declines in product sales, profits and revenues, and have to accelerate cost reductions. Chinese automobile industry urgently needs to improve efficiency and carry out transformation and upgrading. The Chinese government has also issued policy documents such as "Made in China 2020" and "Innovative Development Strategy for Intelligent Connected Vehicles" to guide the upgrading of the automobile industry. Based on this, this paper constructs relevant evaluation indicators for the upgrading of the automotive industry in the context of intelligence, and puts forward relevant suggestions to help relevant enterprises in their intelligent transformation.

2. Construction of Evaluation Indicators

2.1. Principles of Evaluation Index Construction

Through the study of different evaluation theories and methods, it is hoped that based on previous research, combined with the characteristics of the automotive industry and the

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enterprise, a scientific and practical evaluation system with certain practical significance will be constructed. Therefore, it is necessary to follow the corresponding evaluation system construction principles in the evaluation system construction process, including the following points:

(1) Purpose principle:

The purpose of constructing this evaluation system is to provide government departments or related industry associations with a practical analysis model tool to make more specific and objective evaluations and judgments of enterprises in China's industry, and then from policy Help and guide enterprises in terms of resources and resources, and accelerate the development of intelligent transformation and upgrading of the automobile industry; microscopically, for specific automobile enterprises, this evaluation system can be used to help them have a more objective view of the enterprises themselves and industry competitors. , Practical evaluation, and then help business operators to make more reasonable decisions that are more conducive to their own development.

(2) Principle of rationality

Since the construction of the evaluation system of the strategy effect is a relatively complex task, it is necessary to pay attention to the hierarchy and structure of the entire evaluation system, the coordination of various indicators and the entire evaluation system, and the rationality of the hierarchy in the evaluation system. Every effort should be made to ensure that the entire evaluation system structure is reasonable, which can comprehensively evaluate the effects of the upgrade strategy and reduce the duplication of indicators.

(3) Scientific principles

Constructing an evaluation system for strategic effects is a process of practical application of theoretical knowledge. We should strive to select evaluation indicators as reasonably and scientifically as possible through the mastery and rational use of theoretical knowledge, and build an evaluation system to evaluate the actual automotive industry. Intelligent upgrade effect.

(4) Pertinence principle and operability principle

When establishing an evaluation system, we should pay attention to drawing on the theoretical basis, evaluation methods, and indicator selection of predecessors, and we should conduct a serious and objective analysis of the nature of the industry in which the company we study is in, and the business characteristics of the industry. Targeted and scientifically proposed evaluation indicators, and then build the entire evaluation system. In the process of selecting indicators and striving to improve the evaluation system, we should also consider whether it is easy to obtain relevant data. It is necessary to select indicators that are consistent with the statistical indicators as much as possible, to facilitate the acquisition of data, but also to ensure the authenticity and accuracy of the data, which will help make the entire evaluation system more objective and accurate.

2.2. Description of Evaluation Indicators

Based on the above-mentioned indicator construction principles, this article combines the auto industry upgrade goals under the background of intelligence, and selects 16 indicators to construct an evaluation system. Each indicator is selected as follows:

(1) Upgrading of innovation capabilities; the core competitiveness of the automotive industry comes from its innovation capabilities, based on existing research and literature, with the intensity of R&D investment, the proportion of invention patents in the total patent applications, the conversion rate of scientific and technological achievements, and the automotive industry scientific research personnel the proportion is measured. Chinese auto industry has the problems of insufficient independent research and development capabilities and insufficient

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talent quantity and quality. In order to maintain competitiveness in the industry and seize market share, it is necessary to take the path of innovation and development.

(2) The development of intelligent integration; the rapid development of intelligent technology is promoting the transformation of production and manufacturing mode to a new production mode of intelligent manufacturing. Cloud computing, big data, Internet of Things and other technologies are merging and merging with automobile manufacturing. Therefore, this article selects key process numerical control the integration rate, the penetration rate of enterprise ERP (Enterprise Resource Planning System) and the use rate of digital tools in the research and development process are important indicators to measure the development level of intelligent integration.

