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Research on Transfer Pricing Strategy Based on Incomplete Information

Shuting Yi[1], Shaogang Chen[1,*]

[1]School of Mathematical Sciences, University of Electronic Science and Technology of China, Sichuan, Chengdu 611731, China
[*]Corresponding author. Email: csg1966@163.com

ABSTRACT
This paper studies the transfer pricing of enterprise groups when there is incomplete information about the cost in the final product market. It also compares the transfer price, balanced output and profits of the group headquarters under the two methods of uniform pricing and differential pricing. The conclusions are as follows: The internal transfer price of the intermediate product and the equilibrium output of the downstream subsidiary and the external market, the size relation under the two pricing methods is related to the low cost identification factor and the probability that the cost of the external market is high; and the headquarters of the group can get higher profits by differential pricing of intermediate products than by uniform pricing.
Keywords: *Incomplete information, transfer pricing, low cost identification factor, differential pricing*

1. INTRODUCTION

As an important means of tax avoidance and profit adjustment for multinational corporations, transfer pricing has been widely concerned by domestic and foreign scholars for a long time. Most of the early researches were about the concepts and motivations of transfer pricing, and the transfer pricing was carried out in the group headquarters only according to the group itself, ignoring the influence of competitors in the external market on the effect of transfer pricing. Alles and Datar[1] were the first to incorporate the decisions of competitors into the decision of transfer pricing. They pointed out that enterprises should make their own decisions based on the strategies of competitors, rather than making price choices in isolation. Since then, many scholars have begun to study the problem of transfer pricing caused by the existence of external competition among multinational enterprise groups. On this basis, Mu Yinping[2] et al. proposed that group companies should implement price discrimination when there is an external market, which can achieve higher profits compared with unified pricing. Further, Gox[3] studied that the optimal transfer price is greater than the marginal cost of the intermediate product under the condition that there is an external market for the intermediate product and the information is fully sufficient. Under the condition of stacklberg competition in the downstream market, Hu Roncuo[4] et al. demonstrated that differential pricing is more profitable than marginal cost pricing. Mu Yinping and tang Xiaow[5] et al. studied the transfer pricing problem of enterprise groups when there was oligopoly competition in the external market for intermediate products, and considered the optimal transfer price when single pricing was implemented in the internal and external markets and differentiated pricing was implemented. Wan shouyi and wang jing[6] expanded the competitive mode of downstream market from single to mixed, studies the transfer pricing decision of multi-sector enterprise groups facing mixed competition in the final product market under the condition of complete cost information, and draws relevant conclusions.

It can be seen from the existing research results that the transfer pricing under the external market of intermediate products has been studied in detail. Existing literature is always based on downstream markets, where the marginal cost of an enterprise is known information. However, in the actual production, the cost function of the downstream market is often incomplete information, and the downstream competitors cannot completely determine each other's production function. Therefore, this paper mainly uses the method of game theory to study the transfer pricing of Stacklberg competition among enterprise groups in the final product market, assuming that the external market cost information is not complete, and compares the transfer pricing strategies and results of differential pricing and unified pricing.

2. ASSUMPTIONS OF THE MODEL

In order to be comparable with the existing research results, the following assumptions are made.

(1) A multinational enterprise group consists of an upstream enterprise U (parent company) and a downstream enterprise D_1 (subsidiary). In the final product market where the downstream enterprise is located, there is also an external market D_2 as its competitor. The upstream enterprises produce intermediate products and sell them to the downstream market enterprises D_1 and D_2, which are

further processed into final products. The upstream enterprises have monopoly advantages over the intermediate products they produce. For example, Microsoft corporation produces Microsoft systems, sells them to its own downstream companies and to other competitors, and has a monopoly on system production. The upstream enterprise can fully meet all the market demands of the downstream enterprise for intermediate products, and the cost required by the upstream enterprise to produce one unit of intermediate products is recorded as c.

(2) In the final product market, there is no difference between the products produced by the two manufacturers, and they compete for output in the final product market. Suppose the demand function of the final product market is $p_i = a - q_i - q_j$ .Where q_i is the output of the manufacturer D_i's products, and p_i is the price of the manufacturer D_i's products.

(3) Assume that a unit of final product need to consume one unit of intermediate product, D_1 is a well-known multinational enterprise group subsidiary, the intermediate products can be converted to the final product cost per unit is an open, set to c_1, D_2 is a little known enterprise, the unit cost may be high cost c_2^h, may also be a low cost c_2^l, including $c_2^l < c_1 < c_2^h$. Therefore, enterprise D_1 cannot completely determine the cost function of enterprise D_2. It only knows that the probability of D_2 being high cost is μ, and the probability of D_2 being low cost is $1 - \mu$, where μ is the known information of both parties.

