Motorbike Courier’s Performance Evaluation in Real-time Distribution Industry Based on the Hesitant Fuzzy Linguistic PROMETHEE Method

Lizhong Tong and Jiajia Yi

ABSTRACT

The rapid development of the Internet and the accelerated pace of people’s lives have gradually changed people’s consuming habit, which also contribute to the development of Real-time Distribution Industry. Real-time delivery differs from traditional service- Instead of long distances, this industry often serves customers within 5km. The delivery is carried out by motorbike couriers which requires striking a good balance between speedy on time delivery without endangering public safety. Unfortunately, when it comes into courier performance evaluation, currently the majority of the industry heavily emphasize on improving business operation efficiency and pretty much ignore the problems with public safety. Such attitude is reflected on the large amount of quantitative research and evaluating methods on the subject. While qualitative research with regard to ensuring public safety was few and far between. This paper seeks to readdress this current imbalance by adopting a sustainable development approach as a research perspective. Its aim was to create a new performance evaluation system by taking social public safety into account. Under the new system, couriers are measured under five dimensions: “service performance”, ”safety assurance”, “health awareness”, “work attitude” and “business skills”. The paper then adopts the Hesitant Fuzzy Linguistic PROMETHEE Method to rank and sort the performance of each motorbike courier. Finally, through the empirical analysis of the M take-out platform, it provides important application value for the sustainable development of the motorbike courier’s performance evaluation problem for the Real-time Distribution Industry.
1. INTRODUCTION

Driven by the rise of the Internet, Real-time Distribution Industry has become a booming industry. Delivery motorbike couriers can be seen in streets and alleys. However, during the delivery process, illegal activities such as reverse driving, speeding, running red lights are common. In January 2019, there were 10033 traffic accidents involving Express, take-away and other distribution industry in Shanghai-causing 68 deaths and 1134 injuries. The situations in other cities are similar. As this industry often requires motorbike couriers to deliver things to customers as soon as possible, most couriers’ performance evaluation and salaries are solely based on the amount of orders delivered on time. Such one-sided performance evaluation mechanism simply encourages couriers to neglect traffic safety. The situation has become so bad that it has not only become a public nuisance, but also a public hazard that requires heavy government regulations. In turn, this would have a negative impact on the future sustainable development for the industry. Therefore, it is necessary to establish a scientific, rationalized and comprehensive performance evaluation system for the motorbike couriers in Real-time Distribution Industry. At present, researches on performance evaluation system are mainly focused on employees in traditional industries: such as teaching, medical care, restaurant service et al, and most of them are focused on how to improve business efficiencies.

Employees can be assessed through various performance appraisal system whose indicators can be qualitative or quantitative. The most important thing is that each indicator should be fair, reliable and objective. For example, in the healthcare industry, Nasrin assesses nurse performance in terms of professionalism, knowledge, clinical and communication skills, and job performance. [1,2] In the education industry, Jeng-Fung Chen evaluates university teachers from the aspects of teaching plan and preparation, communication and interaction, learning environment management, student satisfaction, learning and development and teaching summary. [3,4] In the information technology industry, the evaluation criteria mainly measure on the level of knowledge, adaptability to testing new tools and technologies, good communication skills, and ability to deal with problems. [5] For the pursuit of fair and honest positions such as prosecutors and lawyers, the assessment of employees generally evaluate performance, ethics, professional skills, legal theory, work attitude and work style. [6]

Due to its complex, multi-criteria, and unstructured nature, performance appraisal is considered a multi-criteria decision (MCDM) problem. [7] There are many ways to solve such problems. Some scholars use the Analytic Hierarchy Process (AHP) to evaluate the performance of clinical nurses and teachers. [8, 9, 10] The evaluation results can more objectively reflect the quality of service of the evaluation object. There are also scholars who use the ANP-Fuzzy method to conduct performance appraisal for power company employees. Such a combined approach is highly operational in performance evaluation. [11, 12] However, they all have certain limitations in solving multi-objective decision problems under
ambiguous situations. Differs from the methods above, the Hesitant Fuzzy Linguistic PROMETHEE Method [13] can convert fuzzy evaluation information into quantitative evaluation values and this is proposed by Liao et al. This has been successfully applied in the evaluation of wine brands and has been recognized by the academic community already.

