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Research Article

Research on the Competitive Strategy of Cross-Border E-Commerce Comprehensive Pilot Area Based on the Spatial Competition

Bo Lu[1] and Huipo Wang[2]

[1]*Center of E-Commerce & Logistics, Dalian University, Dalian 116622, China*
[2]*College of Economics and Management, Dalian University, Dalian 116622, China*

Correspondence should be addressed to Huipo Wang; wanghuipo@dlu.edu.cn

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By now, 13 cross-border e-commerce comprehensive pilot areas have been approved by the State Council of China; Dalian and Tianjin are two of them. But with the development of the construction of the cross-border e-commerce comprehensive pilot areas, the competition between those pilot areas is inevitable. Dalian and Tianjin are located in the Bohai Sea and the distance between them is only 800 kilometers. For Dalian and Tianjin they are in thus competitive situations: first they have to compete with each other; second since they are located in Bohai Sea (North China), they have to compete with other cross-border e-commerce comprehensive pilot areas (South China). In this paper, our aim is to build models to provide best price strategies for these two cities. Based on the two-sided market theory and the geographical position, this paper builds two competitive theory models. Through the analyzing of the equilibrium, we get two main results: (1) according to different service area, the cities (Dalian and Tianjin) should have different price; (2) the two-sided market characters have an impact on their strategies.

1. Introduction

In March 2015, the State Council established the first comprehensive pilot area of cross-border e-commerce in Hangzhou. Within one year, the transaction scale of cross-border e-commerce in Hangzhou increased from 20 million dollars in 2014 to 3.464 billion dollars in 2015, including exports accounting for 2.273 billion dollars and imports accounting for 1.191 billion dollars, which contributed 5.4% for the growth of foreign trade exports in Hangzhou. The establishment of the comprehensive pilot area of cross-border e-commerce in Hangzhou has yielded prominent results. In January 2016, the State Council decided to set up a group of new comprehensive pilot areas of cross-border e-commerce in 12 cities such as Tianjin and Shanghai, and the intention of this decision was to take example by the efficient pattern of comprehensive pilot area in Hangzhou to provide the development of Chinese foreign trade with new motivations and supports [1, 2]. But with the development of the construction of the cross-border e-commerce comprehensive pilot area, the competition between those pilot areas is inevitable. And this kind of competition has obvious spatial characteristics and two-sided market characteristics.

This article takes Tianjin and Dalian as an example to illustrate the competition among the cross-border e-commerce comprehensive pilot areas. Both Tianjin and Dalian are the second batch of the establishment of cross-border e-commerce comprehensive pilot areas in the beginning of 2016. Both of them are located in the north of China. Tianjin is in the west and Dalian is in the east. This kind of layout just divides the domestic enterprises and consumers into four parts, as shown in Figure 1.

The following analysis can be done through the angle of the geographical position: first, because Tianjin is located in the west, Dalian is located in the east. So firms and consumers in the west of Tianjin will take Tianjin as the first choice to do cross-border e-commerce; the firms and consumers in the east of Dalian will take Dalian as the first choice to do

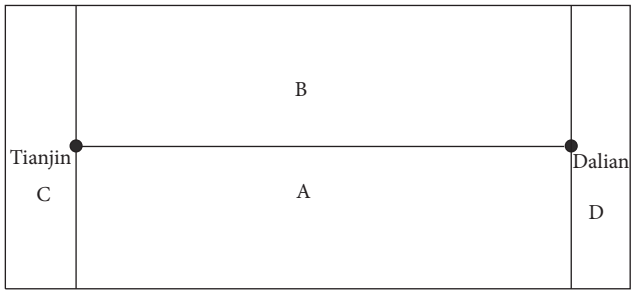

Figure 1: Location map of domestic firms and consumers.

cross-border e-commerce. At the same time the firms and consumers in the south of Dalian Tianjin line can choose Tianjin and Dalian or can also choose other comprehensive pilot areas, for example, Qingdao and Zhengzhou. Therefore, A district is under the competition of multiareas. The firms and consumers in the north of Dalian Tianjin line can only choose Dalian or Tianjin. Therefore, B district is under the competition of Dalian and Tianjin. In summary, there is no competition in C and D zones, and A and B zones are the competition zones. Therefore, this paper will analyze the competitive strategy of cross-border e-commerce comprehensive pilot areas based on spatial competition theory.

Besides, the cross-border e-commerce comprehensive pilot areas are service platforms; on the one hand, they are connecting the domestic firms and consumers, and on the other hand, they are connecting the foreign firms and consumers, so the market is typically a two-sided market [3, 4].

Until now there is no general agreement on a standard definition of two-sided market, but the definitions of Armstrong (2006) [5], Rysman (2009) [6], and Rochet and Tirole (2010) [7] are widely cited and recognized. Coase theorem and the nonneutrality of price structure are two significant features of the two-sided markets. Rochet and Tirole (2010) [7], Armstrong (2006) [5], Kaiser and Wright (2006) [8], and other scholars have proposed their own classification of two-sided market, but the classification of Evans (2003) is widely accepted. He divided the two-sided market into three classifications: market-makers, audience-makers, and demand-coordinators [9]. Cross-border e-commerce comprehensive pilot areas are platforms to do cross-border e-commerce, so they have the main characteristics of two-sided market. In this paper we use two-sided market theory to build the theory model.

Through the above analysis, we know that the firms and consumers in C zone will take Tianjin as the first choice to do cross-border e-commerce; the firms and consumers in D zone will take Dalian as the first choice to do cross-border e-commerce. So there is no need to analyze their strategies on zones C and D. Then, in this paper, we will build two competitive theory models to analyze Dalian and Tianjin's competitive strategies on zone A and zone B, respectively. Also, we will analyze how the two-sided market characteristics affect the revenue of those two cities. Although the model takes Tianjin and Dalian as an example, the conclusions are general.