(3) Coordinated development ability; in the context of intelligence, the structure of the auto industry itself has changed, and the relationship with related supporting industries has become closer, and the cooperation with other industries such as communications and Internet has become more frequent. Coordinated development is the automobile industry. An important factor for the transformation and upgrading of the industry. Therefore, this article selects the growth rate of the number of enterprises in the automobile supporting industries and the growth rate of the output value of the computer, communications and other electronic equipment manufacturing industries as the indicators for the coordinated development of the automobile industry.

(4) Green development level: The energy consumption and pollution caused by the automobile industry are relatively large, so green and sustainable development is an important goal of the automobile industry's upgrade. Improving resource utilization and performance and the development of new energy-related businesses can change the quality of development. Therefore, this article uses the decline rate of energy consumption per unit output value of the automobile industry, the increase rate of new energy vehicle output, and the utilization rate of industrial waste as indicators to measure the level of green development.

(5) The level of industrial income: Increasing product sales and profits is the biggest driving force for enterprises to transform and upgrade. The improvement of the competitiveness of auto industry products can help Chinese auto industry better integrate into the global production network, and realize the transition from low value-added to high value-added Upgrade. Therefore, the profit rate of the automobile industry, the turnover rate of current assets, the increase rate of the total output value of the automobile industry, and the value-added rate of the automobile industry trade are selected as indicators to measure the industrial income.

Based on the above analysis, an evaluation index system for the upgrading of the auto industry under the background of intelligence has been constructed, as shown in Table 1 below:

3. Quantitative Research on Evaluation Index System

3.1. Research Method Introduction

The analytic hierarchy process is a combination of qualitative and quantitative decision analysis methods to solve multiple goals. This method was proposed by Thomas Sati, a well-known American operations researcher. This method decomposes complex problems into multiple elements, layeres and groups these elements, and then compares them to determine the relative relationship of each element in each level. Importance, and finally sort the importance of each element to the target layer.

The application of AHP mainly has the following four steps:

The first step is to determine the target and evaluation factor set

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The second step is to construct a judgment matrix and judge the relative importance through pairwise comparison, as shown in Table 2.

Table 1. Auto industry upgrade index system under the background of intelligence

Target layer	Criterion layer	Index layer	Indicator attributes
Intelligent upgrade of the automotive industry U	Innovation Ability A	R&D expenditure investment intensity A1	+
		The number of invention patents accounted for the proportion of total patent applications A2	+
		Conversion rate of scientific and technological achievements A3	+
		Proportion of research personnel in the automotive industry A4	+
	Intelligent Fusion B	Key process numerical control rate B1	+
		Enterprise ERP (Enterprise Resource Planning System) penetration rate B2	+
		Utilization rate of digital tools in the R&D process B3	+
	Coordinated development C	Growth rate of the number of enterprises in the automobile supporting industry C1	+
		Computer, communications and other electronic equipment manufacturing output value growth rate C2	+
	Green Development D	The reduction rate of energy consumption per unit output value of the automobile industry D1	+
		New energy vehicle production increase rate D2	+
		Industrial waste utilization rate D3	+
	Industry income E	Auto industry profit margin E1	+
		Liquid assets turnover rate E2	+
		Auto industry gross output value increase rate E3	+
		Auto industry trade value-added rate E4	+

Table 2. The scale of evaluation index comparison and its meaning

Scaling	meaning
1	Ia and Ib are equally important
3	Ia is slightly more important than Ib
5	Ia is more important than Ib
7	Ia is more important than Ib
9	Ia is extremely important than Ib
2, 4, 6, 8	At the middle level above
Reciprocal value	When Ia and Ib are compared, it is the reciprocal value

According to the above judgment, the relevant judgment matrix P is obtained

$$P=\begin{pmatrix} u_{11} & u_{12} & \cdots & u_{1n} \\ u_{21} & u_{22} & \cdots & u_{2n} \\ . & . & . & . \\ u_{n1} & u_{n2} & \cdots & u_{nn} \end{pmatrix}$$, Called A-U matrix.

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The third step is to calculate the importance ranking

According to the matrix, the eigenvector corresponding to the largest eigen root is the weight of the evaluation index.

