Research on Community Distribution Model Based on Structural Equation Model

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Abstract: Due to the increasing demand, community logistics has drawn the attention of the industry. Studying the community distribution model can not only reduce logistics costs, but also reduce resource consumption. Based on the structural equation model, this paper effectively combines the planned behavior theory model with the normative activation theory model, and joins the enterprise cost factor to construct a community distribution model, and effectively improves the customer satisfaction.

1. Introduction and research status

The community is the basic component of the city. Due to the rich and diverse needs, the community logistics has gradually attracted the attention of the industry. Studying the community distribution model can not only improve the logistics experience of consumers, but also reduce logistics costs and resource consumption to a certain extent.

Yang Juping (2014) [1] aimed to improve customer satisfaction. He proposed a scheme to save costs by reducing the number of failed delivery. Zhang Zhaobo (2015) [2] studied the robustness and cost sharing of the cabinets. Hu Zhijie, Guo Wenqian (2015) [3] through comparative research found that the cabinet is more feasible in community distribution.

Mikko Punakivi (2002) et al. [4] conducted a study on the feasibility of cabinets through comprehensive analysis of enterprise profitability and distribution service capabilities, and estimated the investment payback period. Lindner (2011) [5] analyzed the requirements involved in e-commerce distribution in a modeling, and proposed a scheme to improve efficiency and reduce costs. Ehmke (2014) et al. [6] believe that the efficiency of distribution has a profound impact on the success of online retailers, and provides specific solutions to improved distribution efficiency.

2. Introduction to related concepts

This paper uses structural equation modeling (SEM) to study consumer preferences for various distribution models. Structural Equation Modeling combines path analysis and factor analysis when exploring causal relationships and presents them in the form of path maps and causal models.

The measurement model can reflect the relationship between the hidden variable and the explicit variable, and the corresponding equation is the measurement equation. The specific expression is:

\[ Y = \Lambda_y \eta + \varepsilon \]  
\[ X = \Lambda_x \xi + \sigma \]
The structural model reflects the relationship between a hidden variable and a hidden variable, and the corresponding equation is called a structural equation. The expression for the structural equation is:

$$\eta = B\eta + \Gamma\xi + \zeta$$  \hspace{1cm} (3)

The Theory of Planned Behavior (TPB) reveals the process of how a researcher changes behavior patterns. And the Theory of Norm Activation (TNA) focuses on the impact of personal norms on other factors. This theory has been applied to the prediction and understanding of prosocial behavior or altruistic behavior [7].

3. Model construction and analysis

3.1. Quantitative analysis of influencing factors

How to reduce cost effectively is the goal that enterprises have been pursuing. Service quality is the soul of enterprise survival, logistics industry is no exception. Therefore, we selects the distribution cost and consumer preference as the influencing factors of community distribution, and analyzes them.

Since the distribution cost can be quantified by data, and the consumer's preference is a factor that is difficult to measure directly with the data, it needs to be quantified and then analyzed.

The research object is the college community. The questionnaire consists of three parts. The first part includes the basic situation of the respondents. The second and the third part are designed using the Likert 5 subscale and are the data source of this paper.

The sample size of most structural equation models is between 200 and 500 [8]. In this study, 300 questionnaires were distributed. After screening for effectiveness and completeness, 258 valid questionnaires were collected, accounting for 86%. The specific situation is shown in Table 1.

| Sample situation                     | Sample size | Ratio (%) |
|--------------------------------------|-------------|-----------|
| Gender                               |             |           |
| Male                                 | 119         | 46.12     |
| Female                               | 139         | 53.88     |
| Under 18                             | 27          | 10.47     |
| 19-22                                | 95          | 36.82     |
| 23-25                                | 130         | 50.39     |
| 26-27                                | 6           | 2.32      |
| Never online shopping                | 2           | 0.78      |
| Rarely online shopping               | 54          | 20.93     |
| Half a month                         | 99          | 38.37     |
| Once a week                          | 70          | 27.13     |
| Twice a week and above               | 33          | 12.79     |
| liberal arts                         | 102         | 39.53     |
| Science and Engineering              | 113         | 43.8      |
| Others                               | 43          | 16.67     |

The KMO value of 0.944 is suitable for factor analysis and the Bartlett spherical test is significant. The load of each standard factor is between 0.67 and 0.92, so the analysis will base on this index.

3.2. Model Construction of Consumers’ Preference for Distribution Mode

Although the influence of subjective norms on the results of TPB is not obvious, and personal norms are also covered in the TNA, there are significant differences between personal norms and subjective norms. In addition, according to the TNA, the awareness of responsibility is affected by the awareness of consequences. Based on this, the theoretical model diagram is shown in Figure 1.
The model evaluation and correction process is as follows: after importing the data in LISREL, generating the covariance matrix, verifying the rationality of the model by using the automatically generated grammar, and then generating the influence of each factor through the structural equation model. The process is similar to the verification factor analysis process. And can be continuously adjusted to the optimal model according to each parameter.