The paper is organized as follows: the first part is Introduction, the second part is The Basic Model Assumptions, the third part is Model (I): Competitive Model on A Zone, the fourth part is Model (II): Competitive Model on B Zone, the fifth part makes A Comparative Analysis of Model (I) and Model (II), the sixth part shows some numerical examples, and the seventh part makes the conclusion.

2. The Basic Model Assumptions

For the convenience of analysis, in this paper, the fundamental assumptions are as follows. Firstly, we assume that there are two kinds of pilot areas: the first one is called the North area, which includes Tianjin and Dalian; the other one is called the South area, which includes other eleven cities. In the North area there are two cities: Tianjin is referred to as position i, and Dalian is referred to as position j. Secondly, hypotheses about the two-sided markets are as follows: the domestic firms and consumers (DF&Cs for short) are called side 1 and the foreign firms and consumers (FF&Cs for short) are called side 2. According to the actual situation, the DF&Cs side is single-homing and the FF&Cs side is multihoming. We assume that t_1 is the matching cost (which includes the transportation cost and other costs) of side 1 and t_2 is the matching cost of side 2, and matching cost of side 1 is equal to that of side 2; namely, $t_1 = t_2 = t$. Thirdly, the hypotheses of network effects are as follows: we assume that there are network effects between groups. The strength of network effects for DF&Cs side gathering in the position i to FF&Cs side is α_{12}^i; the strength of network effects for DF&Cs side gathering in the position j to FF&Cs side is α_{12}^j. The strength of network effects for FF&Cs side gathering in the position i to DF&Cs side is α_{21}^i; the strength of network effects for FF&Cs side gathering in the position j to DF&Cs side is α_{21}^j. Thus, the strength of network effects between groups is α_{12}^i, α_{12}^j, α_{21}^i, α_{21}^j. Under the premise of not influencing the analysis conclusion, we assume that the strength of network effects between groups is equal to α. Fourth, we assume that the reservation utility of side 1 DF&Cs takes the position i as their operating location is $\overline{u}_1^i$; the reservation utility of side 1 DF&Cs takes the position j as their operating location is $\overline{u}_1^j$; the reservation utility of side 2 FF&Cs takes the position i as their operating location is $\overline{u}_2^i$; the reservation utility of side 2 FF&Cs takes the position j as their operating location is $\overline{u}_2^j$. For side 2 FF&Cs, the function of taking l ($l \in \{i, j\}$) position as their operating location can be separated into the function of quality m and the function of price k, because the FF&Cs are maybe multihoming. Only multifunction can lead to multihoming. There is no necessary to separate the function of DF&Cs into quality function and price function because the DF&Cs side is single-homing. Accordingly, $\overline{u}_2^i = \overline{u}_{2m}^i + \overline{u}_{2k}^i$, $\overline{u}_2^j = \overline{u}_{2m}^j + \overline{u}_{2k}^j$ (where $\overline{u}_{2m}^i$ is the utility of quality function m of side 2 FF&Cs that take the position i as their operating location; $\overline{u}_{2m}^j$ is the utility of quality function m of side 2 FF&Cs that take the position j as their operating

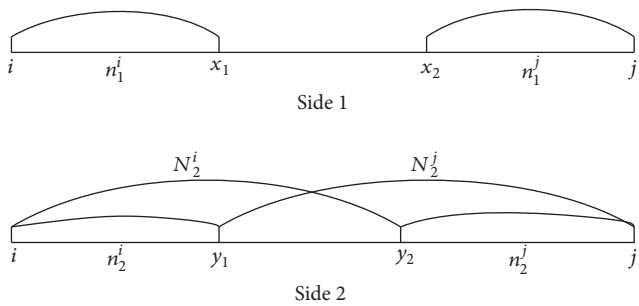

Figure 2: Model (I): Competitive Model on A Zone.

location; $\overline{u}_{2k}^i$ is the utility of price function k of side 2 FF&Cs that take the position i as their operating location; $\overline{u}_{2k}^j$ is the utility of price function k of side 2 FF&Cs that take the position j as their operating location). According to the actual situation, $\overline{u}_{2m}^i > \overline{u}_{2m}^j$, $\overline{u}_{2k}^j > \overline{u}_{2k}^i$. (For Tianjin is more big and international than Dalian, its service quality is high compared to Dalian, but Dalian can provide a lower service price.) p_1^i, p_1^j represent the cost (price) of DF&Cs that take the positions i, j as their operating location, respectively.

3. Model (I): Competitive Model on A Zone

The market is an oligopoly competition market when the North area and the South area are competing for the firms and consumers from A zone. For the North area, Model (I) diagram is shown as in Figure 2. In oligopoly competition market, the DF&Cs can choose to take the North area or the South area as their operating location. In this model the DF&Cs in $[x_1, x_2]$ do not take the North area as their operating location; they take the South area as their operating location.

Description of the notations in Figure 2 is as follows: i: Tianjin; j: Dalian; n_1^i: the DF&Cs who take position i as their operating location; x_1: the edge DF&Cs; n_1^j: the DF&Cs who take position j as their operating location; x_2: the edge DF&Cs; n_2^i: the FF&Cs who take position i as their operating location only; y_1: the edge FF&Cs; N_2^i: the FF&Cs who take position i only or take positions i, j as their operating location; y_2: the edge FF&Cs; n_2^j: the FF&Cs who take position j as their operating location only; y_2:the edge FF&Cs; N_2^j: the FF&Cs who take position j only or take positions i, j as their operating location; y_1: the edge FF&Cs.

