Quotation Strategies of Non-Truck Operating Common Carrier Based on Multivariate Statistical Regression and Triple Pricing Model

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Abstract. Combined with the existing transaction orders of carless carriers, the numerical information and text information are extracted, and the related factors of line guide price are integrated, and the relationship between relevant factors and line guide price is studied. Using the unified unit and 0-1 text setting method, preprocessing data, eliminating the influence of numerical units, quantifying textual data, so that the data can be put into the relevant equations for testing. According to the characterization relationship between the guiding price and factors, a multivariate linear statistical regression model was established, and the statistical P value was used for testing to verify the availability of the model. The index of price overflow rate and equilibrium degree are put forward as the standard to evaluate whether the transaction price of an order is reasonable. The normal distribution of orders can be verified by looking at the scatter plot of the cumulative percentage of transactions and the price spillover rate of orders. According to the central limit theorem of large sample data with normal distribution, the sample can be sampled in sections and the summation can be taken as the transaction probability. According to the operation mode of the vehicle-free carrier platform, the transaction mode of three quotations is added to re-quote the line. The pricing obtained from multiple linear statistical regression is used as the benchmark, and the dynamic pricing strategy is re-customized according to the principle of the first quotation giving priority to lowering the price, the second quotation giving priority to stabilizing the transaction, and the third quotation giving priority to the success rate. The sensitivity analysis shows that the platform can get a revenue increase of 33\%--48\% based on this new pricing strategy, and meanwhile improve the balance and stability of orders. The research report provides a calculation method of a new quotation model with high turnover rate and stable income for the non-truck operating common carrier platform, and has a guiding significance for the construction of the non-truck operating common carrier trading system, especially the rationality of the price formulation and the stability of the transaction order quantity.

1. Introduction
In fact, the history of "car-free carrier" in China can be traced back to 2013, when the relevant documents issued by the Ministry of Transport mentioned the concept and intended to launch the policy of car-free
carrier. By 2015, the development of the Internet has made a qualitative leap, and the car-free carrier has naturally become a new business opportunity for the combination of logistics industry and network technology. In 2016, the key policy "Opinions on Promoting Reform Pilot and Accelerating Innovative Development of Carless Logistics" was implemented, and carless carriers became the outlet for entrepreneurship. Only in 2017, the number of car-free carrier enterprises officially established has reached nearly 300. Since the opening of the domestic road transportation market, the non-truck transportation market has gradually formed a "small, scattered, chaotic" development status. In order to standardize the transportation market, the General Office of the Ministry of Transport issued the Opinions on Promoting the Reform Trial and Accelerating the Innovative Development of VLCC Logistics in September 2016, and preliminarily announced 48 VLCC pilot platforms. With the gradual rise of car-free carrier industry in China, the scientific pricing of car-free routes is an urgent problem for many car-free carriers platforms.

Liu Lizhu[1] in the literature of The Research of the Management of NVOCC, introduces the existing transport platform in our country, by comparing our country and Europe and the United States without a non-vessel shipping market in the specific environment, development process, as well as the similarities and differences of absorbing foreign experiences and lessons of nvocc management, aiming at the present problems of nvocc management, feasible measures are put forward, analysis the influence factors of car free carrier for us to have guiding significance; Luo Yanxin[2] in the Delivery without Original Bill of Lading and Carrier’s Defences against the delivery voucher today in difficult to implement in practice, and the carrier is still endowed with absolute obligation of delivery voucher, makes an explanation of the system of bill of lading and the present situation of the use of deviation from the original bill of lading system, puts forward some conditions to remove the obligation of the carrier delivery voucher some legislative Suggestions, for our analysis of the bounty and pricing problem, car free transport platform has certain direction significance. Wang Xianjie, Liu Penghui, shu-yun wang [3] in the Inventory Ordering and Pricing Policy for Cold Chain Iterms with Weibull Survival and Death Characteristics, established the infinite period cold-chain products with Weibull survive death characteristics, random demand and inventory replenishment affected by price pricing model, find out the replenishment pricing strategy influential factors, these findings can help us optimize system model, to solve practical problems and to use has certain guiding significance, with analysis of the problem but also has some not to recommend it.

