Research on Subsidy Strategy of Mobike Based on Complete Information Static Game

Meng CHEN
Xia Men University Tan Kah Kee College, Zhangzhou, FuJian, China

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Abstract. This paper take Intelligent sharing bicycle company Mobike for example, first introduce the current situation of Mobike, then establishes a complete information static game model for the fixed amount subsidy strategy and the fixed proportion subsidy strategy, and analyzes its strategic equilibrium solution and reasonable price range, get conclusion that Mobike company expand the market share through the subsidy in the short term, but it cannot be maintained for a long time and needs diversification the profitability approach.

Questions Raised

Public bicycle travel system (public bike) contain the data center, parking stations, parking electronic anti-theft locks, bicycles and the corresponding communications, monitoring equipment [1], the purpose is to solve the urban transport "last mile" problem. Mobike is a short-distance travel solution developed by Beijing Mobike Technology, download the APP, you can view the cycling location, make an appointment and find a bicycle, scanning code lock you can start riding cars, the lock integrated with an embedded chip, GPS module and SIM card intelligent information module, etc. After arriving at the destination, the user can manually complete the return procedure within the white area of the street, and the cost is as low as 1RMB half an hour. At present, the global public bicycle project is difficult to profit [2], So Mobike expect to use the subsidies to improve the riding rate.

At present, scholars have studied the construction of public bicycle system from many aspects [3-4]. mainly are qualitative introduction, and solve the problem of their survival problems are not involved, so this article mainly from the subsidy angle, use the complete information static game model to explore the relationship between the cycling platform and the user, and provide reference for the setting of the subsidy policy of the bicycles and the related public bicycle system subsidy policy.

Mobike and User Benefit Analysis Model Hypothesis

Now Mobike APP on the launch of top-up ¥20 donated ¥10, ¥100 donated ¥110 policy to reduce consumers’ cost, and to expand the market share and economic efficiency. To simplify the model:

Assumption 1: Mobike take the subsidy policy ,the subsidy cost is C, do not subsidize C = 0.
Assumption 2: Mobike users need to pay P, the number of users Q, so the profit is R = P * Q.
Assumption 3: If the company does not take subsidy policy, the number of users will be reduced.
Assumption 4: The inverse demand function of Mobike is Q = a-bP, a, b are coefficients.

The economic benefits of the company are D = R-C = PQ-C, where P, Q, C, D, R> 0, a, b> 0.
Mobike site is not fixed, no need to take the card, more flexible, so user access larger utility, $U_{total^{mobike}} = U_{1}^{mobike} + U_{2}^{mobike} + U_{3}^{mobike}$, and the other short-distance travel utility is $U_{total^{other}} = U_{1}^{other} + U_{2}^{other} + U_{3}^{other}$, IF no subsidies, the price of Mobike generally higher than the other, so the price utility is negative.
The Complete Information Static Game of the Fixed Subsidy Policy

The Utility Analysis

Assuming Mobike subsidies S to the user, S<P, The user use the bicycle price for \( P_1 = P - S \), user numbers for \( Q_1 = a - bP_1 = a - b(P - S) \), The company's profits for

\[
R_1 = P_1Q_1 = (P-S)(a-b(P-S)) = a(P-S)-b(P-S)^2
\]

The cost of subsidies for the company

\[
C_1 = Q_1S = (a-b(P-S))S
\]

And the company's economic interests

\[
D_1 = R_1 - C_1 = (a(P-S)-b(P-S)^2-a(b(P-S))S = aP-2aS-bP^2-2bS^2+3PSb
\]

IF Mobike give users no subsidies, S=0, the interests of the company is

\[
D_1^0 = R-C = aP-bP^2
\]

If Mobike company give users subsidies but users do not choose it, and choose other similar public bike, the company's economic interests -C_1 = -Q_1S<0. If Mobike do not give users subsidies, and the user don't choose the bicycle, the company's economic interests is 0.

User Utility Analysis

When the user selects the bike and the Mobike company give users subsidies, because the price effect is negative, so the user's utility is \( U_{\text{total}}^\text{mo} = U_{1\text{mo}} + C \);

When user selects Mobike but the company did not give subsidies, the user's utility is \( U_{\text{total}}^\text{mo} = U_{1\text{mo}} \);

When the user selects other public bicycle with subsidies, user utility for \( U_{\text{total}}^\text{other} = U_{1\text{other}} + C \);

When the user selects other public bike without subsidies, user utility for \( U_{\text{total}}^\text{other} - U_{1\text{other}} \).

