Research on Quality Evaluation of Customized Plank Furniture Based on the Entropy Weight-Analytical Hierarchy Process

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Abstract: Custom-made furniture is a product of the marketplace. At present, the concept of whole-house custom-made furniture has not been clearly defined. In the market, custom-made furniture for the whole house is mainly designated panel furniture. As the custom furniture market continues to expand, consumer complaints about custom furniture are increasing. However, there is no effective supervision model for the new decoration business of whole-house custom-made furniture. The market for customized furniture is constantly expanding. Under the current circumstances, the regulatory approach is difficult to implement effectively for a time. Faced with this transitional stage, this article proposes to evaluate the quality risk of custom-made furniture by means of evaluation. Combined with industry experts' discussion on consumer complaints and concerns, this article builds a customized furniture product quality evaluation system. According to the constructed quality evaluation system of customized furniture products, with the help of the basic theory of entropy weight method and analytic hierarchy process, determine the weight of each index. Finally, through empirical research, it is proved that this method has a strong operability for the quality evaluation of customized furniture.

1. Introduction

With people's continuous pursuit of quality life, the consumption of customized products in the home decoration industry has gradually increased. From the original questioning, to the wait-and-see, and then to becoming a trend, customized furniture shows the good development prospects of the decoration industry. Customized furniture belongs to a new decoration format spawned by the market. It is a comprehensive consumption model that integrates sales, installation, and after-sales service.

Compared with the concept of customized furniture, customized home has a broader meaning, including custom furniture, doors, walls, and floor tiles [1].

Customized furniture is the product of people's pursuit of personal life. With the continuous expansion of the sales market, the problems of customized furniture are also highlighted. First, the characteristics of individual customization make it difficult for each family to customize the quality, quantity, and specifications of products with a unified standard. At present, there is no specific national standard for customized furniture, which makes it difficult to monitor the market. Second, most of the customized furniture is composed of plank furniture. A weakness of plank furniture is the
use of large amounts of adhesive. Consumers pay more attention to the issue of harmful gas release after decoration. The main sources of harmful gases are adhesives, preservatives used in the processing of plates, etc. The third is that customized furniture is a customized product. After the customization is completed, consumers can experience the quality and service of the product [2-3]. In the decoration process, the quality of customized furniture is related to the quality of multiple manufacturers and decoration construction. Once the after-sales problem occurs, it is difficult for consumers to protect their rights.

At present, there is relatively little research on custom furniture. The more relevant is JZ / T1-2015 "Full House Customized Furniture Products". In 2017, China Furniture Association released the group standard T / CNFA 1-2017 "Customized Furniture". In 2018, Shanghai Chemical Building Materials Industry Association released T / 310101002-C011-2018 "Whole House Customized Wood (Made) Furniture". It can be seen that customized furniture is getting more and more important.

The research object of this article is the product quality of fixed plank customized furniture with wood as the main material. Because these products are the main concern of consumers, and are the core of customized furniture.

2. Quality analysis of customized furniture

2.1 Public opinion reports
Case 1: In September 2018, Chen Qi (pseudonym) of Yancheng complained that the doors of the custom-made study closet and bookcase had fallen after two years of use.

Case 2: In November 2017, Swedish furniture IKEA announced that it had recalled a total of 17.3 million Malm drawers in the United States and Canada. The cause of the incident was that a child was killed by falling over furniture.

Case 3: In March 2016, a 3-year-old child was knocked on the head by the sharp corner of the children's wardrobe after falling. The incident was due to the fact that the corner of the children's wardrobe was not rounded.

Case 4: A consumer in Yunnan complained that the customized furniture hinges had loosened after one month of use and the doors were not closed properly. The merchant only repaired and did not replace, and failed to solve the quality problem for several month.

2.2 Condition analysis
According to the online public opinion survey, the main risk sources of customized furniture are reflected in the following:

(1) Structural safety: Making full use of space is the main selling point of customized furniture. Sharp objects, protrusions, and high center of gravity of customized furniture are the main causes of physical injury.

(2) Chemical hazards: the release of harmful substances such as formaldehyde and TVOC, and the migration of heavy metals on the surface are the focus of consumers after home improvement.

(3) Product durability: The quality of hardware and connectors has a great influence on the durability of customized furniture products. Consumers complain that the quality of cabinet doors in custom furniture is closely related to the quality of hardware.

(4) Carrying capacity: Different households have different utilization rates of home improvement space. There is an inevitable positive relationship between the carrying capacity and the release of harmful substances from customized furniture. Controlling the carrying capacity of customized furniture is one of the effective ways to control chemical hazards.

(5) Assembly quality: The quality of customized furniture is closely related to the level of assembly service. The phenomenon of under-installation and missing installation of screws and hardware has a direct impact on the physical and chemical risks of customized furniture products.
3. Evaluation system of customized furniture quality

The product quality of customized furniture mainly includes four aspects: structural safety, chemical hazards, product durability, and after-sales service.

This article mainly combines the current national standards, industry conditions and consumer complaints to build a customized furniture quality evaluation index system, as shown in Table 1.