(4) The multinational enterprise group is partially decentralized. The final product output and price are decided by D_1's manager, and the intermediate product price and production are decided by U. It is assumed that when D_1 and D_2 decide the final product output, they can completely observe the intermediate product transfer price and external sales price set by U. Moreover, as U is a monopolist in the intermediate product market, D_1 has a long-term leading position in the final product market. Therefore, after observing the pricing, D_1 makes the choice of output first, and then D_2 makes the choice of its own output. That is, the end product market is the Stacklberg competitive model. The decision-making process is a dynamic game with incomplete information.

3. MODELING

According to the model assumption, the decision order of each game party is as follows:

Stage one: On the premise of maximizing the profits of their own headquarters, the upstream enterprises price the intermediate products of the downstream enterprises and the external market.

Stage two: After observing U's decisions, D_1 determine the output in the final product market on the premise of maximizing their own profits.

Stage three: After observing the decisions of U and D_1, D_2 determines the output of the final product market in terms of profit maximization.

3.1. Uniform pricing

The selling price of intermediate products sold in a uniform pricing method is denoted as w. According to the backward induction method of dynamic game solving, the third stage of game is analyzed firstly. Since the unit cost of producing the final product in the external market is private information, it is necessary to determine the optimal output q_2^h and q_2^l of D_2 at high cost and low cost respectively after observing the price of intermediate products and the optimal output of the D_1 in stage three.

When the unit cost of D_2 is high, the profit maximization expression is

$$max\ \pi_2^h = \left(a - q_1 - q_2^h - w - c_2^h\right) \cdot q_2^h \quad (1)$$

According to the first-order condition of profit maximization, the reaction function under the high cost of D_2 is

$$q_2^{h*} = \frac{a - q_1 - w - c_2^h}{2} \quad (2)$$

Similarly, the reaction function of D_2 at low cost is

$$q_2^{l*} = \frac{a - q_1 - w - c_2^l}{2} \quad (3)$$

In the analysis of the second stage of game, before making a decision, D_1 understands the production decision-making mode of D_2 under its high cost and low cost. However, since D_1 does not know the real cost of D_2, D_1 will choose q_1 under the expected profit function to maximize its own profit. The expected profit maximization expression is

$$max\ \pi_1 = \left(a - q_1 - q_2^{h*} - w - c_1\right) \cdot q_1 \cdot \mu + \left(a - q_1 - q_2^{l*} - w - c_1\right) \cdot q_1 \cdot (1 - \mu) \quad (4)$$

According to the first-order condition of profit maximization, the reaction function under the high cost of D_1 is

$$q_1^* = \frac{a - w - 2c_1 + c_2^h \cdot \mu + c_2^l \cdot (1 - \mu)}{2} \quad (5)$$

According to equation (5), we can get the optimal output function of D_2 under high cost and low cost is

$$\begin{cases} q_2^{h*} = \dfrac{a - w + 2c_1 - c_2^h \cdot (2 + \mu) - c_2^l \cdot (1 - \mu)}{4} \\ q_2^{l*} = \dfrac{a - w + 2c_1 - c_2^h \cdot \mu - c_2^l \cdot (3 - \mu)}{4} \end{cases} \quad (6)$$

Finally, in game stage one, U determines w according to the output functions of D_1 and D_2 obtained in stage two and stage three, so as to maximize its own profit

$$max\ \pi_U = (w - c) \cdot \left(\left(q_1^* + q_2^{h*}\right)\mu + \left(q_1^* + q_2^{l*}\right) \cdot (1 - \mu)\right) \quad (7)$$

According to the first-order conditions of profit maximization, the equilibrium transfer price of the intermediate product is

$$w = \frac{3a + 3c - 2c_1 - c_2^h \cdot \mu - c_2^l \cdot (1 - \mu)}{6} \quad (8)$$

By substituting equation (8) into equations (5), (6) and (7), it can be concluded that when the unified pricing is implemented, the optimal output of D_1 and D_2 and the profit of U are respectively

$$\begin{cases} q_1^* = \dfrac{3a-3c-10c_1+7c_2^h\cdot\mu+7c_2^l\cdot(1-\mu)}{12} \\ q_2^{h*} = \dfrac{3a-3c+14c_1-c_2^h\cdot(12+5\mu)-5c_2^l\cdot(1-\mu)}{24} \\ q_2^{l*} = \dfrac{3a-3c+14c_1-5c_2^h\cdot\mu-c_2^l\cdot(17-5\mu)}{24} \end{cases} \quad (9)$$

$$\pi_U = \frac{\left(3a-3c-2c_1-c_2^h\cdot\mu-c_2^l\cdot(1-\mu)\right)^2}{48} \quad (10)$$

3.2. Differential Pricing

The internal transfer price and external selling price of the intermediate product sold by differential pricing are recorded as w_1 and w_2. The production of D_2 is considered first. Since the unit cost of producing the final product in the external market is private information, it is necessary to determine the optimal output q_2^h and q_2^l of D_2 at high cost and low cost respectively after observing the price of intermediate products and the optimal output of the D_1 in stage three.