Because the price is the cost of user to use short-distance transportation, so:

The total utility for the user to select Mobike is \( U_{\text{total}}^\text{mo} = U_{1\text{mo}} + U_{3\text{mo}} \);

The total utility for the user to select other public bike is \( U_{\text{total}}^\text{other} = U_{1\text{other}} + U_{3\text{other}} \)

<table>
<thead>
<tr>
<th>Customer</th>
<th>Use</th>
<th>Nonuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobike subsidy</td>
<td>(aP-2aS-bP^2-2bS^2+3PSb, ( U_{\text{total}}^\text{mo} - U_{1\text{mo}} + C ))</td>
<td>(-C_1, ( U_{\text{total}}^\text{other} - U_{1\text{other}} + C ))</td>
</tr>
<tr>
<td>No subsidies</td>
<td>(aP-bP^2, ( U_{\text{total}}^\text{mo} - U_{1\text{mo}} ))</td>
<td>(0, ( U_{\text{total}}^\text{other} - U_{1\text{other}} ))</td>
</tr>
</tbody>
</table>

Strategy Analysis

Mobike Choice Strategy. When users choose Mobike, the company should consider subsidies users or not,

\[
D_1 - D_1^0 = aP-2aS-bP^2-2bS^2+3PSb-(aP-bP^2) = -2aS - 2bS^2 + 3PSb
\]

when \( D_1 > D_1^0 \), \( P^2 > \frac{2(a+bS)}{3b} \) The benefits of subsidies are greater, Mobike choose subsidies;
when $D_1 < D_1^0$, means when the $p < \frac{2(a + bS)}{3b}$, Mobike company should choose not subsidy policy. when user chooses not to use mobike, $-C_1 < 0$, so the company should choose no subsidy policy.

**User Strategy Choice.** When Mobike company subsidize users, users should compare use or is not applicable to the bicycle to the size of the utility.

$$U_{total}^{mo} - U_{1}^{mo} + C - (U_{total}^{other} - U_{1}^{other} + C) = (U_{total}^{mo} - U_{total}^{other}) - (U_{1}^{mo} - U_{1}^{other})$$

According to above analysis, because the bike has no fixed pile, high flexibility and the relative price also is higher, so $U_{total}^{mo} > U_{total}^{other}$, $U_{1}^{mo} > U_{1}^{other}$,$U_{total}^{mo} - U_{total}^{other} > 0$, $U_{1}^{mo} - U_{1}^{other} > 0$.

When $U_{total}^{mo} - U_{total}^{other} > U_{1}^{mo} - U_{1}^{other}$, the user to select the Mobike for the convenience and comfort of the utility is greater than the difference between the two prices, and can make up for extra price, the user will choose Mobike first ;On the contrary, the users choose other public bicycle way.

The company chose not to subsidies to the user, the user needs to compare $U_{total}^{mo} - U_{1}^{mo}$ and $U_{total}^{other} - U_{1}^{other}$, the effectiveness of its size, reasoning and the above conclusion.

**Equilibrium Strategy Analysis**

When $U_{total}^{mo} - U_{total}^{other} > U_{1}^{mo} - U_{1}^{other}$, And $p < \frac{2(a + bS)}{3b}$, Models have unique equilibrium solution (not subsidies, the use of). The user a good riding habit, and Mobike convenience, comfort, etc are more satisfied, no additional subsidies will first choose this kind of short-distance travel way, at this point the bicycle to get the best economic benefits, we are looking for the optimal Nash equilibrium.

When $U_{total}^{mo} - U_{total}^{other} > U_{1}^{mo} - U_{1}^{other}$, And $p > \frac{2(a + bS)}{3b}$, Model has only one Nash equilibrium (subsidies, use), The user will choose the bicycle if the Mobike company chose to subsidies, the company income, but need to pay cost of subsidies, so the company earnings are smaller.

When $U_{total}^{mo} - U_{total}^{other} < U_{1}^{mo} - U_{1}^{other}$, Users will not choose to use the bicycle, the best choice of Mobike is not subsidies, have unique Nash equilibrium (not subsidies, do not use)[5], leads to the companies operating difficulties and even can't live, the equilibrium solution is worthless.