(1) Normalize each column of the judgment matrix, and the normalization formula is:

$$\overline{\mu_{ij}} = \frac{\mu_{ij}}{\sum_{k=1}^{n} \mu_{kj}} (i, j = 1, 2..., n)$$

$$w_i = \frac{\overline{w_i}}{\sum_{j=1}^{n} \overline{w_j}} (i, j = 1, 2..., n)$$

$$\lambda_{\max} = \frac{1}{n} \sum \frac{(pw_i)}{w_i}$$

(2) After each column is normalized, the matrix rows are added:

$$\overline{w_i} = \sum_{j}^{n} \overline{\mu_{ij}} (i, j = 1, 2..., n)$$

(3) Normalize the vector: $\overline{w_i} = (\overline{w_1}, \overline{w_2} \cdots \overline{w_n})^T$

$$w_i = \frac{\overline{w_i}}{\sum_{j=1}^{n} \overline{w_j}} (i, j = 1, 2..., n)$$

The obtained $\overline{w_i} = (\overline{w_1}, \overline{w_2} \cdots \overline{w_n})^T$ is the required feature vector.

(4) Calculate the maximum eigenvalue λ_{max} of the judgment matrix

$$\lambda_{\max} = \frac{1}{n} \sum \frac{(pw_i)}{w_i}$$

The fourth step, consistency check

Through the consistency test, we can judge whether the weight distribution is reasonable, and then continue to do further level analysis. CR is the random consistency ratio of the judgment matrix, $CR = CI / RI$, where CI is the consistency index of the judgment matrix, and its formula is: $CI = (\lambda_{\max} - n) / (n - 1)$. RI is the average random consistency index of the judgment matrix. For n=1~9, Satie gives the value of RI, as shown in Table 3. When CR<0.1, the judgment matrix is considered to pass the consistency test; when CR>0.1, adjustments are needed to make the consistency satisfactory. The weight calculated by the analytic hierarchy process can reduce the influence of subjective factors on the target layer.

If the artificial subjective judgment deviates from the objective facts, then the value can help correct this difference and enhance the rationality of the judgment index.

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Table 3. Average random consensus index RI

Order	n
1	0
2	0
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45

3.2. Construct a Judgment Matrix

Regarding the establishment of an evaluation index system for the upgrading of the automobile industry in the context of intelligence, this study uses an expert scoring method to judge the relative importance of each index. Through calculation, the results are as follows.

(1) For the overall goal of the intelligent upgrade of the automobile industry, the judgment matrix consistency index CI=0.1107, the average random consistency index RI=1.12, and the random consistency ratio CR=0.0988<0.1. Table 4 shows the weights and important conditions of each indicator.

Table 4. The weight and relative importance of the criteria layer

U	A	B	C	D	E	W
A	1	4	6	5	7	0.5051
B	1/4	1	3	3	7	0.227
C	1/6	1/3	1	3	6	0.1481
D	1/5	1/3	1/3	1	3	0.0818
E	1/7	1/7	1/6	1/3	1	0.0381

(2) For the innovation ability criterion layer, the consistency index of the judgment matrix CI=0.0064, the average random consistency index RI=0.9, and the random consistency ratio CR=0.0071<0.1. Table 5 shows the weight and relative importance of each index at the next level.

Table 5. Index weights and relative importance of subordinate levels of innovation ability

U	A_1	A_2	A_3	A_4	W
A_1	1	3	2	7	0.4894
A_2	1/3	1	1/2	3	0.1623
A_3	1/2	2	1	5	0.2879
A_4	1/7	1/3	1/5	1	0.0604

(3) For the intelligent fusion criterion layer, the judgment matrix consistency index CI=0.0092, the average random consistency index RI=0.58, and the random consistency ratio CR=0.0158<0.1. Table 6 shows the weight and relative importance of each index at the next level.

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Table 6. Index weights and relative importance of subordinate levels of intelligent fusion

U	B_1	B_2	B_3	W
B_1	1	3	1/2	0.3202
B_2	1/3	1	1/4	0.1226
B_3	2	4	1	0.5571

(4) For the coordinated development criterion layer, the consistency index of the judgment matrix CI=0, the average random consistency index RI=0, and the random consistency ratio CR=0<0.1. Table 7 shows the weight and relative importance of each index at the next level.