The utility of the DF&Cs who take position i as their operating location is

$$u_1^i = \overline{u}_1^i - p_1^i - tx_1 + \alpha y_2. \tag{1}$$

The utility of DF&Cs is 0 if the DF&Cs located between x_1 and x_2, and the DF&Cs will take the South area as their operating location. So

$$\overline{u}_1^i - p_1^i - tx_1 + \alpha y_2 = 0. \tag{2}$$

The utility of the DF&Cs who take position j as their operating location is

$$u_1^j = \overline{u}_1^j + \alpha(1 - y_1) - t(1 - x_2) - p_1^j. \tag{3}$$

The utility of DF&Cs is 0 if the DF&Cs located between x_1 and x_2, and the DF&Cs will take the South area as their operating location. So

$$\overline{u}_1^j + \alpha(1 - y_1) - t(1 - x_2) - p_1^j = 0. \tag{4}$$

The utility of the FF&Cs who take position i as their operating location is

$$u_2^i = \overline{u}_2^i + \alpha x_1 - ty_1. \tag{5}$$

The utility of the FF&Cs who take positions i and j as their operating locations is

$$u_2^{ij} = \overline{u}_{2m}^i + \overline{u}_{2k}^j + \alpha[x_1 + (1 - x_2)] - t. \tag{6}$$

The utility of the FF&Cs who take position j as their operating location is

$$u_2^j = \overline{u}_{2m}^j + \overline{u}_{2k}^j + \alpha(1 - x_2) - t(1 - y_2). \tag{7}$$

Let $V_1^d = \overline{u}_1^i - \overline{u}_1^j$, $V_2^d = \overline{u}_{2k}^j - \overline{u}_{2k}^i + \overline{u}_{2m}^i - \overline{u}_{2m}^j$, $V_{2k}^d = \overline{u}_{2k}^j - \overline{u}_{2k}^i$, $V_{2m}^d = \overline{u}_{2m}^i - \overline{u}_{2m}^j$.

At point y_1, the FF&Cs who take position i as their operating locations or take positions i and j as their operating locations are indifferent. So

$$\begin{gathered} u_2^i = u_2^{ij}, \\ \overline{u}_2^i + ax_1 - ty_1 = \overline{u}_{2m}^i + \overline{u}_{2k}^j + a[x_1 + (1 - x_2)] - t. \end{gathered} \tag{8}$$

Simplifying this function, we can get

$$y_1 = \frac{\overline{u}_{2k}^i - \overline{u}_{2k}^j}{t} - \frac{a}{t} + \frac{ax_2}{t} + 1. \tag{9}$$

At point y_2, the FF&Cs who take position j as their operating locations or take positions i and j as their operating locations are indifferent. So

$$\begin{aligned} &u_2^j = u_2^{ij}, \\ &\overline{u}_{2m}^j + \overline{u}_{2k}^j + a(1 - x_2) - t(1 - y_2) \\ &\quad = \overline{u}_{2m}^i + \overline{u}_{2k}^j + a[x_1 + (1 - x_2)] - t. \end{aligned} \tag{10}$$

Simplifying this function, we can get

$$y_2 = \frac{\overline{u}_{2m}^i - \overline{u}_{2m}^j}{t} + \frac{ax_1}{t}. \tag{11}$$

Substituting (11) into (2), we can get

$$\overline{u}_1^i + a\left(\frac{\overline{u}_{2m}^i - \overline{u}_{2m}^j}{t} + \frac{ax_1}{t}\right) - tx_1 - p_1^i = 0. \tag{12}$$

Simplifying this function, we can get

$$x_1 = \frac{t}{t^2 - a^2}\left[\overline{u}_1^i - p_1^i + \frac{a\left(\overline{u}_{2m}^i - \overline{u}_{2m}^j\right)}{t}\right]. \quad (13)$$

From Figure 2, we know that

$$x_1 = n_1^i. \quad (14)$$

So

$$n_1^i = \frac{t}{t^2 - a^2}\left[\overline{u}_1^i - p_1^i + \frac{a\left(\overline{u}_{2m}^i - \overline{u}_{2m}^j\right)}{t}\right]. \quad (15)$$

Substituting (9) into (4), we can get

$$\overline{u}_1^j + a\left(\frac{a}{t} - \frac{ax_2}{t} - \frac{\overline{u}_{2k}^i - \overline{u}_{2k}^j}{t}\right) - t + tx_2 - p_1^j = 0. \quad (16)$$

Simplifying this function, we can get

$$x_2 = 1 - \frac{t}{t^2 - a^2}\left[\overline{u}_1^j - p_1^j - \frac{a\left(\overline{u}_{2k}^i - \overline{u}_{2k}^j\right)}{t}\right]. \quad (17)$$

From Figure 2, we know that

$$n_1^j = 1 - x_2. \quad (18)$$

So

$$n_1^j = \frac{t}{t^2 - a^2}\left[\overline{u}_1^j - p_1^j - \frac{a\left(\overline{u}_{2k}^i - \overline{u}_{2k}^j\right)}{t}\right]. \quad (19)$$

Profit function is

$$\pi = n_1^i \cdot p_1^i + n_1^j \cdot p_1^j = \frac{t}{t^2 - \alpha^2}\left[\overline{u}_1^i p_1^i - \left(p_1^i\right)^2 + \frac{\alpha V_{2m}^d}{t} p_1^i + \overline{u}_1^j p_1^j - \left(p_1^j\right)^2 + \frac{\alpha V_{2k}^d}{t} p_1^j\right]. \quad (20)$$

π is the function of (p_1^i, p_1^j), take the first-order derivative of p_1^i and p_1^j, and the reaction functions are

$$\frac{\partial \pi}{\partial p_1^i} = \frac{t}{t^2 - \alpha^2}\left(\overline{u}_1^i - 2p_1^i + \frac{aV_{2m}^d}{t}\right),$$
$$\frac{\partial \pi}{\partial p_1^j} = \frac{t}{t^2 - \alpha^2}\left(\overline{u}_1^j - 2p_1^j + \frac{aV_{2k}^d}{t}\right). \quad (21)$$

Let the reaction functions be zero, and the Bertrand-Nash equilibrium prices are

$$p_1^i = \frac{1}{2}\overline{u}_1^i + \frac{\alpha}{2t}V_{2m}^d, \quad (22)$$

$$p_1^j = \frac{1}{2}\overline{u}_1^j + \frac{\alpha}{2t}V_{2k}^d. \quad (23)$$

When $t > \alpha$, $\partial\pi^2/\partial(p_1^i)^2 < 0$, $\partial\pi^2/\partial(p_1^j)^2 < 0$, p_1^i and p_1^j are the solutions when π is maximization.