2. CRITERIA FRAMEWORK

With developing a new sustainable performance evaluation appraisal system for the real-time distribution industry as its ultimate goal, this paper first establishes 16 qualitative and quantitative indicators from 5 key areas. These 5 key areas are “service performance”, “safety assurance”, “health awareness”, “work attitude”, and “business skills”. Based on existing literature and through rigorous expert panel discussion, 46 relevant indicators were chosen for the preliminary research. These 46 indicators were then incorporated into a questionnaire which was subsequently completed by 200 people working within the industry. The samplers were drawn from all walks of life within the trade. They include corporate executives, takeaway motorbike couriers, and traffic control workers. To increase the validity of our samples, different types of business such as catering, retailers or new take away delivery services are included. After data integration and filtering, we incorporate the best 16 indicators into our new evaluation system, which is shown in Table 1. The new appraisal system was then tested and validated with a case study. The materials and methods section should contain sufficient detail so that all procedures can be repeated. It may be divided into headed subsections if several methods are described.

| TABLE I. MOTORBIKE COURIER’S PERFORMANCE EVALUATION SYSTEM FOR THE SUSTAINABLE DEVELOPMENT OF THE REAL-TIME DISTRIBUTION INDUSTRY. |
| --- | --- | --- | --- |
| **Aim** | **Indicator** | **Sub-indicator** | **Definitions** |
| Motorbike Courier’s Performance Evaluation System for the sustainable development of the Real-time Distribution Industry | Delivery order quantity C1 | Total numbers of delivery orders |
| | On-time delivery rate C2 | On - time delivery orders accounted for the proportion of the total number of orders |
| | Customer satisfaction C3 | The proportion of good customer comments to total comments |
| | Number of customer complaints C4 | Total numbers of reports from customers who are dissatisfied with the |
| Criteria                        | Description                                      |
|--------------------------------|--------------------------------------------------|
| Safety Assurance B2            |                                                  |
| Delivery error ratio C5        | The proportion of the number of incorrect delivery orders to the total number of orders |
| Traffic safety awareness C6    | Motorbike Courier’s traffic safety knowledge level |
| The accident rate C7           | Number of violations of the Motorbike Courier    |
| Motor vehicle driving years C8 | Motorbike Courier’s driving level                |
| Health Awareness B3            |                                                  |
| Health certificate C9          | Motorbike Courier’s health level                 |
| Distribute container cleanliness C10 | Cleanliness of distribution containers          |
| Personal image C11            | Cleanliness of work clothes, hair style and nails |
| Work Attitude B4               |                                                  |
| The sense of responsibility C12| Attendance, initiative and responsibility        |
| Real-time contact C13          | Whether can contact at any time during working    |
| Business familiarity C14       | Familiarity with operation procedure and route of responsible area |
| Business Skills B5             |                                                  |
| Communication skills C15       | Ability to communicate accurately and timely with customers, superiors, etc. |
| Learning and innovation ability C16 | Ability to quickly improve through training or self-study |

3. RESEARCH METHOD

Liao et al. [13] proposed the hesitant fuzzy linguistic PROMETHEE method for multiple criteria decision making by introducing the hesitant fuzzy linguistic set theory and improves the preference function. This improved method is commonly used to describe and deal with evaluation and decision-making issues in complex qualitative information environments. It can convert fuzzy evaluation information into quantitative evaluation values. This has been successfully applied in the evaluation of wine brands and has been recognized by the academic community already. This paper uses the hesitant fuzzy linguistic PROMETHEE method to
evaluate the performance of motorbike couriers in the real-time distribution industry.