Table 1. Evaluation system for the quality of customized panel furniture

| Primary indicator       | Secondary indicator          | Indicator description                                                                                                                                 |
|------------------------|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| B1: Structural safety  | C1: centers of gravity       | The center of gravity should be kept stable to prevent tipping over and hitting people.                                                                  |
|                        | C2: Surface and edges        | The accessible surfaces and edges should be rounded. There are no burrs or beveled edges that can be touched.                                               |
|                        | C3: Tip                      | The accessible parts shall not have accessible sharp points.                                                                                           |
|                        | C4: obstructive              | Proper protrusions should be used to protect the parts that may cause physical damage.                                                                     |
| B2: Chemical hazard    | C5: Carrying capacity        | Carrying capacity directly affects the release of toxic and hazardous substances. The load-bearing rate of customized furniture in the room. However, there is no clear statement on the limit value of load-bearing rate in the furniture industry. |
|                        | C6: Edge banding technology of sheet metal | Effective sheet edge banding technology can effectively reduce the release rate of toxic and harmful substances. However, drilling holes during assembly will promote the release of toxic and harmful substances |
|                        | C7: "peculiar smell"         | A new focus of consumer complaints in recent years has been the "peculiar smell" of custom furniture throughout the house. At present, there is no clear answer to the ingredients and sources of "peculiar smell" generally reflected by consumers. |
|                        | C8: Paint film technology on the surface of customized furniture | Paint film technology has an impact on the migration of heavy metals in furniture surfaces.                                                                 |
|                        | C9: Product quality of adhesive used for decoration | In the decoration, if the adhesive uses MDI ecological adhesive, it will greatly reduce the release of toxic and harmful substances. Because MDI ecological adhesive is expensive, it is rarely used in the domestic decoration industry. |
| B3: Product durability  | C10: Product quality of plates | The wood of the product should be consistent with the product identification and quality card.                                                             |
|                        | C11: Product quality of hardware and connectors | The hardware and connectors should ensure that they are not cracked, loosened, or s |
This paper uses the method of AHP and entropy weight method to determine the index weight. The weights of the primary indicators are determined according to the method determined by AHP, and the weights of the second-level indicators are determined according to the entropy weight method.

4 Based on the entropy weight method to evaluate the quality of customized furniture

4.1 Basic theory of entropy weight method

The determination of the weight is crucial to the evaluation of the quality of customized furniture. This article introduces the basic theory of entropy weight method. The German physicist Claus introduced the concept of entropy for the formatting of the second law of thermodynamics, and later the concept of entropy was introduced into information theory[4]. In information theory, entropy is used to indicate the uncertainty of an accident. It is a measure of the disorder of information in the system. If the smaller the entropy value of the information, the greater the amount of information contained in the information, the greater the role of the information in the comprehensive evaluation, and the higher the weight[5]. The entropy weight method is a relatively objective weight calculation method. The steps of calculating weights by entropy weight method are as follows[6]:

(1) Data standardization
First, standardize the data of the calculation evaluation system. Assuming that there are k indicators \(X_1, X_2, X_3, \ldots, X_k\) \(: X_i = \{x_1, x_2, \ldots, x_n\}\). The standardized value of each indicator is \(Y_1, Y_2, Y_3, \ldots, Y_k\), then
\[
y_j = \frac{x_j - \min(x_j)}{\max(x_j) - \min(x_j)}.
\]

(2) Calculate information entropy
According to the definition of information entropy, information entropy is
\[
E_j = -\frac{1}{\ln(n)} \sum_{i=1}^{n} p_j \ln p_j .
\]
In the formula, \(p_j = \frac{y_j}{\sum y_j}\), if \(p_j = 0\), then define the information entropy is 0.

(3) Calculate the weight
The information entropy of each index is calculated as \(E_1, E_2, E_3, \ldots, E_k\). The weight of each indicator is:
\[
W_i = \frac{1 - E_i}{k - \sum E_i}.
\]

4.2. Empirical Research

This article takes the two-bedroom custom-made furniture for home as an example, and selects 5 sets of custom-made furniture that have been completed in the family house decoration. For 5 sets of examples, according to the established quality evaluation system of customized furniture products, the entropy weight method is used to calculate them. Thus, the final evaluation results of 5 sets of examples are obtained. Provide reference for consumers in the choice of customized furniture. Invite industry experts, decoration technicians, and consumers. A total of 11 experts at 3 levels will be compared with Table 1 to score 5 examples.
4.2.1 AHP determines the weight of first-level indicators. This paper constructs a judgment matrix to determine the primary indicators weight, as shown in Table 2.