Lemma 1. *The user scale of the DF&Cs who take position i as their operating location is* $n_1^i = (t/2(t^2-\alpha^2))[\overline{u}_1^i+(\alpha/t)V_{2m}^d]$, *the user scale of the DF&Cs who take position j as their operating location is* $n_1^j = (t/2(t^2 - \alpha^2))[\overline{u}_1^j + (\alpha/t)V_{2k}^d]$, *the user scale of the FF&Cs who take position i only or take positions i, j as their operating location is* $N_2^i = V_{2m}^d/t + (\alpha/2(t^2 - \alpha^2))[\overline{u}_1^i + (\alpha/t)V_{2m}^d]$, *the user scale of the FF&Cs who take position j only or take positions i, j as their operating location is* $N_2^j = V_{2k}^d/t + (\alpha/2(t^2 - \alpha^2))[\overline{u}_1^j + (\alpha/t)V_{2k}^d]$, *the cost (price) of DF&Cs who take the position i as their operating location is* $p_1^i = (1/2)\overline{u}_1^i + (\alpha/2t)V_{2m}^d$, *the cost (price) of DF&Cs who take the position j as their operating location is* $p_1^j = (1/2)\overline{u}_1^j + (\alpha/2t)V_{2k}^d$, *and the total income of the North area is* $\pi = (t/4(t^2 - \alpha^2))[(\overline{u}_1^i + (\alpha/t)V_{2m}^d)^2 + (\overline{u}_1^j + (\alpha/t)V_{2k}^d)^2]$.

Proof. According to formula (15), $n_1^i = (t/(t^2 - a^2))[\overline{u}_1^i - p_1^i + a(\overline{u}_{2m}^i - \overline{u}_{2m}^j)/t]$; substitute formula (22) into it. Simplify it; then we can get $n_1^i = (t/2(t^2 - \alpha^2))[\overline{u}_1^i + (\alpha/t)V_{2m}^d]$.

According to formula (19), $n_1^j = (t/(t^2 - a^2))[\overline{u}_1^j - p_1^j - a(\overline{u}_{2k}^i - \overline{u}_{2k}^j)/t]$; substitute formula (23) into it. Simplify it; then we can get $n_1^j = (t/2(t^2 - \alpha^2))[\overline{u}_1^j + (\alpha/t)V_{2k}^d]$.

From Figure 2, we know that

$$N_2^i = y_2. \quad (24)$$

According to formula (11),

$$y_2 = \frac{\overline{u}_{2m}^i - \overline{u}_{2m}^j}{t} + \frac{ax_1}{t}. \quad (25)$$

We also know that $x_1 = n_1^i$; substitute $n_1^i = (t/2(t^2 - \alpha^2))[\overline{u}_1^i + (\alpha/t)V_{2m}^d]$ into formula (11). Simplify it; then we can get

$$N_2^i = \frac{V_{2m}^d}{t} + \frac{\alpha}{2\left(t^2 - \alpha^2\right)}\left[\overline{u}_1^i + \frac{\alpha}{t}V_{2m}^d\right]. \quad (26)$$

From Figure 2, we know that

$$N_2^j = 1 - y_1. \quad (27)$$

According to formula (11)

$$y_1 = \frac{\overline{u}_{2k}^i - \overline{u}_{2k}^j}{t} - \frac{a}{t} + \frac{ax_2}{t} + 1. \quad (28)$$

We also know that $x_2 = 1 - n_1^j$; substitute $n_1^j = (t/2(t^2 - \alpha^2))[\overline{u}_1^j + (\alpha/t)V_{2k}^d]$ into formula (9). Simplify it; then we can get

$$N_2^j = \frac{V_{2k}^d}{t} + \frac{\alpha}{2\left(t^2 - \alpha^2\right)}\left[\overline{u}_1^j + \frac{\alpha}{t}V_{2k}^d\right]. \quad (29)$$

According to formulae (22) and (23), $p_1^i = (1/2)\overline{u}_1^i + (\alpha/2t)V_{2m}^d$ and $p_1^j = (1/2)\overline{u}_1^j + (\alpha/2t)V_{2k}^d$.

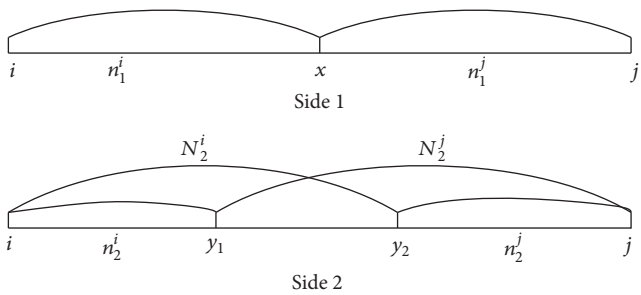

Figure 3: Model (II): Competitive Model on B Zone.