There are m experts (represented by D), n criteria (represented by B), and 1 scheme (represented by E), which have the following 7 steps:

**Step 1:** Determine the language term set \( S' \) for indicator importance assessment and the set of language terms \( S \) for the performance evaluation of each scheme under each criterion. Invite experts to make an assessment and construct the hesitation fuzzy language index importance evaluation matrix \( H_{S'} \) and the scheme criterion performance evaluation matrix \( H_S \).

\[
H_{S'} = \left( \begin{array}{ccc}
D_1B_1 & \cdots & D_1B_n \\
\vdots & \ddots & \vdots \\
D_mB_1 & \cdots & D_mB_n 
\end{array} \right) ; \quad H_S = \left( \begin{array}{ccc}
E_1B_1 & \cdots & E_1B_n \\
\vdots & \ddots & \vdots \\
E_lB_1 & \cdots & E_lB_n 
\end{array} \right)
\]

**Step 2:** Determine the weight value of each criterion based on \( H_{S'} \). Among them, \( 0 \leq \omega \leq 1 \) and \( \sum_{j=1}^{n} \omega_j = 1 \).

\[
\omega = \{\omega_1, \omega_2, \omega_3 \ldots \omega_n\}^T ;
\]

**Step 3:** According to \( H_S \), determine the positive ideal solution \( A^+_n \) and the negative ideal solution \( A^-_n \) under the criterion \( B_n \), and calculate the dispersion \( d_n(A^+_n, A^-_n) \).

\[
A^+ = \{A^+_1, A^+_2 \ldots A^+_n\} \quad A^- = \{A^-_1, A^-_2 \ldots A^-_n\}
\]

**Step 4:** Determine preference function. Under the positive and negative attribute \( B_j \), the degree to which the scheme \( E_i \) is better than \( E_k \) is represented by the preference function. The improved linear criterion preference function is shown below, \( i, k = 1, 2, \ldots, l ; j = 1, 2, \ldots, n \).

\[
P_j(E_i, E_k) = \begin{cases} 
0, & d_j(E_i, E_k) \leq 0 \\
\frac{d_j(E_i, E_k)}{\theta d_j(A^+_j, A^-_j)}, & 0 < d_j(E_i, E_k) \leq \theta d_j(A^+_j, A^-_j) \\
1, & d_j(E_i, E_k) > \theta d_j(A^+_j, A^-_j)
\end{cases}
\]  \quad (1)

**Step 5:** Determine the prioritization index \( \pi(E_i, E_k) \). The priority index indicates the degree to which the scheme \( E_i \) is better than the scheme \( E_k \). The closer it is to 1, the better the superiority of the scheme \( E_i \). \( i = 1, 2, \ldots, l ; j = 1, 2, \ldots, n \).

\[
\pi(E_i, E_k) = \sum_{j=1}^{n} \omega_j P_j(E_i, E_k)
\]  \quad (2)

**Step 6:** According to the priority index, calculate the inflow \( \phi^+(E_i) \) and the outflow \( \phi^-(E_i) \) of each scheme.

\[
\phi^+(E_i) = \sum_{k=1}^{l} \pi(E_i, E_k) \quad \phi^-(E_i) = \sum_{l=1}^{i} \pi(E_k, E_l)
\]  \quad (3)

Among them, \( j = 1, 2, \ldots, n ; i, k = 1, 2, \ldots, l \). \( \phi^+(E_i) \) indicates the extent to which \( E_i \) is superior to other schemes. The larger the value, the higher the superiority of \( E_i \) relative to other schemes. \( \phi^-(E_i) \) indicates the possibility that
other schemes are better than scheme $E_i$. The smaller the value, the higher the superiority of the scheme $E_i$ relative to other schemes.

**Step 7:** Calculate the net flow of the scheme $E_i$.

\[
\phi(E_i) = \phi^+(E_i) - \phi^-(E_i)
\]  

(5)

When the value of $\phi(E_i)$ is larger, it indicates that the scheme is better. If $\phi(E_i) > \phi(E_k)$, the scheme $E_i$ is better than the scheme $E_k$. So on and so forth, we can get the sort of available solutions.

