Dynamic Thinking on the Construction and Development of Hydrogen Stations: Research on Influencing Factors Based on Factor Analysis Method

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Abstract. This article studies the influencing factors of hydrogen refueling station construction from the macro, meso, and micro levels, based on the first-hand questionnaire data and using factor analysis to analyze influencing factors. It is concluded that industry development factors have the greatest impact on the construction of hydrogen refueling stations, and on this basis, the influence weights of various specific factors are calculated. On the basis of the above analysis, relevant suggestions are put forward for the construction of hydrogen refueling stations in my country.

1. Introduction
With the emergence of energy crisis and environmental pollution, the pressure to adjust the industrial structure and improve energy efficiency is further expanding, and energy development is facing many problems and challenges. Hydrogen energy is regarded as an important secondary energy source in the 21st century due to its special advantages of pollution-free, zero-emission, and sustainability, and has become the focus of energy strategic transfer and research in various countries. At the same time, hydrogen energy has the characteristics of clean combustion products and no pollution, it also has a high calorific value as an obvious advantage for its large-scale development. During the large-scale development and application of hydrogen energy, fuel cell vehicles have become one of the application directions. At present, China's fuel cell vehicles are in the stage of demonstration operation and are also facing bottlenecks such as infrastructure and technical reserves. Among them, hydrogen stations are considered to be one of the main factors restricting the development of fuel cell vehicles.

Fuel cell vehicles and hydrogen refueling station only have been paid attention from the industry in the past two years. They are still in their infancy without much relevant studies, but there are many factors that affect the construction of hydrogen refueling stations. This article discusses the construction influencing factors of hydrogen refueling stations from three levels: macro, meso, and micro which are divided into policy factors, industry development factors and own factors. Based on extensive first-hand questionnaire data, descriptive statistical analysis and factor analysis methods are used to construct a model for the influence mechanism of hydrogen refueling station construction. Carrying out empirical analysis to provide theoretical reference and countermeasure suggestions for the construction of hydrogen refueling stations in China.

2. Research methods and data sources
2.1. Research methods
"Factor analysis" was first proposed by psychologist C.E. Spearman. The so-called factor analysis is to extract a small number of unrelated comprehensive variables from a large number of variables. These comprehensive variables contain a large amount of raw data information to reflect the essential characteristics of things. The factor analysis in this article includes the following steps.

1. Identify the influencing factors
2. Reliability analysis
3. Validity test
4. Factor analysis

2.2 Data sources
This paper uses a questionnaire survey method to collect data. Fuel cell vehicle-related companies, local governments and industry experts are the main targets of this survey. Questionnaire surveys are mainly used to collect data: one is to design survey questionnaires on the questionnaire survey website Questionnaire Star, and obtain data through various methods such as WeChat and WeChat groups. The second is to send emails to relevant companies in the industry for data collection through email.

3. Empirical Analysis of Influencing Factors in Hydrogen Refuelling Station

3.1. Identify influencing factors
In order to achieve accurate identification of influencing factors, this paper selects 18 hydrogen refuelling station construction related variables from the three levels of macro, meso, and micro through literature review and government and corporate investigations, including national fiscal and tax subsidy policies, national innovative support policies, centralized management of construction, technical reserves of key components, etc. They are shown in Table 1.

| Number | Select indicator |
|--------|------------------|
| X1     | National fiscal and tax subsidy policy |
| X2     | National Innovation Support Policy |
| X3     | National Master Plan |
| X4     | Strategic positioning of hydrogen energy |
| X5     | Construction centralized management department |
| X6     | Approval Process |
| X7     | Land nature |
| X8     | Construction standards |
| X9     | Technical standard |
| X10    | Technical reserve of key components |
| X11    | Development of hydrogen source production, storage and transportation technology |
| X12    | Safe question |
| X13    | Fuel cell vehicle technology |
| X14    | Number of fuel cell vehicles |
| X15    | Hydrogen supply |
| X16    | Hydrogen price |
| X17    | Construction cost |
| X18    | Operating cost |
3.2. Reliability analysis
Reliability is a measure of the reliability of the measurement tool itself and the stability of a certain concept. A measurement tool with high reliability has relative stability and consistency for multiple measurement results of the same thing. The most commonly used reliability coefficient is Cronbach α.