Substituting formulae (22) and (23) into formula (20) and simplify them, we can get

$$\pi = \frac{t}{4\left(t^2-\alpha^2\right)}\left[\left(\overline{u}_1^i+\frac{\alpha}{t}V_{2m}^d\right)^2+\left(\overline{u}_1^j+\frac{\alpha}{t}V_{2k}^d\right)^2\right]. \quad (30)$$

□

4. Model (II): Competitive Model on B Zone

When x_1 overlaps with x_2, Model (II) diagram is shown as in Figure 3. The utility of the DF&Cs who take position i as their operating location is

$$u_1^i = \overline{u}_1^i - p_1^i - tx + \alpha N_2^i. \quad (31)$$

The utility of the DF&Cs who take position j as their operating location is

$$u_1^j = \overline{u}_1^j - p_1^j - t(1-x) + \alpha N_2^j. \quad (32)$$

The utility of the FF&Cs who take position i as their operating location is

$$u_2^i = \overline{u}_2^i + \alpha n_1^i - ty_1. \quad (33)$$

The utility of the FF&Cs who take both positions i and j as their operating location is

$$u_2^{ij} = \overline{u}_{2m}^i + \overline{u}_{2k}^j + \alpha - t. \quad (34)$$

The utility of the FF&Cs who take position j as their operating location is

$$u_2^j = \overline{u}_2^j + \alpha n_1^j - t\left(1-y_2\right). \quad (35)$$

At point x, the DF&Cs who take position i or j as their operating location are indifferent. So

$$\begin{gathered} u_1^i = u_1^j \\ \overline{u}_1^i + aN_2^i - p_1^i - tx = \overline{u}_1^j + aN_2^j - p_1^j - t(1-x). \end{gathered} \quad (36)$$

Solving it,

$$x = \frac{1}{2} + \frac{\overline{u}_1^i - \overline{u}_1^j}{2t} + \frac{a\left(N_2^i - N_2^j\right)}{2t} + \frac{p_1^j - p_1^i}{2t}. \quad (37)$$

From Figure 3, we know that

$$n_1^i = x. \quad (38)$$

So

$$n_1^i = \frac{1}{2} + \frac{\overline{u}_1^i - \overline{u}_1^j}{2t} + \frac{a\left(N_2^i - N_2^j\right)}{2t} + \frac{p_1^j - p_1^i}{2t}. \quad (39)$$

At point y_1, the FF&Cs who take position i or positions i and j as their operating location are indifferent. So

$$\begin{gathered} u_2^i = u_2^{ij}, \\ \overline{u}_2^i + an_1^i - ty_1 = \overline{u}_{2m}^i + \overline{u}_{2k}^j + a - t. \end{gathered} \quad (40)$$

Solving it,

$$y_1 = 1 + \frac{\overline{u}_{2k}^i - \overline{u}_{2k}^j}{t} - \frac{a}{t}n_1^j. \quad (41)$$

From Figure 3, we know that

$$n_2^i = y_1. \quad (42)$$

So

$$n_2^i = 1 + \frac{\overline{u}_{2k}^i - \overline{u}_{2k}^j}{t} - \frac{a}{t}n_1^j. \quad (43)$$

At point y_2, the FF&Cs who take position j or positions i and j as their operating location are indifferent. So

$$\begin{gathered} u_2^{ij} = u_2^j, \\ \overline{u}_{2m}^i + \overline{u}_{2k}^j + a - t = \overline{u}_2^j + an_1^j - t\left(1-y_2\right). \end{gathered} \quad (44)$$

Solving it,

$$y_2 = \frac{\overline{u}_{2m}^i - \overline{u}_{2m}^j}{t} + \frac{an_1^i}{t}. \quad (45)$$

From Figure 3, we know that

$$\begin{gathered} n_2^j = 1 - y_2, \\ n_2^j = 1 + \frac{\overline{u}_{2m}^j - \overline{u}_{2m}^i}{t} - \frac{a}{t}n_1^i. \end{gathered} \quad (46)$$

Because $n_2^i + N_2^j = 1$ and $n_2^j + N_2^i = 1$, $N_2^j = 1 - n_2^i$ and $N_2^i = 1 - n_2^j$. So $N_2^i - N_2^j = (1-n_2^j) - (1-n_2^i) = n_2^i - n_2^j$. Because $n_1^i + n_1^j = 1$, $n_1^j = 1 - n_1^i$.

Substituting $N_2^i - N_2^j$ into formula (39), we can get

$$n_1^i = \frac{1}{2} + \frac{\overline{u}_1^i - \overline{u}_1^j}{2t} + \frac{a\left(n_2^i - n_2^j\right)}{2t} + \frac{p_1^j - p_1^i}{2t}. \quad (47)$$

Because $n_2^i - n_2^j = (\overline{u}_{2k}^i - \overline{u}_{2k}^j + \overline{u}_{2m}^i - \overline{u}_{2m}^j)/t + a(n_1^i - n_1^j)/t$, $n_1^i - n_1^j = n_1^i - 1 + n_1^i = 2n_1^i - 1$.

So

$$n_2^i - n_2^j = \frac{\overline{u}_{2k}^i - \overline{u}_{2k}^j + \overline{u}_{2m}^i - \overline{u}_{2m}^j}{t} + \frac{a}{t}\left(2n_1^i - 1\right). \quad (48)$$

Substitute formula (48) into formula (47). Solving it, we can get

$$n_1^i = \frac{1}{2} + \frac{t\left(\overline{u}_1^i - \overline{u}_1^j\right)}{2\left(t^2 - a^2\right)} + \frac{a\left(\overline{u}_{2k}^i - \overline{u}_{2k}^j + \overline{u}_{2m}^i - \overline{u}_{2m}^j\right)}{2\left(t^2 - a^2\right)} + \frac{t\left(p_1^j - p_1^i\right)}{2\left(t^2 - a^2\right)}. \quad (49)$$

Because $n_1^j = 1 - n_1^i$,

$$n_1^j = \frac{1}{2} - \frac{t\left(\overline{u}_1^i - \overline{u}_1^j\right)}{2\left(t^2 - a^2\right)} - \frac{a\left(\overline{u}_{2k}^i - \overline{u}_{2k}^j + \overline{u}_{2m}^i - \overline{u}_{2m}^j\right)}{2\left(t^2 - a^2\right)} - \frac{t\left(p_1^j - p_1^i\right)}{2\left(t^2 - a^2\right)}. \quad (50)$$