4. Case Study

From our questionnaire, we had found out that three of the most common indicators that the industry value and fits into most cases are short distances, high frequencies and sensitive to uneven ordering time. As a catering take away business fits into all these three criteria, we have chosen the M-take out platform drives as a real case study to test and validate our new performance evaluation under the hesitant fuzzy linguistic PROMETHEE method.

4.1 Motorbike Couriers’ Performance Evaluation System for Takeaway Platform

According to the criteria determined in Table 1, for easy understanding and analysis, this paper selects five first-level indicators in our case study. This includes service performance (B1), safety assurance (B2), health (B3), work attitude (B4) and business skills (B5). These five indicators are all positive indicators. It then randomly selects the evaluation index data from four couriers in C city, a hesitant fuzzy linguistic PROMETHEE method for performance evaluation and ranking are then applied in these cases. The hierarchical structure of the decision problems is shown in Figure 1.
4.2 The Application of Hesitant Fuzzy Linguistic PROMETHEE Method

**Step 1:** In this paper, the language term set $S'$ for the evaluation of the importance of the five indicators can be expressed as $S' = \{ s'_0 = \text{Very Low}, s'_1 = \text{Low}, s'_2 = \text{Relatively Low}, s'_3 = \text{Medium}, s'_4 = \text{Relatively High}, s'_5 = \text{High}, s'_6 = \text{Very High} \}$. The set of language terms $S$ for each evaluation object to be evaluated under each indicator can be expressed as $S = \{ s_0 = \text{Very Poor}, s_1 = \text{Poor}, s_2 = \text{Relatively Poor}, s_3 = \text{Medium}, s_4 = \text{Relatively Good}, s_5 = \text{Good}, s_6 = \text{Very Good} \}$.

In order to obtain a more reasonable and effective evaluation result, a further questionnaire was sent to 4 experts for investigation. The four experts D1, D2, D3, and D4 are from the human resources management department, marketing department, operation department, and motorbike couriers management department of M takeaway platform. They assessed the importance of the indicator and the performance of the four couriers s E1, E2, E3, E4 in the region. And the hesitant fuzzy language evaluation matrix of the importance of evaluating indicators ($H_{S'}$) and each motorbike courier’s performance per indicator ($H_S$) were constructed, as shown below:

$$H_{S'} = \begin{bmatrix}
S_6 & S_6 & S_4 & S_5 & S_2 \\
S_5 & S_6 & S_3 & S_4 & S_3 \\
S_6 & S_5 & S_3 & S_5 & S_2 \\
S_6 & S_5 & S_6 & S_4 & S_4 \\
\end{bmatrix}.$$ 

$$H_S = \begin{bmatrix}
\{s_4\} & \{s_4, s_5\} & \{s_3, s_5\} & \{s_4, s_5\} & \{s_2, s_3\} \\
\{s_6\} & \{s_1, s_2, s_4\} & \{s_5\} & \{s_5, s_6\} & \{s_3, s_5\} \\
\{s_3\} & \{s_5\} & \{s_5, s_6\} & \{s_3, s_5, s_6\} & \{s_3, s_4, s_5\} \\
\{s_4\} & \{s_3, s_5\} & \{s_4, s_5\} & \{s_4\} & \{s_3, s_4\} \\
\end{bmatrix}.$$
Step 2: Because the level of knowledge of the four experts is comparable, in order to determine the weight of the indicator, we used the arithmetic mean. According to $H_{S'}$, the weights of the five indicators of service performance (B1), security (B2), health (B3), work attitude (B4), and business skills (B5) are as follows:

$$\omega = (0.26, 0.24, 0.18, 0.20, 0.12)^T$$

Step 3: Determining the positive ideal solution $A^+ = \{s_6, s_5, s_6, s_6, s_5\}$ and negative ideal solution $A^- = \{s_3, s_1, s_3, s_3, s_2\}$. These five indicators are all positive indicators. Calculate the dispersion $d_j(A_j^+, A_j^-)$ between the positive ideal solution $A^+$ and the negative ideal solution $A^-$ of the hesitant fuzzy language, as shown in the Table II:

| $B_i$ | $A^+$ | $A^-$ | $d_j(A_j^+, A_j^-)$ |
|------|------|------|-----------------|
| $B_1$ | $s_6$ | $s_3$ | 3               |
| $B_2$ | $s_5$ | $s_1$ | 4               |
| $B_3$ | $s_6$ | $s_3$ | 3               |
| $B_4$ | $s_6$ | $s_3$ | 3               |
| $B_5$ | $s_5$ | $s_2$ | 3               |

Step 4: Further determine the preference function, according to the needs of the decision facts and the investor's preference for strict superiority, take $\theta = 0.6$. Under the positive indicator $B_i$, the degree to which the courier $E_i$ ($i = 1, 2, 3, 4$) is better than the other courier $E_k$ ($k = 1, 2, 3, 4$) is calculated by the improved linear criterion preference function. The results are shown in the Table III:

| $P_j(E_1, E_2)$ | $B_1$ | $B_2$ | $B_3$ | $B_4$ | $B_5$ |
|-----------------|------|------|------|------|------|
| $P_j(E_1, E_3)$ | 0    | 11/12| 0    | 0    | 0    |
| $P_j(E_2, E_1)$ | 5/9  | 0    | 0    | 0    | 0    |
| $P_j(E_2, E_3)$ | 0    | 5/24 | 0    | 5/18 | 0    |
| $P_j(E_3, E_1)$ | 1    | 0    | 5/9  | 5/9  | 5/6  |
| $P_j(E_3, E_2)$ | 1    | 0    | 0    | 4/9  | 0    |
| $P_j(E_3, E_4)$ | 1    | 0    | 5/18 | 5/6  | 5/18 |
| $P_j(E_4, E_1)$ | 0    | 5/24 | 5/6  | 1/9  | 5/6  |
| $P_j(E_4, E_2)$ | 0    | 1    | 5/18 | 0    | 0    |
| $P_j(E_4, E_3)$ | 0    | 5/12 | 5/9  | 7/18 | 5/18 |
| $P_j(E_4, E_4)$ | 0    | 0    | 5/18 | 0    | 5/9  |
| $P_j(E_5, E_1)$ | 0    | 17/24| 0    | 0    | 0    |
| $P_j(E_5, E_2)$ | 5/9  | 0    | 0    | 0    | 0    |
Step 5: According to formula (2), the calculation of the priority index can be obtained, as shown in the Table IV:

| $\pi(E_1, E_2)$ | $\pi(E_1, E_3)$ | $\pi(E_1, E_4)$ | $\pi(E_2, E_3)$ | $\pi(E_2, E_4)$ | $\pi(E_3, E_4)$ |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 0.22            | 0.14            | 0.11            | 0.57            | 0.35            | 0.51            |
| 0.57            | 0.29            | 0.31            | 0.32            | 0.17            | 0.14            |
| 0.12            | 0.17            | 0.14            |                  |                  |                  |

Step 6: According to the formulas (3) and (4), calculate the inflow $\phi^+(E_i)$ and the outflow $\phi^-(E_i)$ of each scheme (rider).

- $\phi^+(E_1) = 0.47$, $\phi^+(E_2) = 1.43$, $\phi^+(E_3) = 0.92$, $\phi^+(E_4) = 0.43$,
- $\phi^-(E_1) = 1.01$, $\phi^-(E_2) = 0.68$, $\phi^-(E_3) = 0.63$, $\phi^-(E_4) = 0.93$.

Step 7: According to formula (5), calculate the net flow of each courier and get: $\phi(E_1) = -0.54$, $\phi(E_2) = 0.75$, $\phi(E_3) = 0.29$, $\phi(E_4) = -0.5$. It can be seen that the performance evaluation of the four riders is $E_2 > E_3 > E_4 > E_1$.