Table 7. Index weights and relative importance of subordinate levels of coordinated development

U	C_1	C_2	W
C_1	1	4	0.8
C_2	1/4	1	0.2

(5) For the green development criterion layer, the consistency index of the judgment matrix CI=0.0018, the average random consistency index RI=0.58, and the random consistency ratio CR=0.0032<0.1. Table 8 shows the weight and relative importance of each index at the next level.

Table 8. Index weights and relative importance of subordinate levels of green development

U	D1	D2	D3	W
D1	1	5	3	0.6479
D2	1/5	1	1/2	0.1222
D3	1/3	2	1	0.2299

(6) For the industry income criterion layer, the consistency index of the judgment matrix CI= -0.0137, the average random consistency index RI=0.9, and the random consistency ratio CR= -0.0152<0.1. Table 9 shows the weight and relative importance of each index at the next level.

Table 9. Index weights and relative importance of the subordinate levels of industry income

U	E1	E2	E3	E4	W
E1	1	2	1	6	0.3732
E2	1/2	1	1/3	5	0.1977
E3	1	2	1	6	0.3732
E4	1/6	1/5	1/6	1	0.0558

In summary, the above judgment matrices have passed the consistency test. According to the requirements of the analytic hierarchy process, the consistency test of the total hierarchy is also required. The formula is $CR = \frac{w_1 CI_1 + w_2 CI_2 + \ldots + w_n CI_n}{w_1 RI_1 + w_2 RI_2 + \ldots + w_n RI_n}$,when CR<0.1, the total ranking of the hierarchy is considered to pass the consistency test, after calculation, the total ranking consistency ratio of the hierarchy CR=0.003<0.1, and it is concluded that the consistency of the total ranking is acceptable.

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3.3. Determination of Comprehensive Weight

The five criterion-level indicators A, B, C, D, and E corresponding to the overall goal U of the automotive industry upgrade evaluation in the context of intelligence are ranked as $W_U=\{W_{UA}, W_{UB}, W_{UC}, W_{UD}, W_{UE}\}^T$, and the four sub-indices A_1, A_2, A_3 of the criterion-level indicator A , The level single order vector of A4 to A is $W_A=\{W_{A1}, W_{A2}, W_{A3}, W_{A4}\}^T$, then the weight vector of criterion level indicators A_1, A_2, A_3, A_4 relative to the target level U can be expressed as $W_{UA}=\{W_{UA}\times W_{A1}, W_{UA}\times W_{A2}, W_{UA}\times W_{A3}, W_{UA}\times W_{A4}\}^T$, and so on, we can get B, C, D, E The weight vectors WUB, WUC, WUD, WUE of the following indicators of the criterion level indicators for the overall target are shown in Table 10 below:

Table 10. Weights of evaluation indicators for intelligent upgrading of the automobile industry

Criterion layer	A	B	C	D	E	Weights
Index layer	0.5051	0.227	0.1481	0.0818	0.0381	
A1	0.4894					0.247
A2	0.1623					0.082
A3	0.2879					0.145
A4	0.0604					0.031
B1		0.3202				0.073
B2		0.1226				0.028
B3		0.5571				0.126
C1			0.8			0.118
C2			0.2			0.030
D1				0.6479		0.053
D2				0.1222		0.010
D3				0.2299		0.019
E1					0.3732	0.014
E2					0.1977	0.008
E3					0.3732	0.014
E4					0.0558	0.002

The weight vectors of the above indicators are the specific weights of the evaluation indicators of the auto industry upgrade schemes under the background of intelligentization. They quantify the auto industry upgrade evaluation indicators, clarify the direction of the auto industry's intelligent upgrade, and provide an important reference for enhancing the competitiveness of the Chinese auto industry in accordance with.