Profit functions are

$$\begin{aligned}\pi^i &= n_1^i \cdot p_1^i = \left[\frac{1}{2} + \frac{tV_1^d}{2\left(t^2 - \alpha^2\right)} + \frac{\alpha}{2\left(t^2 - \alpha^2\right)}\left(V_{2m}^d - V_{2k}^d\right) + \frac{p_1^j t}{2\left(t^2 - \alpha^2\right)} - \frac{p_1^i t}{2\left(t^2 - \alpha^2\right)}\right] \cdot p_1^i, \\ \pi^j &= n_1^j \cdot p_1^j = \left[\frac{1}{2} - \frac{t}{2\left(t^2 - \alpha^2\right)}V_1^d - \frac{\alpha}{2\left(t^2 - \alpha^2\right)}\left(V_{2m}^d - V_{2k}^d\right) - \frac{p_1^j t}{2\left(t^2 - \alpha^2\right)} + \frac{p_1^i t}{2\left(t^2 - \alpha^2\right)}\right] \cdot p_1^j\end{aligned} \quad (51)$$

π^i is the function of p_1^i; take the first-order derivative of p_1^i; π^j is the function of p_1^j; take the first-order derivative of p_1^j; the reaction functions are

$$\frac{\partial \pi_1}{\partial p_1^i} = \frac{1}{2} + \frac{t}{2\left(t^2 - \alpha^2\right)}V_1^d + \frac{\alpha}{2\left(t^2 - \alpha^2\right)}\left(V_{2m}^d - V_{2k}^d\right) + \frac{p_1^j t}{2\left(t^2 - \alpha^2\right)} - \frac{p_1^i t}{\left(t^2 - \alpha^2\right)}, \quad (52)$$

$$\frac{\partial \pi_2}{\partial p_1^j} = \frac{1}{2} - \frac{t}{2\left(t^2 - \alpha^2\right)}V_1^d - \frac{\alpha}{2\left(t^2 - \alpha^2\right)}\left(V_{2m}^d - V_{2k}^d\right) + \frac{p_1^i t}{2\left(t^2 - \alpha^2\right)} - \frac{p_1^j t}{\left(t^2 - \alpha^2\right)}. \quad (53)$$

Let the reaction functions be zero, respectively, and the Bertrand-Nash equilibrium prices are

$$\begin{aligned}p_1^i &= \frac{t^2 - \alpha^2}{t} + \frac{1}{3}V_1^d + \frac{\alpha}{3t}\left(V_{2m}^d - V_{2k}^d\right), \\ p_1^j &= \frac{t^2 - \alpha^2}{t} - \frac{1}{3}V_1^d - \frac{\alpha}{3t}\left(V_{2m}^d - V_{2k}^d\right).\end{aligned} \quad (54)$$

When $t > \alpha$, $\partial\pi^2/\partial(p_1^i)^2 < 0$, $\partial\pi^2/\partial(p_1^j)^2 < 0$, p_1^i and p_1^j are the solutions when π is maximization.

Lemma 2. *The user scale of the DF&Cs who take position i as their operating location is* $n_1^i = 1/2 + (t/6(t^2 - \alpha^2))V_1^d + (\alpha/6(t^2 - \alpha^2))(V_{2m}^d - V_{2k}^d)$, *the user scale of the DF&Cs who take position j as their operating location is* $n_1^j = 1/2 - (t/6(t^2 - \alpha^2))V_1^d - (\alpha/6(t^2 - \alpha^2))(V_{2m}^d - V_{2k}^d)$, *the user scale of the FF&Cs who take position i only or take positions i, j as their operating location is* $N_2^i = \alpha/2t + V_{2m}^d/t + (\alpha/6(t^2 - \alpha^2))V_1^d + (\alpha^2/6t(t^2 - \alpha^2))(V_{2m}^d - V_{2k}^d)$, *the user scale of the FF&Cs who take position j only or take positions i, j as their operating location is* $N_2^j = \alpha/2t + V_{2k}^d/t - (\alpha/6(t^2 - \alpha^2))V_1^d - (\alpha^2/6t(t^2 - \alpha^2))(V_{2m}^d - V_{2k}^d)$, *the cost of DF&Cs who take the position i as their operating location is* $p_1^i = (t^2 - \alpha^2)/t + (1/3)V_1^d + (\alpha/3t)(V_{2m}^d - V_{2k}^d)$, *the cost of DF&Cs who take the position j as their operating location is* $p_1^j = (t^2 - \alpha^2)/t - (1/3)V_1^d - (\alpha/3t)(V_{2m}^d - V_{2k}^d)$, *and the total income of the North area is* $\pi = (t^2 - \alpha^2)/t + (t/9(t^2 - \alpha^2))[V_1^d + (\alpha/t)(V_{2m}^d - V_{2k}^d)]^2$.

Proof. According to formula (49),

$$n_1^i = \frac{1}{2} + \frac{t\left(\overline{u}_1^i - \overline{u}_1^j\right)}{2\left(t^2 - a^2\right)} + \frac{a\left(\overline{u}_{2k}^i - \overline{u}_{2k}^j + \overline{u}_{2m}^i - \overline{u}_{2m}^j\right)}{2\left(t^2 - a^2\right)} + \frac{t\left(p_1^j - p_1^i\right)}{2\left(t^2 - a^2\right)}. \quad (55)$$

Substitute formula (54) into it and simplify it. We can get

$$n_1^i = \frac{1}{2} + \frac{t}{6\left(t^2 - \alpha^2\right)}V_1^d + \frac{\alpha}{6\left(t^2 - \alpha^2\right)}\left(V_{2m}^d - V_{2k}^d\right). \quad (56)$$