4.3 Sensitivity analysis

The purpose of the sensitivity analysis is to consider what happens to the performance evaluation ranking of motorbike couriers when we choose different decision makers or different indicators. Because uncertainties might arise and this would affect the final rankings, it is necessary to carry out a sensitivity analysis to ensure data validities. The analysis was performed through nine experiments: e.g., the standard weights in the proposed model indicators were changed and the ranking of the alternatives was observed. The details are shown in the table V. For example, in the sixth experiment, only service performance (B1) and decision makers (D1, D2, D3, D4) were considered. According to this sensitivity analysis, changing the fuzzy weight will change the overall ranking of the fuzzy takeaway rider. Although the ordering of different motorbike couriers has changed based on different standards, E2 is usually chosen as the best rider. Therefore, it can be concluded that the method is robust and the decision process is occasionally sensitive to standard weights. In addition, because the decision-making process is sensitive to the type of standards, the number of experts, and their professional judgment on the standards, they should be carefully chosen when making decisions.
TABLE V. SENSITIVITY ANALYSIS.

| Condition          | Decision Criteria | DS   | Rank          |
|--------------------|-------------------|------|---------------|
| Initial Condition  | B1, B2, B3, B4, B5| D1, D2, D3, D4 | $E_2 > E_3 > E_4 > E_1$ |
| 1                  | B1, B2, B3, B4, B5| D1, D2, D3 | $E_2 > E_3 > E_1 > E_4$ |
| 2                  | B1, B2, B3, B4, B5| D1   | $E_2 > E_3 > E_1 = E_4$ |
| 3                  | B1, B2, B3, B4, B5| D2   | $E_2 > E_3 > E_4 > E_1$ |
| 4                  | B1, B2, B3, B4, B5| D3   | $E_2 > E_3 > E_1 > E_4$ |
| 5                  | B1, B2, B3, B4, B5| D4   | $E_3 > E_2 > E_4 > E_1$ |
| 6                  | B1, B2, B3, B4    | D1, D2, D3, D4 | $E_2 > E_3 > E_1 > E_4$ |
| 7                  | B1, B2, B3        | D1, D2, D3, D4 | $E_2 > E_3 > E_1 > E_4$ |
| 8                  | B1, B2            | D1, D2, D3, D4 | $E_2 > E_1 > E_4 > E_3$ |
| 9                  | B1                | D1, D2, D3, D4 | $E_2 > E_1 = E_4 > E_3$ |

5. RESEARCH CONCLUSIONS

From a sustainable development point of view, when it comes to the evaluation of courier in the real-time distribution industry, this paper suggests the following points should be observed:

(1) From a sustainable development perspective, the real-time distribution industry should not solely use financial indicators and business efficiencies as means of evaluating their courier performances. Non-financial social indicators that had an impact on the society should also be taken into account. In other words, enterprises should reward motorbike courier with excellent performance in overall evaluation. On the other hand, reckless motorbike couriers who were obsessed with achieving business sales targets and putting others safety at risk should be given a certain penalty or even fired in extreme cases. The government ought to do more to persuade and educate stakeholder in the industry that it is in their best business interest to adopt a sustainable approach as a means of growth in the future.

(2) Traditional general evaluation tools in other industries are inadequate to meet needs of the real-time industry. More emphasis and indicators such as the courier’s familiarity with local routes, call answering ability and quality of services should be included during evaluation. These problems have been subsequently addressed by the devised new method in this paper.

(3) This paper applies the Hesitant Fuzzy Linguistic PROMETHEE Method. On one hand, by offering new quantifiable benchmarks which were previously difficult to quantify with traditional methods. It helps and encourage enterprises to evaluate their couriers in a responsible manner that are both concretely achievable and beneficial to the society and industry in the long run.

(4) The new sustainable evaluation method devised by this paper are not only limited to the Real-time Distribution Industry, but can also be applied to other
offline distribution and logistical enterprises. This new method is robust and flexible enough for other companies to adjust and twitch the evaluation indicators to suit the needs in their particular field. In such way, society and enterprises can growth sustainably in the future.

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