![Theoretical model diagram](image1)

**Fig. 1 Theoretical model diagram**

![Reduced Comprehensive Model of Consumer Choice Intention](image2)

**Fig. 2 The reduced Comprehensive Model of Consumer Choice Intention**

The final model is shown in Figure 3. And each parameter is significant at 95% confidence level. And the reduced conceptual model is shown in Figure 2.

![Comprehensive Model of Consumer Choice Intention](image3)

**Fig. 3 The Comprehensive Model of Consumer Choice Intention**

As can be seen from the above figure, there are both indirect and direct effects between variables, and the results of the effect are shown in Table 2.

| effect           | behavior attitude | subjective norm | perceived behavior control | personal norm | awareness of responsibility | awareness of consequence |
|------------------|-------------------|-----------------|----------------------------|---------------|-----------------------------|--------------------------|
| direct impact    | 0.35              | 0               | 0                          | 0.78          | -0.49                       | 0.27                     |
According to the data collected according to the question "whether the behavior is greatly influenced by objective environmental factors or individual internal factors", there are 132 persons who choose "individual internal factors", accounting for 0.511, and choosing objective environmental factors are 126 persons, accounting for 0.488. Taking it as the weight of TNA and TPB, after normalizing the total impact in Table 2, the weighted average method can be used to obtain the proportion of the consumer's preference for a certain distribution mode. The ratio of the self-lifting is 0.502, that is, the $\theta_1$ value is 0.502, and the $\theta_2$ value is 0.498.

3.3. Analysis of Enterprises’ Choice of Distribution Mode Based on Consumer Preference
Firstly, the quadratic exponential smoothing model is used to calculate the demand, and other parameters can be obtained by investigation.

The following is a rough summary of the daily consumer goods delivered by the company to the community within 10 months. The overall data movement is relatively stable, so the value is 0.6. To reduce the influence of the initial value, the average of the first three data is taken as the initial smoothed value, that is $S_0^{(1)} = S_0^{(2)} = 8670$, the calculation result of each data is as shown in Table 3.

| Observation period | Actual consumption | 0.6 | 0.6 | Relative error (%) |
|--------------------|--------------------|-----|-----|--------------------|
| 0                  |        | 8670 | 8670 |                |
| 1                  | 8567   | 8608.20 | 8632.92 | 0.77%   |
| 2                  | 8765   | 8702.28 | 8674.54 | 1.03%   |
| 3                  | 8678   | 8687.71 | 8682.44 | 0.05%   |
| 4                  | 8798   | 8753.88 | 8725.31 | 0.83%   |
| 5                  | 8921   | 8854.15 | 8802.62 | 1.33%   |
| 6                  | 9276   | 9107.26 | 8985.40 | 3.13%   |
| 7                  | 8945   | 9009.90 | 9000.10 | 0.62%   |
| 8                  | 8887   | 8936.16 | 8961.74 | 0.84%   |
| 9                  | 9067   | 9014.66 | 8993.49 | 0.81%   |
| 10                 | 9104   | 9068.27 | 9038.36 | 0.72%   |

The relative error of the quadratic exponential smoothing model is 0.84%, so $a_t$ and $b_t$ can continue to be solved.

$$a_t = 2S_t^{(1)} - S_t^{(2)} = 2*9068.27 - 9038.36 = 9098.17$$

$$b_t = (\alpha / (1 - \alpha)) (S_t^{(1)} - S_t^{(2)}) = 0.6/0.4 * (9068.27-9038.36) = 44.86$$

Then the prediction model is $y_{t+T} = a_t + b_T T = 9098.17 + 44.86 T$

Based on this, the demand for the next month can be calculated to be 9143, which is $Q = 9143$.

3.3.1. Cost composition of different delivery modes. The cost of self-lifting mode is:

$$C_1 = R + mf + (w + t\gamma)Q + (1-t)T + (1-\theta_1)Q\tau$$

(4)

The cost of home delivery mode is:
\[ C_2 = R + mf + wQ + (1 - \theta_1)Q\tau \] (5)

Among them, the total cost of the self-lifting mode is \( C_1 \), the total cost of home delivery is \( C_2 \), the cost of the delivery operation is \( R \), the number of employees required for the delivery operation is \( m \), the basic salary of the delivery employee is \( f \), the one-piece commission of the delivery employee is \( w \), and the total quantity of the goods delivered is \( Q \). \( \theta_1 \) represents the ratio of distribution quantity in the self-lifting mode, and the ratio of distribution quantity in the home delivery mode is \( \theta_2 \). \( \tau \) indicating the loss rate of the consumer. Use \( T \) to indicate the fixed cost of establishing a self-lifting point, and \( \gamma \) indicate the fee paid to other partners. When the self-lifting point is established, the value of \( t \) is 0; otherwise the value of \( t \) is 1.

If the enterprise only provides two modes of self-lifting and home delivery, the total cost is:

\[ C = qC_1 + pC_2 \] (6)

The cost of company distributes completely according to consumer preferences is:

\[ C_0 = R + (m_1 + m_2)f + (\theta_1(w_1 + t\gamma) + \theta_2w_2)Q + (1 - t)T \] (7)

The symbols in this formula are consistent with the above definitions, subscript 1 represents the self-lifting mode, and subscript 2 represents the home delivery mode. \( q \) represents the proportion of self-lifting, and \( p \) represents the proportion of the home delivery.