According to formula (50),

$$n_1^j = \frac{1}{2} - \frac{t\left(\overline{u}_1^i - \overline{u}_1^j\right)}{2\left(t^2 - a^2\right)} - \frac{a\left(\overline{u}_{2k}^i - \overline{u}_{2k}^j + \overline{u}_{2m}^i - \overline{u}_{2m}^j\right)}{2\left(t^2 - a^2\right)} - \frac{t\left(p_1^j - p_1^i\right)}{2\left(t^2 - a^2\right)}. \quad (57)$$

Substitute formula (54) into it and simplify it. We can get

$$n_1^j = \frac{1}{2} - \frac{t}{6\left(t^2 - \alpha^2\right)}V_1^d - \frac{\alpha}{6\left(t^2 - \alpha^2\right)}\left(V_{2m}^d - V_{2k}^d\right). \quad (58)$$

From Figure 3, we know that

$$N_2^i = 1 - n_2^j. \quad (59)$$

According to formula (46),

$$N_2^i = \frac{\overline{u}_{2m}^i - \overline{u}_{2m}^j}{t} + \frac{a}{t} n_1^i. \tag{60}$$

Substitute formula (56) into it and simplify it. We can get

$$\begin{aligned} N_2^i = {} & \frac{\alpha}{2t} + \frac{V_{2m}^d}{t} + \frac{\alpha}{6\left(t^2-\alpha^2\right)} V_1^d \\ & + \frac{\alpha^2}{6t\left(t^2-\alpha^2\right)}\left(V_{2m}^d - V_{2k}^d\right). \end{aligned} \tag{61}$$

From Figure 3, we know that

$$N_2^j = 1 - n_2^i. \tag{62}$$

According to formula (43),

$$N_2^j = \frac{\overline{u}_{2k}^j - \overline{u}_{2k}^i}{t} + \frac{a}{t} n_1^j. \tag{63}$$

Substitute formula (58) into it and simplify it. We can get

$$\begin{aligned} N_2^j = {} & \frac{\alpha}{2t} + \frac{V_{2k}^d}{t} - \frac{\alpha}{6\left(t^2-\alpha^2\right)} V_1^d \\ & - \frac{\alpha^2}{6t\left(t^2-\alpha^2\right)}\left(V_{2m}^d - V_{2k}^d\right). \end{aligned} \tag{64}$$

According to formula (54), $p_1^i = (t^2-\alpha^2)/t + (1/3)V_1^d + (\alpha/3t)(V_{2m}^d - V_{2k}^d)$ and $p_1^j = (t^2-\alpha^2)/t - (1/3)V_1^d - (\alpha/3t)(V_{2m}^d - V_{2k}^d)$.

Substitute formula (54) into formula (51). Add them and simplify; we can get

$$\pi = \frac{\left(t^2-\alpha^2\right)}{t} + \frac{t}{9\left(t^2-\alpha^2\right)}\left[V_1^d + \frac{\alpha}{t}\left(V_{2m}^d - V_{2k}^d\right)\right]^2. \tag{65}$$

□

5. A Comparative Analysis of Model (I) and Model (II)

Under normal condition, the reservation utility of side 1 DF&Cs who take the position i as their operating locations $\overline{u}_1^i$ is much bigger than V_1^d which is the difference of the utility of DF&Cs who take the position i as their operating locations and the DF&Cs who take the position j as their operating locations. And $\overline{u}_1^i$ is much bigger than V_2^d which is the difference of the utility of FF&Cs who take the position i as their operating locations and the FF&Cs who take the position j as their operating locations. The relationships are also existing to $\overline{u}_1^j$, V_1^d and V_2^d. So we get Proposition 3.

Proposition 3. *Dalian and Tianjin should charge different price to the DF&Cs from zone A and zone B. And the price and total income of the two cities from zone A are higher than those from zone B.*

Proof. According to Lemmas 1 and 2, one has the following.

From zone A,

$$\begin{aligned} p_1^i &= \frac{1}{2}\overline{u}_1^i + \frac{\alpha}{2t} V_{2m}^d, \\ p_1^j &= \frac{1}{2}\overline{u}_1^j + \frac{\alpha}{2t} V_{2k}^d, \\ \pi &= \frac{t}{4\left(t^2-\alpha^2\right)}\left[\left(\overline{u}_1^i + \frac{\alpha}{t}V_{2m}^d\right)^2 + \left(\overline{u}_1^j + \frac{\alpha}{t}V_{2k}^d\right)^2\right]. \end{aligned} \tag{66}$$

From zone B,

$$\begin{aligned} p_1^i &= \frac{t^2-\alpha^2}{t} + \frac{1}{3}V_1^d + \frac{\alpha}{3t}\left(V_{2m}^d - V_{2k}^d\right), \\ p_1^j &= \frac{t^2-\alpha^2}{t} - \frac{1}{3}V_1^d - \frac{\alpha}{3t}\left(V_{2m}^d - V_{2k}^d\right), \\ \pi &= \frac{\left(t^2-\alpha^2\right)}{t} \\ &\quad + \frac{t}{9\left(t^2-\alpha^2\right)}\left[V_1^d + \frac{\alpha}{t}\left(V_{2m}^d - V_{2k}^d\right)\right]^2. \end{aligned} \tag{67}$$

They are different and that means Dalian and Tianjin should charge different price in different zones.