The internal reliability of the questionnaire is measured by the Cronbach α coefficient. The larger the value, the higher the reliability and the reliability of detection. In exploratory research, an alpha value greater than 0.7 means that it is quite reliable. If the Cronbach alpha coefficient is below 0.6, it indicates that the reliability of the questionnaire cannot be required. This article uses Cronbach's alpha coefficient to test the consistency of the questionnaire.

| Cronbach alpha coefficient | Credibility          |
|-----------------------------|-----------------------|
| α < 0.6                     | Poor credible         |
| 0.6 ≤ α < 0.7               | Acceptable            |
| 0.7 ≤ α < 0.8               | Generally credible    |
| 0.8 ≤ α < 0.9               | More credible         |
| 0.9 ≤ α                     | Very credible         |

This paper uses spss 22 to test the reliability of the corresponding samples. According to the principle of reliability, from the overall consideration of the scale, in Table 3, it can be found that there are a total of 18 measurement items. The Cronbach α coefficient is 0.968, which is greater than 0.9. It’s in a very credible interval, indicating that the overall reliability of the scale part is high. It can be seen from Table 4 that compared to the overall reliability, the reliability coefficient of each variable is roughly between 0.966-0.968, and the Cronbach α coefficient values are all greater than 0.9, indicating that the data reliability of each variable is higher. Both the overall reliability and subscale reliability meet the requirements, and the data obtained from the questionnaire scale has high credibility.

| Research variables | Cronbach α |
|--------------------|------------|
| Overall reliability of the questionnaire | 0.968 |

| Number | Cronbach α |
|--------|------------|
| X1     | 0.966      |
| X2     | 0.967      |
| X3     | 0.966      |
| X4     | 0.966      |
| X5     | 0.966      |
| X6     | 0.967      |
| X7     | 0.968      |
| X8     | 0.966      |
| X9     | 0.967      |
| X10    | 0.966      |
| X11    | 0.966      |
| X12    | 0.966      |
3.3. Validity test

The results of the questionnaire data reflect that the extent of the survey content is measured by validity. The more consistent the survey results are with the scheduled survey content, the higher the validity, otherwise, the lower the validity. In this article, the content validity and structure validity are mainly analyzed. If the questions in the design questionnaire can cover all the content that the research needs to discuss, the questionnaire has good content validity. The survey questionnaire in this article is formed after many discussions and revisions. It can be considered that the questionnaire scale used in this research has high content validity.

This article uses factor analysis to structurally test the overall situation of the questionnaire. The factor analysis method can extract potential common factors from a large number of variables, and summarize variables with the same characteristics into one factor, which can reduce the number of variables and perform correlation hypothesis tests on the variables. In the factor analysis results, there are three main indicators for evaluating the validity of the structure, namely the cumulative contribution rate of variance, the degree of commonality, and the factor load. They are based on the cumulative effectiveness of the common factor to the scale and the effectiveness of the common factor to explain the initial variables, the degree of correlation between the initial variables and the common factors explains the validity.

Before performing factor analysis on the data, it needs to be tested to determine whether it is suitable for the model. The methods used in this paper are Bartlett's sphere test and KMO test. The independent variable data is tested, and the data in Table 5 are obtained. From Table 5, it can be seen that the KMO value is 0.831, which is greater than 0.5, and the significance P is less than 0.01. The test is qualified and factor analysis can be performed.

| KMO value | 0.831 |
|-----------|-------|
| Bartlett approximate chi-square | 1248.950 |
| Degree of freedom | 153 |
| Significance | 0.000 |

Through factor analysis, the variance contribution rate result and the rotated component matrix result are formed. It can be seen from the total variance analysis data that this paper extracted three factors with eigenvalues greater than 1, and the cumulative variance contribution rate reached 80.040%, indicating that the collected data passed the structural validity test and performed well. Judging from the gravel diagram, it can be seen that there is an obvious bend at the third point, so the X-axis number corresponding to this point is the number of factors that should be retained, that is, three factors are retained.

3.4. Factor analysis

The following results are obtained through factor analysis. Factor 1 includes seven items X1, X2, X3, X4, X5, X6, X7, covering national fiscal and tax subsidy policies, national innovation support policies, national master plans, national strategic positioning for hydrogen energy, construction centralized management departments, the approval process and the nature of land belong to the category of macro factors, which are called policy factors in this article. Factor 2 contains seven items X14, X13, X15,
X18, X11, X17, X16, covering hydrogen source system, storage and transportation technology development, fuel cell vehicle technology, fuel cell vehicle ownership, hydrogen source supply, hydrogen price, construction costs and operating costs, etc., belong to the category of microscopic factors, this paper is called industry development factors. Factor 3 includes four items: X9, X8, X12, and X10, covering construction standards, technical standards, technical reserves of key components, and safety issues. It belongs to the category of micro-factors, which is called ontological factors in this paper.