Research Significance: In recent years, mobile Internet technology has been deeply integrated with freight logistics industry, and new business models such as carless carriers have emerged in freight logistics market. NTRC is a road cargo transport operator who signs a transport contract with the shipper as a carrier, assumes the responsibilities and obligations of the carrier and entrust the actual carrier to complete the transport task. Through the knowledge of multivariate statistical regression and image analysis, this study can obtain a more reasonable quotation strategy of the platform, so as to improve the transaction success rate and revenue expectation of each order. This will contribute to the stability of the order and the rationality of the quotation.

2. Related Work

2.1. Multivariate statistical regression model of line guide price
For each shipment order, the platform can get feedback information: ① digital information: total mileage, transportation time, total cost, line guide price, line price (transaction price). ② Text information: business type, transportation level, emergency degree of demand, demand type, vehicle specifications, starting and ending locations, whether to renew, etc. In order to determine pricing, filter out information that can be quantified, and eliminate information that can't be quantified, simplifying the impact of location. Set the transportation level and business type as 0-1 variables and analyze quantitatively.

It is also assumed that the platform pricing does not take into account factors that cannot be quantified, such as the origin and destination locations. After excluding factors that cannot be quantified, the

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Following relevant factors are used: total mileage, type of service, level of transportation, urgency of demand, and type of demand.

Table 1. Parameter Settings

| Variable                  | Parameter Settings                          |
|---------------------------|---------------------------------------------|
| Total mileage             | $x_1$ ~ mileage of the order, in kilometers |
| Business types            | $x_2$ ~ 0- speed, 1- heavy cargo             |
| Demand Type 2             | $x_3$ ~ 0- plan, 1- temporary                |
| Transport Level           | $x_4$ ~ 1- level 1, 0- others. $x_5$ ~ 1- level 2, 0- others |
| Emergency Level of Demand | $x_6$ ~ 0.6 - Extraordinary, 0.4 - Urgent, 0.2 - General |
| Time                      | $t$ ~ The time of scheduled start time and scheduled end time, unit: hours |

The pricing is for the carrier, assuming that the pricing plays a role in guiding the transaction, so the data used to fit the equation uses the line guide price. Numerical parameters are set for relevant factors and multivariate statistical regression model is established. $\hat{y}_1$ is the statistic of line guide price to be estimated, it is first assumed that there is a linear relationship between it and the dependent variable:

$$\hat{y}_1 = \hat{a}_0 + \hat{a}_1 x_1 + \hat{a}_2 x_2 + \hat{a}_3 x_3 + \hat{a}_4 x_4 + \hat{a}_5 x_5 + \hat{a}_6 x_6 + \hat{a}_7 t + \varepsilon$$ (1)

In the initial fitting, the estimated values of each parameter are as follows:

Table 2. The first fit

| Estimator | Point Estimates | 0.95 Interval Estimate |
|-----------|-----------------|------------------------|
| $\hat{a}_0$ | 9.8692 | [-11.0001,30.7385]   |
| $\hat{a}_1$ | 4.0350 | [3.8699,4.1980]    |
| $\hat{a}_2$ | 81.5093 | [66.9977,96.0210]  |
| $\hat{a}_3$ | -18.5886 | [-44.1287,6.9513]  |
| $\hat{a}_4$ | 216.3442 | [-72.2374,504.9258] |
| $\hat{a}_5$ | 19.1316 | [0.9399,37.3234]   |
| $\hat{a}_6$ | 174.5692 | [104.6986 244.4398] |
| $\hat{a}_7$ | 28.2985 | [19.5778,37.0193]  |

Goodness of fit: $R=0.9869$

$F$ test value: 112081.6576

Significance level: $SignifyF=0.0000 \ll 0.05$

There is an interval containing zero, and the zero contained in the demand type 2 of $x_3$ in the model is in the middle position, which is removed.

There is an estimate with a small value, and the pre-grade coefficient $\hat{a}_5$ of second-level of $x_5$ transportation in the model is small. That is to say, when the transportation grade is second-level, the guide price will only increase by 20 yuan. Moreover, the confidence interval is very close to 0, and the test value $p$ is greater than 0.05, so it will be excluded.

The zero range of $x_4$ contained in the model is small, and the test value $p = 0.18$ is relatively small, which can be retained.