According to the research and analysis results, the parameter values of this paper are shown in Table 4.

Table 4 The description of Model Indexes setting

| Parameter                        | Parameter value |
|----------------------------------|-----------------|
| Management costs \( R \)         | 1250            |
| employee count \( m_1 \)         | 2               |
| employee count \( m_2 \)         | 1               |
| Basic salary of employees \( f \) | 2000            |
| One-piece commission \( w_1 \)   | 0.5             |
| One-piece commission \( w_2 \)   | 1.5             |
| The proportion of self-raised quantity to total distribution \( \theta_1 \) | 0.502 |
| Delivery to the door to the total amount of distribution \( \theta_2 \) | 0.498 |
| Total quantity of goods \( Q \)   | 9143            |
| Other participants' commission \( \gamma \) | 0.5 |
| Loss rate \( \tau \)              | 0.25            |
| other fee \( T \)                | 5000            |

Taking the S enterprise as the background, combined with the corresponding parameter settings above and the formula (4)–(7), \( t=0 \) represents the establishment of the self-raising point, and \( t=1 \) represents using the cabinet or cooperation with the third party. The results were shown in Table 5.

Table 5 Cost Results

| Parameter                  | Parameter value | Parameter                  | Parameter value |
|----------------------------|-----------------|----------------------------|-----------------|
| Cost of home delivery mode | 16659.8         | Cost of home delivery mode | 16659.8         |
| Self-lifting mode cost     | 18011.9         | Self-lifting mode cost     | 18374.7         |
Cost calculated according to consumer preferences 17450.7 Cost calculated according to consumer preferences 17351.5

3.3.2. Process analysis. This paper believes that the services of different distribution modes are optimal, so the distribution mode will become the key to customer satisfaction. By assigning (6) and (7) formulas, the percentage difference between the two costs, as well as the actual distribution and the preferred distribution is obtained, and see it as the consumer satisfaction.

(1) The analysis process of establishing the self-lifting point as follows:

This paper selects the cost gap of 3% as an acceptable range. From the first point that meets the requirements, gradually use the formula \( (C_i - C_{i+1})/C_i \) \((i = 1, 2, \ldots, n)\) and \( (q_i - q_{i+1})/q_i \) \((i = 1, 2, \ldots, n)\) calculates the satisfaction improvement and cost savings of the neighboring points. Accurate to one place after the decimal point, and the comparison result is shown in Fig. 4. For the convenience of display, the satisfaction value plotted in the figure has been reduced by 90%.

As can be seen from Figure 4, the cost starts to grow steadily at 48.1%, that is, the increase is larger and larger, and the satisfaction reaches a small peak of growth here, which can be considered more satisfactory. The cost gap at this point is 1.27%, consumer satisfaction is 95.2%, and the self-lifting is 48.1%, the home delivery rate is 51.9%.

(2) The process of using cabinet or cooperation with the third-party collection platform as follows:

Similarly, the cost gap is 3% for the acceptable range, and the satisfaction value is reduced by 90%. The comparison result is plotted in Figure 5.

As can be seen from Figure 5, the cost gap is small at 53.0%, but will gradually increase thereafter, the satisfaction is higher here, and then gradually decreases, which is considered to be more satisfactory.
The cost gap at this point is 1.37%, consumer satisfaction is 97.2%, and the self-lifting is 53.0%, the ratio of home delivery is 47.0%.

In summary, the ratio and cost, as well as consumer satisfaction, can be obtained. The results are shown in Table 6. According to this result, it can be considered that the company can achieve a good balance between cost and satisfaction.

| Variable                              | t=0          | Variable                              | t=1          |
|---------------------------------------|--------------|---------------------------------------|--------------|
| Cost calculated according to consumer preferences | 17450.7      | Cost calculated according to consumer preferences | 17351.5      |
| Final cost                            | 17227.5      | Final cost                            | 17031.6      |
| Self-lifting ratio                    | 48.1%        | Self-lifting ratio                    | 53.0%        |
| home delivery ratio                   | 51.9%        | home delivery ratio                   | 47.0%        |
| Consumer satisfaction                 | 95.2%        | Consumer satisfaction                 | 97.2%        |

4. Conclusion
It can be seen from the above that the satisfaction of distribution according to consumer preference is the highest, but the actual distribution is not completely based on this ratio. But it can be regarded as the ultimate goal, seeking a balance between reducing costs and improving satisfaction. However, the results of this paper are based on the above parameter values. If the parameter values are changed, the optimal distribution ratio will also change. Therefore, specific analysis is needed.

This paper is based on the empirical analysis of S companies and college communities, and roughly estimates the relevant costs, so the limitations of the results need to be known. However, this method can be used as a reference. After analyzing the distribution community, determining its preference for the distribution model can help the company to improve its customer satisfaction and reduce costs.

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