**The Complete Information Static Game of the Fixed Proportion Subsidy Policy**

**The Utility Analysis**

Now consider Mobike company subsidizes users in the price of a certain proportion, Assuming the proportion is $t$, $0 < t < 1$, Subsidies is $tP$. The user use the bicycle price $P_2 = P - tP = (1-t)P$, user numbers $Q_2 = a - bP = a - b(1-t)P$, the company's profits

$$R_2 = P_2 Q_2 = (1-t)P \times [a - b(1-t)P] = aP - atP - b(1-t)^2P^2$$

$$C_2 = Q_2 P = [a - b(1-t)P] P = atP - bt(1-t)P^2$$

If the company subsidizes for users, and users choose to use, Mobike company economic benefits

$$D_2 = R_2 - C_2 = aP - atP - b(1-t)^2P^2 - 3btP^2$$

If Mobike company does not give the user subsidies but users choose to use the bicycle, the $t = 0$, so the economic interests of the company is

$$D_2^0 = R - C = aP - bP^2$$

If the company give users subsidies but users do not choose, the Mobike company's economic benefits $-C_2 = Q_2 P = bt(1-t)P^2 - atP < 0$.If the company did not give users subsidies, and the user didn't choose the bicycle, Mobike company 's economic interests is 0.

**User Utility Analysis**

Because two kinds of subsidies for the user the result is the same, differences are only different subsidies, so user utility is consistent with the fixed amount of subsidy.
Table 2. Under the constant proportion subsidy the company gains matrix with users.

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<td>Mobike</td>
<td>(aP-2atP-bP$^2$-2bt$^2$P$^2$+3btP$^2$, U$^\text{subsidy}_\text{mo}$ - U$^\text{subsidy}_1$)</td>
<td>(-C$<em>2$, U$^\text{total}</em>\text{other}$ - U$^\text{subsidy}_1$)</td>
</tr>
<tr>
<td>No subsidies</td>
<td>(aP-bP$^2$, U$^\text{total}_\text{mo}$ - U$^\text{total}_1$)</td>
<td>(0, U$^\text{total}_\text{other}$ - U$^\text{subsidy}_1$)</td>
</tr>
</tbody>
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Strategy Analysis

The Company and User Strategy Choice. When users choose Mobike, the company should consider subsidy users or not,

$$D_2 - D_2^0 = aP - 2atP - bP^2 - 2bt^2P^2 + 3btP^2 - (aP - bP^2) = -2atP - 2bt^2P^2 + 3btP^2$$ (12)

To solve the above formula, make $D_2 - D_2^0 = 0$,

$$-2atP - 2bt^2P^2 + 3btP^2 = 0$$, so

$$P = \frac{2a}{b(3 - 2t)}$$ (13)

When $D_2 > D_2^0$, $P > \frac{2a}{b(3 - 2t)}$, obike company subsidies user generated by economic interests than not subsidies to produce economic benefits, the company should choose subsidies;

When $D_2 < D_2^0$, $P < \frac{2a}{b(3 - 2t)}$, obike company should choose not subsidy policy.

When the user chooses not to use Mobike, $-C_2 < 0$, so the company choose no subsidy policy.

When $U^\text{total}_\text{mo} - U^\text{total}_\text{other} > U^\text{mo}_1 - U^\text{other}_1$, the user to select the Mobike for the convenience and comfort of the utility is greater than the difference between the two prices, the difference between the utility and can make up for that extra pay a higher price, the user will give preference to Mobike; On the contrary, users choose other public bicycle.

Equilibrium Strategy Analysis. When $U^\text{total}_\text{mo} - U^\text{total}_\text{other} > U^\text{mo}_1 - U^\text{other}_1$, and $P < \frac{2a}{b(3 - 2t)}$, Model have unique equilibrium solution (subsidies, not use), Mobike company get the best economic benefits.

When $U^\text{total}_\text{mo} - U^\text{total}_\text{other} > U^\text{mo}_1 - U^\text{other}_1$, and $P > \frac{2a}{b(3 - 2t)}$, Model has only one Nash equilibrium (subsidies, use), the user will use the bicycle if the company choose to subsidies, at this time the company has a certain income, but not more.