In addition, considering that there may be a linear relationship between total mileage and time, we drew a scatter diagram of time and total mileage for fitting:
Fitting results: $x_1 = -0.742 + 55.011 t$

Test $P$ value: $0.052 < 0.1$

$F$ test value: $23259.2254$

Figure 1. Scatter plots of time and total mileage

So, we can replace the variable $t$ with the variable $x_1$. It can also get high precision results, after adding interaction terms $x_2 x_4$. The model is as follows:

$$
\hat{y}_1 = a_0 + a_1 x_1 + a_2 x_2 + a_4 x_4 + a_6 x_6 + \beta_1 x_2 x_4 + \varepsilon
$$

(2)

Once again, the model is fitted for several times. After eliminating the items with noise greater than 1000, the fitting results of the second round of line guide price are as follows:

$$
\hat{y}_1 = 219.33 + 4.48x_1 - 135.80x_2 - 81.43x_4 + 95.33x_6 + 102.16x_2 x_4 + \varepsilon
$$

(3)

All relevant tests passed, and the residual analysis of the model was carried out to check the residual graph of the total mileage, < transport class and transport type > : 

Table 3. All kinds of combination

| 10 combination | First stage transport + express transport |
| 20 combination | Second stage transport + express transport |
| 30 combination | Third stage transport + express transport |
| 11 combination | First stage transport + heavy cargo |
| 21 combination | Second stage transport + heavy cargo |
| 31 combination | Third stage transport + heavy cargo |

According to the estimation formula obtained from the analysis, in the case that the order is not a combination of first-class transportation and express transportation, the guiding price will be increased by 4.48 yuan for every 1 km increase in the total mileage. However, when the order is first-class transportation, the order can only be first-class transportation + heavy cargo, so both $x_2$, $x_4$ values are 1. The guide price should be reduced by 115.07 yuan correspondingly, which obviously goes against
our common sense. As the difficulty of shipping increases, the price is reduced. Therefore, although the
test of this interaction model is passed, it is still not applicable to the solution of this model.
After observation, 10 combinations were eliminated as a whole and 11,20,21,30 and 31 were retained.
Multiple linear regression was repeated to obtain the following results:

| Estimator | Point Estimates | 0.95 Interval Estimate |
|-----------|-----------------|------------------------|
| $\hat{a}_0$ | 30.7437 | [13.0023,48.4851] |
| $\hat{a}_1$ | 4.4699 | [4.3810,4.5588] |
| $\hat{a}_2$ | 80.1973 | [67.0343,93.3603] |
| $\hat{a}_3$ | 389.5565 | [169.9627,609.1504] |
| $\hat{a}_6$ | 179.6729 | [115.8430,243.5028] |

**Goodness of fit:**
- $R=0.9824$
- $F$ test value: 112081.6576
- Significance level: $\text{SignifyF}=0.0000 \ll 0.05$

### 2.2. Model conclusion
The model can be used as a whole after several factors are removed. The interval credibility and p-value
test pass, and the second regression data also eliminates the problem of $x_4$ that the confidence interval
contains zero, and the reliability is further improved. Finally, the estimated value of the forecast line
guide price is expressed as follows:

$$\hat{y}_1 = 30.7437 + 4.4699x_1 + 80.1973x_2 + 389.5565x_4 + 179.6729x_6$$

(4)

The model shows that the price of the order should increase by 4.47 yuan for each additional
kilometer of the total mileage. If a single shipment of goods is heavy goods, it should be increased by
80.20 yuan of value-added fees. If the goods carried are valuables of the first class transportation, the
value added fee of RMB 389.56 should be increased accordingly. If the goods to be carried need urgent
transportation, then according to the emergency degree, ordinary type of increase 35.93 yuan,
emergency type increase 71.87 yuan, urgent type increase 107.80 yuan.

### 3. Price spillover rate index analysis and order quotation rationalization

#### 3.1. Quantify the data of the completed orders
Define $\eta = \frac{y - y_0}{y_0}$ as the price spill rate, which is a measure of the platform's yield per order. After
calculating the price spillover rate of the previous orders, the scatter diagram of transaction price and
price spillover rate of the completed orders and the fitting diagram of normal distribution are given.