4. Specific Analysis of Weight

For the overall goal of the intelligent upgrade of the automotive industry in the context of intelligence, the index weights of the criterion layer are, in order, innovation capability (0.5051), intelligent integration (0.227), coordinated development (0.1481), green development (0.0818), and industry revenue (0.0381)). It can be seen that improving innovation capability is the core link of the intelligent transformation and upgrading of the automotive industry. Intelligent integration is the main goal of the current automotive industry upgrade. Coordinated

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green development is an important criterion for measuring the upgrading of the automobile industry.

In the overall ranking of levels, for the overall goal of auto industry upgrading, the R&D expenditure investment intensity (0.247), the conversion rate of scientific and technological achievements (0.145), the use of digital tools in the R&D process (0.126), and the growth rate of the number of enterprises in the automotive industry (0.118), the proportion of the number of invention patents in the total patent applications (0.082) is the top five in terms of weight in the secondary index. It can be seen that the use of digital tools is the main means to promote the upgrading of the automobile industry, and the transformation of scientific research results provides a strong driving force for the upgrading of the automobile industry.

The industry income represented by the industry profit rate accounts for a small proportion of the evaluation index weight, which shows that under the background that big data intelligent technology has gradually integrated into the automobile industry, the profit rate and other revenue indicators are no longer used to evaluate the automobile industry. The only standard for upgrading, the auto industry upgrading pays more attention to technological innovation, industrial coordinated development and green development with enterprises. Consider upgrading strategies from multiple perspectives to improve the international competitiveness of the industry.

5. Summary and Recommendations

At present, Chinese automobile industry has problems such as insufficient research and development capabilities, low production concentration, lack of a division of labor coordination mechanism, and weak independent brands. Combining these problems, this article proposes an evaluation index system for the upgrading of the automobile industry under the background of intelligence, and different levels of index weight data, and put forward the following countermeasures and suggestions for the future development of Chinese automobile industry:

(1) In response to the problem of insufficient R&D capabilities, auto companies need to increase R&D investment and R&D efforts, train and introduce senior technical personnel, and promote the implementation of scientific research technology and results. OEMs should devote themselves to the R&D and production of core links, and outsource the R&D and production of non-core components to increase the added value of products. The parts and components enterprises have carried out strategic reorganization, and strived to realize the systematization and modularization of supply methods, and formed a large-scale competitive parts and components business group, breaking through geographical restrictions, and gradually becoming a domestic supplier. On top of this, with the help of the global multinational company procurement system, it has gradually developed in the direction of global suppliers.

(2) Focus on the development of intelligent networked vehicles, promote the development of automotive products in the direction of intelligence and connectivity, build a smart car industrial park and manufacturing base, and closely integrate industrialization and informatization in the process of key vehicles and parts, to promote the optimization of the production process and improve production efficiency. Digital tools should also be used in the daily management process of the enterprise, to save management costs and improve management efficiency.

(3) Break the restrictions on resource allocation by departments and regions, and promote the rational movement of technology and labor; establish regional and national technology innovation platforms, and establish effective technology input and output mechanisms. Encourage technological alliances and common development to accelerate the pace of R&D and innovation industrialization; first improve the policy system for promoting innovation. The development of China's automobile industry is largely influenced by government policy

guidance. The government should support auto companies to enhance their independent innovation capabilities in terms of policies and funds, form an effective mechanism to encourage independent innovation, and achieve coordinated development.

(4) Give priority to the development of new energy vehicles and promote the "green" transformation. For the government, for the government, the standardization of market order is the main task, and regular and unified policies must be implemented. Speed up the construction of new energy vehicle infrastructure such as charging piles. For the company, vigorously develop key component technologies, such as batteries and motors, based on existing industries, and strive to make up for shortcomings as soon as possible, reduce unit industrial value, increase energy consumption and carbon dioxide emissions, and improve energy utilization.

(5) Improve business management and promote common development. For companies, on the one hand, they must focus on the interests of employees and increase their enthusiasm for work; on the other hand, they need to change their production methods to adapt to changes in market demand. The ultimate goal of production is consumption. Currently, consumer needs are more diverse and personalized. It is necessary to establish a more flexible production system, eliminate outdated production technologies and maintain technological progress, so that enterprises can realize the dynamic link between the supply structure and the demand structure, and focus on the improvement of industrial income. To better realize the intelligent upgrade of the automobile industry.

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