When $U^\text{total}_\text{mo} - U^\text{total}_\text{other} < U^\text{mo}_1 - U^\text{other}_1$, Users will choose the other similar public bicycle, there is only one Nash equilibrium (not subsidies, do not use), Mobike eventually will exit the market.

Two Kinds of Subsidies of Price Difference Strategy and Model results

The Price Difference under the Two Kinds of Subsidies Policy

When the user is subsidized at a fixed amount, and $P_\text{fix} = \frac{2(a + bS)}{3b}$, the company can reach an equilibrium, namely whether the user is subsidized, the company can earn the same benefits, $D_1 = D_1^0$;

Similarly, if the user is subsidized at a fixed proportion, $P_\text{percent} = \frac{2a}{b(3 - 2t)}$, the company can reach equilibrium, whether the user is subsidies or not, the economic interests of the company access to the same, $D_2 = D_2^0$. What we need to analyze the key point is to compare the price between $P_\text{fix}$ and $P_\text{percent}$.

$$P_\text{fix} - P_\text{percent} = \frac{2(a + bS)}{3b} - \frac{2a}{b(3 - 2t)} = \frac{6bS - 4at - 4btS}{3b(3 - 2t)}$$

When $P_\text{fix} > P_\text{percent}$, $6bS - 4at - 4btS > 0$, the price of a Mobike subsidies in a fixed amount is higher than the
fixed promotion subsidy. Because $0 < t < 1$, then 
$3-2t < 0, 6bS - 4at - 4btS > 0$, finally 
$t > \frac{3bS}{2a + 2bS}$,

if $t < \frac{3bS}{2a + 2bS}$, $P_{fix} > P_{percent}$, $P_{percent}$ is small at this time, thus lower prices are generally more attractive to the consumer for their lower-cost transportation. Apparently, the company should choose fixed proportion subsidies as their priority.

Conversely, if $t > \frac{3bS}{2a + 2bS}$, $P_{fix} < P_{percent}$, the company should adopt a fixed amount of subsidization which can improve the customers’ cycling rate and the total income of the corporation.

The Results of Model

This paper use complete information static game, get the following results:

When Mobike give a user $S$ fixed subsidies, 
$P_{fix} = \frac{2(a + bx)}{3b}$, choose subsidies or not is no difference for the company; But when $U_{total} - U_{total} > U_{1} - U_{1}$, $P < \frac{2a}{b(3-2t)}$, model is the optimal Nash equilibrium (not subsidies, use), at this point the company get the best economic benefits.

when Mobike give a certain proportion subsidies for users, $P_{percent} = \frac{2a}{b(3-2t)}$, the economic interests of the company subsidies or not is the same; But when $U_{total} - U_{total} > U_{1} - U_{1}$, and $P < \frac{2a}{b(3-2t)}$, the optimal Nash equilibrium is (not subsidies, use);

When $t < \frac{3bS}{2a + 2bS}$, Mobike will adopt a fixed proportion to expand market share and achieve better economic benefits; when $t > \frac{3bS}{2a + 2bS}$, Mobike will adopt fixed amount $S$ to subsidies users.

Model Results and Suggestions

In the short term, Mobike company use subsidy policy can quickly improve user utilization, Mobike must choose reasonable way of subsidies, in order to attract users, grab market share.

The long term, the Mobike company cannot just rely on subsidies policy for long-term success, suggested the Mobike company set the prise between $0 < P < \frac{2(a + bx)}{3b}$ or $0 < P < \frac{2a}{b(3-2t)}$ after a certain time of market cultivation, equilibrium solution are (not subsidies, use), users do not value subsidies, if $U_{total} - U_{total} > U_{1} - U_{1}$, users will choose Mobike. The company get long-term stable profitability.

The long term, the company should develop diversified ways of profit. Mobike company should learn the experience of the domestic and foreign counterparts, improve comfort and convenience, increase the coverage of the vehicles measures, let user preferred Mobike in short-distance travel. Then Mobike company should combine body advertising, system development, model output and so on to expand profit way, step by step to lower the price of users, make consumers free of charge.

The government should actively play a role of publicity and coordination, and continue to coordinate users, thanks to the company and other interest groups such as the relationship between the rivals, safeguard the legitimate interests of the company.

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References