Table 2. Judgment matrix and weight of the primary indicators relative to the overall goal

|   | B1 | B2 | B3 | B4 | Wi   |
|---|----|----|----|----|------|
| B1| 1  | 1/2| 3  | 6  | 0.3352 |
| B2| 2  | 1  | 2  | 7  | 0.4406 |
| B3| 1/3| 1/2| 1  | 4  | 0.1724 |
| B4| 1/6| 1/7| 1/4| 1  | 0.0518 |

Note: $\lambda_{\text{max}} = 4.1270$; CR=0.0476;

4.2.2 Entropy weight method to determine the weight of secondary indicators

Table 3. Scores of secondary indicators (C1, C2, C3, C4)

| Evaluation object | C1 | C2 | C3 | C4 |
|-------------------|----|----|----|----|
| A                 | 80 | 85 | 70 | 75 |
| B                 | 89 | 80 | 90 | 85 |
| C                 | 80 | 70 | 75 | 85 |
| D                 | 75 | 80 | 75 | 75 |
| E                 | 80 | 75 | 70 | 80 |

Use the basic theory of entropy weight method to determine the weights of C1, C2, C3 and C4. The initial scores in Table 3 are standardized, and the information entropy and weights of the four indicators are calculated and shown in Table 4.

Table 4. Information entropy and weight of secondary indicators (C1, C2, C3, C4)

| Secondary indicator | C1   | C2   | C3   | C4   |
|---------------------|------|------|------|------|
| Information entropy | 0.60 | 0.43 | 0.19 | 0.66 |
| Weights             | 0.19 | 0.27 | 0.38 | 0.16 |

Table 5. Scores of other secondary indicators (C5-C14)

| Evaluation object | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 |
|-------------------|----|----|----|----|----|-----|-----|-----|-----|-----|
| A                 | 80 | 85 | 70 | 88 | 75 | 85  | 80  | 80  | 80  | 75  |
| B                 | 70 | 85 | 75 | 85 | 70 | 80  | 85  | 78  | 85  | 85  |
| C                 | 80 | 90 | 70 | 85 | 75 | 85  | 78  | 78  | 90  | 80  |
| D                 | 75 | 85 | 76 | 83 | 68 | 80  | 80  | 80  | 80  | 65  |
| E                 | 65 | 83 | 70 | 80 | 70 | 80  | 75  | 80  | 70  | 65  |

Referring to Table 3 and Table 4, calculate Table 5 to obtain respective information entropy and weight statistics tables as shown in Table 6.

Table 6. Information entropy and weight of secondary indicators (C5-C14)

| Secondary indicators | C5 | C6 | C7 | C8 | C9 |
|----------------------|----|----|----|----|----|
| Information entropy  | 0.81| 0.74| 0.43| 0.83| 0.76|
| Weights              | 0.13| 0.18| 0.40| 0.12| 0.17|

| Secondary indicators | C10| C11| C12| C13| C14 |
|----------------------|----|----|----|----|-----|
| Information entropy  | 0.43| 0.80| 0.68| 0.83| 0.66|
| Weights              | 0.53| 0.18| 0.29| 0.33| 0.67|
According to the determined weights, the final scoring results of the second-level indicators in 5 examples are shown in Table 7.

**Table 7.** Evaluation results of each secondary indicator

| Secondary indicators | A  | B  | C  | D  | E  |
|----------------------|----|----|----|----|----|
| C1                   | 15.2 | 16.91 | 15.2 | 14.25 | 15.2 |
| C2                   | 22.95 | 21.6 | 18.9 | 21.6 | 20.25 |
| C3                   | 26.6 | 34.2 | 28.5 | 28.5 | 26.6 |
| C4                   | 12 | 13.6 | 13.6 | 12 | 12.8 |
| C5                   | 10.4 | 9.1 | 10.4 | 9.75 | 8.45 |
| C6                   | 15.3 | 15.3 | 16.2 | 15.3 | 14.94 |
| C7                   | 28 | 30 | 28 | 30.4 | 28 |
| C8                   | 10.56 | 10.2 | 10.2 | 9.96 | 9.6 |
| C9                   | 12.75 | 11.9 | 12.75 | 11.56 | 11.9 |
| C10                  | 45.05 | 42.4 | 45.05 | 42.4 | 42.4 |
| C11                  | 14.4 | 15.3 | 14.04 | 14.4 | 13.5 |
| C12                  | 23.2 | 22.62 | 22.62 | 23.2 | 23.2 |
| C13                  | 26.4 | 28.05 | 29.7 | 26.4 | 23.1 |
| C14                  | 50.25 | 56.95 | 53.6 | 43.55 | 43.55 |

According to the weight of the first-level indicators determined by AHP, the final score is shown in Table 8.

**Table 8.** Comprehensive evaluation results

|          | A  | B  | C  | D  | E  |
|----------|----|----|----|----|----|
| Total score | 77.9 | 80.9 | 78.1 | 76.9 | 74.3 |

It can be seen from Table 8 that the final scores of the five examples are 77.9, 80.9, 78.1, 76.9, and 74.3. Among them, the B comprehensive score is the highest.

5. Conclusion

Based on the analysis of the main risk sources of customized panel furniture, this paper builds an evaluation system for the quality of customized panel furniture. AHP and entropy weight method are used to determine the weight of each index. Through the operation of examples, the method is proved to be highly operable.

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