![Figure 4. Order distribution scatter chart](image)

![Figure 5. Distribution of small orders](image)

![Figure 6. Distribution of large orders](image)

According to the figures above, we can see that the data are roughly divided into two levels: 1 group
for orders over 5000 and 2 groups for orders below 5000. The relationship of price spillover rate between
the two groups is similar to linear distribution. Large orders and small orders have different normal
distribution diagrams on price spillover rate, so it is necessary to separate large data from small data. The fitting results are as follows:

Table 5. The fitting results of large order and small order

| Order Type    | Variance | Mean Value |
|---------------|----------|------------|
| Small Order   | 0.083    | 0.1469     |
| Large Order   | 0.037    | 0.3296     |

Equilibrium degree index was defined as \( \zeta \):

Differentiate the 25 and 75 quartiles of the order to get the equilibrium \( \zeta = z_{0.75} - z_{0.25} \). The larger the \( \zeta \) is, the longer and shorter the graph is, and the more data in the middle of the 25 and 75 quantiles, the more stable the transaction is. Otherwise, the more volatile the trade is considered.

The results are as follows:

Table 6. The equalization result of large order and small order

| Overflow Rate Type | \( z_{0.75} \) | \( z_{0.25} \) | \( \zeta \) | Mean Value |
|--------------------|----------------|----------------|------------|------------|
| Small Order        | 0.4322         | 0.0811         | 0.3511     | 0.1469     |
| Large Order        | 0.4313         | 0.2284         | 0.2029     | 0.3296     |

3.2. Reasonableness analysis and improvement direction of completed orders

Divide the data and observe the image to get two characteristics of previous orders:

① The average spillover rate of large orders is high, and the cost price of large orders is already high. Therefore, the platform's guidance pricing and final transaction price for large orders are ill-considered and inconsistent. The price raising range can be appropriately reduced to reduce the price spillover rate. The average spillover rate of small orders is stable and closest to the bimodal normal distribution. It can be considered that the guiding price of small orders is basically the same as the transaction price, and only fluctuates within a very small range.

② According to the difference between 0.75 and 0.25 quantile, the transaction price of the platform is more stable for the small amount, while the change range is larger for the large amount.

Therefore, the platform needs to improve the quotation, so as to reduce the fluctuation range of the revenue of orders, make the transaction price of more orders match the line cost, and the return rate of orders as close as possible to the middle section, so as to achieve the effect of stable transaction of a large number of orders.

4. Platform Triple Quotation Model and Revenue Analysis Method

4.1. Quotation strategy analysis

When the platform and the carrier carry out the balance transaction, the platform finds a reasonable quotation strategy, which can not only make the expectation of the transaction amount not too high, but also make the majority of the quotation accepted by the carrier, and promote the rapid progress of the transaction, which is the core part of the quotation model to be discussed.

First of all, it needs to be clear that the carrier has the right to refuse to accept the order, and the number of times the platform tests the carrier to accept the lowest price has a certain limit, and it cannot offer an infinite number of times. According to the specific provisions of the relevant platforms, this paper believes that three reasonable quotations are complementary to each other, which is enough to solve the problem of quotation. This paper is a simplified model, which does not consider the counterargument of the carrier for the price, that is, each transaction is formulated and proposed by the platform, and the carrier can choose whether to accept the offer according to its own acceptance.

4.2. The establishment of quotation model

Assume \( p_i \) to be the transaction probability of the quoted price of order \( i \) to be quoted, and \( \mu_i \) to be the
spillover rate \( \mu_i = \frac{c_i - y_2}{y_2} \) of the relative cost of order \( i \) to be quoted, that is, when an integer is taken, it represents the raising rate, and when a negative number is taken, it represents the lowering rate.

\[
E\mu = \mu_1 p_1 + \mu_2 (1 - p_1) + \mu_3 (1 - p_2) (1 - p_1)
\]

is the expected spillover rate based on the third pricing

Assume that the probability summation percentage represents the ratio of the overflow rate \( \frac{n}{n} \) to the sum of the number of orders under this order for a given order to all samples

A large number of samples, it can be considered that the cumulative percentage sum of \( \frac{n}{n} \) is the completed orders represents the probability of the transaction under the current overflow rate \( \mu \).

For an uncompleted order, if we set the overflow rate of the \( i \)-th quotation of \( \mu_i = \mu \), then we can also consider the probability of the transaction is \( p_i = p \) at the overflow rate.