$\overline{u}_1^i$ and $\overline{u}_1^j$ are the reservation utility of the two cities; they are absolute values. V_1^d, V_2^d, V_m^d, and V_k^d are the difference value. Under normal condition the difference values are much smaller than the absolute values. So the price and total income of the two cities from zone A are higher than those from zone B. □

Proposition 4. *When the intensity of cross network effects between the two-sided users increases, the cost of DF&Cs from zone A who take Dalian and Tianjin as operating locations and the total income of the North area from zone A will be increased accordingly.*

Proof.

$$\begin{aligned} \frac{\partial p_1^i}{\partial \alpha} &= \frac{V_{2m}^d}{2t} > 0, \\ \frac{\partial p_1^j}{\partial \alpha} &= \frac{V_{2k}^d}{2t} < 0, \\ \frac{\partial \pi}{\partial \alpha} & \\ &= \frac{\left(t\overline{u}_1^i + \alpha V_{2m}^d\right)\left(\alpha\overline{u}_1^i + tV_{2m}^d\right) + \left(t\overline{u}_1^j + \alpha V_{2k}^d\right)\left(\alpha\overline{u}_1^j + tV_{2k}^d\right)}{2\left(t^2-\alpha^2\right)^2} \\ &> 0. \end{aligned} \tag{68}$$

So the North area can take measures to increase the intensity between cross network effects of two-sided users in order to increase the viscosity between two-sided users and to improve the service experience of two-sided users. Ultimately it can improve the revenue of Dalian and Tianjin. □

Table 1: The set of the characters and the results.

Characters	Situation 1		Situation 2		Situation 3		Situation 4	
	Zone A	Zone B	Zone A	Zone B	Zone A	Zone B	Zone A	Zone B
$\overline{u}_1^i$	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
$\overline{u}_1^j$	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500
$\overline{u}_{2m}^i$	1.250	1.250	1.250	1.250	2.050	2.050	1.250	1.250
$\overline{u}_{2m}^j$	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
$\overline{u}_{2k}^i$	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
$\overline{u}_{2k}^j$	1.200	1.200	1.200	1.200	1.200	1.200	1.300	1.300
t	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
a	0.300	0.300	0.500	0.500	0.300	0.300	0.300	0.300
p_1^i	5.038	1.122	5.063	0.992	5.158	1.202	5.038	1.132
p_1^j	4.780	0.698	4.800	0.508	4.780	0.618	4.795	0.688
π	52.994	0.959	64.892	0.828	54.339	1.003	53.152	0.964

When the differences of quality utility V_{2m}^d and price utility V_{2k}^d for the FF&Cs who take positions i and j as their operating locations increase, the price and total income of the North area will be increased accordingly. So we get Proposition 5.

Proposition 5. *When the differences of quality utility and price utility increase, the price of the DF&Cs from zone A who take North area as their operating locations and the income of the North area from zone A will be increased.*

Proof.

$$\begin{aligned}
\frac{\partial p_1^i}{\partial V_{2m}^d} &= \frac{\alpha}{2t} > 0, \\
\frac{\partial p_1^j}{\partial V_{2k}^d} &= \frac{\alpha}{2t} > 0, \\
\frac{\partial \pi}{\partial V_{2m}^d} &= \frac{t\alpha\overline{u}_1^i + \alpha^2 V_{2m}^d}{2t\,(t-\alpha)\,(t+\alpha)}, \\
\frac{\partial \pi}{\partial V_{2k}^d} &= \frac{t\alpha\overline{u}_1^j + \alpha^2 V_{2k}^d}{2t\,(t-\alpha)\,(t+\alpha)}.
\end{aligned} \tag{69}$$

When $t > \alpha$, then we can get: $\partial\pi/\partial V_{2m}^d > 0$, $\partial\pi/\partial V_{2k}^d > 0$. □

The North area can arrange service with bigger difference of quality on Dalian and Tianjin, respectively, so the North area can get more income. For example, compared with providing the same service in Dalian and Tianjin providing difference services in Dalian and Tianjin, the quality utility of the latter is better than the former, and the North area (both Dalian and Tianjin) can get more income.

6. Numerical Example

Suppose Dalian and Tianjin face four situations; the set of the characters and the results are shown in Table 1.

Comparing the results of zone A and zone B, p_1^i, p_1^j, and π are different, and the former is higher than the latter. So Proposition 3 is confirmed.

Comparing the results of Situation 1-zone A and Situation 2-zone A with the increasing of a, p_1^i, p_1^j, and π are increasing.

Comparing the results of Situation 1-zone A and Situation 3-zone A with the increasing of V_{2m}^d, p_1^i, p_1^j, and π are increasing. Comparing the results of Situation 1-zone A and Situation 4-zone A with the increasing of V_{2k}^d, p_1^i, p_1^j, and π are increasing. So Proposition 5 is confirmed.

7. Conclusion

Based on the two-sided markets this paper built two theoretical models to analyze the competitive strategy of cross-border e-commerce comprehensive pilot areas of Dalian and Tianjin of the North area. Through the equilibrium results of comparative static analysis, this article draws the following conclusions.

(1) Dalian and Tianjin should charge different price to the DF&Cs from zone A and zone B. And the price and total income of the two cities from zone A are higher than those from zone B.

(2) The strength of network effects between groups will affect the revenue of the North area. The greater the network effect is, the greater the revenue of the North area will be.

(3) When the FF&Cs take the North area as the operating location, the difference of the quality utility and the difference of the price utility impact the revenue of the North area. The greater the difference in the quality utility or price utility is, the greater the income of the North area will be.

But there are still some shortcomings of this model. First, this model is a theory model; it is hard to use in practice. The characters should be collected and evaluated. Second some assumptions are too strict; for example, the DF&Cs from C and D zones may not choose Dalian or Tianjin as their operation location. Also DF&Cs in zone B may also choose

other cross-border e-commerce comprehensive pilot areas as their operation location.

Even though the model still casts same managerial implications to us,

(1) in order to maximize their revenue, Dalian and Tianjin should charge different price for the DF&Cs from different zones;

(2) in order to increase the revenue from zone A, the cities can increase the network effects a, the difference of quality utility V_{2m}^{d}, and the price utility V_{2k}^{d}.

Future research: in this article South area is set exogenous, in the future research we can make it endogenous in the model. Another possible direction is to verify the model proposed in this article through simulation.

Competing Interests

The authors declare that they have no competing interests.

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