Combining the respective cumulative variance contribution ratios of factor 1, factor 2, and factor 3, the total factor score expression can be obtained, that is, the weight expression of the systemic factors affecting the construction of hydrogen refueling stations is:

\[ Y = 0.329Y_1 + 0.423Y_2 + 0.248Y_3 \]

In terms of systemic influencing factors, industry development factors have a greater impact on the construction of hydrogen refueling stations, including upstream hydrogen source technology level, supply situation, price level, downstream fuel cell vehicle technology level, inventory situation, the resulting construction cost and operating costs. It mainly due to the fact that the construction unit takes profitability as the primary consideration in the initial stage of construction, and supply and demand factors are considered in the decision-making process, resulting in an increase in the weight of industry development factors. As a top-level design, policy factors have a strong guiding role in the construction of hydrogen refueling stations, and their influence is in the middle. Ontological factors are mainly considering technical standard issues, etc., which have the weakest impact on the construction of hydrogen refueling stations.

For the subdivision factors, through factor analysis, the final expression of the factors affecting the construction of hydrogen refueling stations is:

\[ Y = 0.05X_1 + 0.043X_2 + 0.048X_3 + 0.052X_4 + 0.05X_5 + 0.048X_6 
+ 0.038X_7 + 0.062X_8 + 0.062X_9 + 0.061X_{10} + 0.067X_{11} + 0.064X_{12} 
+ 0.062X_{13} + 0.058X_{14} + 0.062X_{15} + 0.052X_{16} + 0.061X_{17} + 0.062X_{18} \]

It can be seen from the above formula that at the level of subdivision factors, the development of hydrogen source production, storage, and transportation technology has the largest impact on the construction of hydrogen refueling stations. At present, there are still many technical bottlenecks in hydrogen source production, storage, and transportation technology, which seriously affect hydrogen station construction and product development. The impact of safety issues on the construction of hydrogen refueling stations ranks second. The state manages hydrogen as a hazardous chemical, and there are many restrictive factors such as safety and site selection. In addition, eight hydrogen energy standards, including Hydrogen Refueling Station Safety Technical Specifications, the Safety Technical Requirements for Hydrogen Storage Devices for Hydrogen Stations, the Management Regulations for the Safe Operation of Hydrogen Refueling Facilities for Hydrogen Energy Vehicles, and the Safety Test Methods for Low Pressure Hydrogen Storage Devices for Small Fuel Cell Vehicles, all involve hydrogen refueling stations, hydrogen storage and other fields. Safety occupies an important position in all standards, and safety issues have seriously affected the construction of hydrogen refueling stations.

4. Suggestions for the development of hydrogen refueling stations

4.1. Establishing a long-term mechanism for hydrogen source production, storage, and transportation technologies

Relying on universities and scientific research institutions, industry backbone enterprises jointly building national laboratories, national technology centers, national science and technology innovation centers and other institutions. Jointly carrying out research on key technologies related to hydrogen sources, establishing a knowledge sharing mechanism, and maximize the value of resources. Strengthening national and local support for key technology research and development and
industrialization. Setting up hydrogen energy demonstration zones in areas where conditions permit, and taking advantage of clusters to improve the overall efficiency of research and development. Strengthening international exchanges, implement hydrogen energy international scientific plans and major projects, and form an international collaboration mechanism.

4.2. Increasing policy subsidies and financial support for the entire industry chain of hydrogen refueling stations

Establishing a policy-driven and market-led parallel mechanism. Formulating the decision-making basis for investment demonstrations such as benchmark returns of hydrogen refueling stations throughout the industry chain, and gradually establishing scientific and reasonable subsidy policies. Gradually establishing a scientific and reasonable subsidy policy. The state should include hydrogen refueling stations in the infrastructure supported by the state, providing support through tax cuts and subsidies. At the same time, during the construction of hydrogen refueling stations, it is necessary to continuously expand investment and financing channels, encourage social capital to join, and form a diversified investment and financing system.

4.3. Improve safety supervision and technical standard system

The state should expedite the introduction of top-down management methods for key approval items such as safety evaluation, and establish safe and green approval channels for hydrogen refueling stations. It is necessary to accelerate the introduction of the national hydrogen energy standard system and improve the relevant standards for the design, construction and acceptance of hydrogen refueling stations. At the same time, the hydrogen refueling station is included in the urban planning considerations. Gradually establishing and improving the industrial access mechanism, hydrogen refueling station quality and safety evaluation system, and responsibility extension system.

5. Conclusion

This paper studies the influencing factors of hydrogen refueling station construction from the macro, meso, and micro levels, using factor analysis methods to analyze the influencing factors, and concludes that industry development factors have the greatest impact on the construction of hydrogen refueling stations. At the level of subdivision factors, the development of hydrogen source system, storage and transportation technology has the greatest influence on the construction of hydrogen refueling stations.

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