4.3. Starting from the quotation model of three quotation strategy

The strategy for the first quotation is to use a quotation below cost price to test the shipper. According to the overflow rate and cumulative percentage sum given by 3.1, only the parts with negative overflow rate are examined. It can be found that the absolute value of negative overflow rate increases, so does the cumulative percentage sum. Because of the large sample size, \( \mu p = \mu \), \( p = \text{exception} \), a critical point can be found where the expected overflow rate is the lowest.

It is applicable to minimize the cumulative percentage and sorting, and the results of the first pricing are as follows:

Table 7. The result of the first pricing

| Order Type   | \( p_i \) | \( \mu_i \) |
|--------------|-----------|-------------|
| Small Order  | 30.6%     | -0.0881     |
| Large Order  | 3.6%      | -0.1832     |

Second quotation: use difference analysis to figure out the value of cumulative percentage/overflow rate for small orders in excel. It is observed that the data from lines 170-430 tends to grow steadily, so the percentage-overflow rate distribution can be considered to be close to a straight line. Use SPSS to find the least square line

![Figure 7](image_url)

Figure 7. Change of cumulative percentage sum with premium rate (normalized)

When we observe the image, there is a convex point in the part with the cumulative percentage of about 60%, whose distance from the least square line is the shortest in the range of the cumulative percentage of 50%-70%. Using Excel function to get the distance and sort, you can find the reasonable position of the second quotation.

Small order: \( p_2 = 66.3\% \) \( \mu_2 = 0.3199 \) Large order: \( p_2 = 65.6\% \) \( \mu_2 = 0.3924 \)

The third quotation: the third quotation is the last quotation, so the primary task of this quotation is to ensure the turnover rate. Here, it is assumed that the platform needs at least \( k\% \) of the order transactions to succeed, so the planning function of the third quotation can be listed:
Based on the turnover rate of the first two quotations and the given K %, the position can be solved and then taken out accordingly. Take here K % = 95% to complete solution.

**Table 8. The result of solution**

| Order Type   | $p_3$ | $\mu_3$ |
|--------------|-------|---------|
| Small Order  | 79.3% | 0.4728  |
| Large Order  | 58.4% | 0.5441  |

Final result: small orders $E\mu = 0.1595$ and large orders $E\mu = 0.3472$ are obtained according to expectation, which is a quotation rate 33% and 48% higher than the original quotation result, respectively.

4.4. **Price adjustment strategy and model sensitivity analysis**

If we assume that the price increase/decrease ratio can fluctuate within 5%, then the probability of closing will also fluctuate within $1-(1-p_3 \pm \Delta p_3)(1-p_3 \pm \Delta p_3)(1-p_3 \pm \Delta p_3)$. We can adjust the pricing strategy appropriately, raise or lower the overflow rate by 5%, and see the change of the final closing rate:

**Table 9. Changes in the final closing rate**

| $\Delta\mu_3$ | Small order $\Delta k\%$ | Large order $\Delta k\%$ |
|--------------|--------------------------|--------------------------|
| +5%          | -4.32%                   | -6.33%                   |
| -5%          | +4.46%                   | +4.07%                   |

4.5. **Model Conclusion**

Triple quotation model of three quotations from low to high, with a high turnover rate to ensure that the shipper and the actual carrier fast transaction.

Compared with the original pricing strategy for small amount, it can save up to 33%~48% of the cost, and at the same time, it can also guarantee the transaction rate of more than 95% according to the probability. All data of the model are sampled from real orders, so the accuracy of the results can be guaranteed. This is a strategy that can increase platform revenue and order turnover, and has a good range and value. For the overwhelming order, this model can simply and universally improve the transaction quality of the platform, and it is also of great benefit to the calculation of the future expected revenue.

5. **Conclusion**

In this paper, from the angle of multiple regression model and statistics, through hypothesis testing, we get the equation relationship between price and related factors. The second step, respectively from the car free carrier platform side's point of view the same orders, Taipei and transportation used to measure both orders when a price difference, the statistical model of pricing and the ratio between the transportation acceptance to clinch a deal valence samples, using the combination model three quotations of the samples, very good solution to the island's pricing is difficult, and transportation is difficult question. From the data point of view, the combination of the two models can increase the expectation of price spillover of orders, compress the width of orders, reduce the difference and increase the stability. Therefore, it can be considered that the model has an enlightening effect on the standardization of car free carrier platform pricing.

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