When the unit cost of D_2 is high, the profit maximization expression is

$$max\,\pi_2^h = \left(a-q_1-q_2^h-w_2-c_2^h\right)\cdot q_2^h \quad (11)$$

According to the first-order condition of profit maximization, the reaction function under the high cost of D_2 is

$$q_2^{h*} = \frac{a-q_1-w_2-c_2^h}{2} \quad (12)$$

Similarly, the reaction function of D_2 at low cost is

$$q_2^{l*} = \frac{a-q_1-w_2-c_2^l}{2} \quad (13)$$

In the analysis of the second stage of game, before making a decision, D_1 understands the production decision-making mode of D_2 under its high cost and low cost. However, since D_1 does not know the real cost of D_2, D_1 will choose q_1 under the expected profit function to maximize its own profit. The expected profit maximization expression is

$$\begin{aligned} max\,\pi_1 = &\left(a-q_1-q_2^{h*}-w_1-c_1\right)\cdot q_1\cdot\mu + \\ &\left(a-q_1-q_2^{l*}-w_1-c_1\right)\cdot q_1\cdot(1-\mu) \end{aligned} \quad (14)$$

According to the first-order condition of profit maximization, the reaction function under the high cost of D_1 is

$$q_1^* = \frac{a-2c_1+w_2-2w_1+c_2^h\cdot\mu+c_2^l\cdot(1-\mu)}{2} \quad (15)$$

According to equation (15), we can get the optimal output function of D_2 under high cost and low cost is

$$\begin{cases} q_2^{h*} = \dfrac{a-3w_2+2w_1+2c_1-c_2^h\cdot(2+\mu)-c_2^l\cdot(1-\mu)}{4} \\ q_2^{l*} = \dfrac{a-3w_2+2w_1+2c_1-c_2^h\cdot\mu-c_2^l\cdot(3-\mu)}{4} \end{cases} \quad (16)$$

Finally, in game stage one, U determines w_1 and w_2 according to the output functions of D_1 and D_2 obtained in stage two and stage three, so as to maximize its own profit

$$max\,\pi_U = (w_1-c)\cdot q_1^* + (w_2-c)\cdot\left(q_2^{h*}\cdot\mu+q_2^{l*}\cdot(1-\mu)\right) \quad (17)$$

According to the first-order conditions of profit maximization, the internal transfer price and external sales price of intermediate products can be obtained as

$$\begin{cases} w_1 = \dfrac{a+c-c_1}{2} \\ w_2 = \dfrac{a+c-c_2^h\cdot\mu-c_2^l\cdot(1-\mu)}{2} \end{cases} \quad (18)$$

By substituting equation (18) into equations (15), (16) and (17), it can be concluded that when the differential pricing is implemented, the optimal output of D_1 and D_2 and the profit of U are respectively

$$\begin{cases} q_1^* = \dfrac{a-c-2c_1+c_2^h\cdot\mu+c_2^l\cdot(1-\mu)}{4} \\ q_2^{h*} = \dfrac{a-c+2c_1-c_2^h\cdot(4-\mu)+c_2^l\cdot(1-\mu)}{8} \\ q_2^{l*} = \dfrac{a-c+2c_1+c_2^h\cdot\mu-c_2^l\cdot(3+\mu)}{8} \end{cases} \quad (19)$$

$$\begin{aligned} \pi_U = &\frac{1}{16}\left(a-c-\left(c_2^h\cdot\mu+c_2^l\cdot(1-\mu)\right)\right)^2 + \\ &\frac{1}{8}\left(\left(a-c-c_1\right)^2+\left(c_2^h\cdot\mu+c_2^l\cdot(1-\mu)-c_1\right)^2\right) \end{aligned} \quad (20)$$

4. COMPARISON OF UNIFORM PRICING DIFFERENTIAL PRICING

Comparing the two transfer pricing methods, the following conclusions are drawn.

For the convenience of conclusion two and three, low cost identification factor is introduced, denoted as λ , and equation $\lambda = (c_2^h - c_1)/(c_2^h - c_2^l)$ holds, where $\lambda \in (0,1)$.With the determination of c_2^h and c_2^l, λ can reflect the degree to which the unit cost of the downstream subsidiary is far away from the high cost in the external market[7].

Conclusion one: The price w of the uniform pricing of the intermediate product must be between the price w_1 and w_2 of differential pricing.

Proof: Notice that, by equations (8) and (18)

$$w-w_1 = \frac{c_1-\left(c_2^h\cdot\mu+c_2^l\cdot(1-\mu)\right)}{6} \quad (21)$$

$$w-w_2 = \frac{c_2^h\cdot\mu+c_2^l\cdot(1-\mu)-c_1}{3} \quad (22)$$

the two above are different signs, so that conclusion one is established.

Conclusion two: When differential pricing is implemented for intermediate products, the relationship between the internal transfer price and the external selling price is related to low cost identification factor and the probability that the cost of D_2 is high.

Proof: According to the low cost identification, c_1 can be represented by c_2^h and c_2^l, that is $c_1 = c_2^h - \lambda \cdot (c_2^h - c_2^l)$, and then by equation (18)

$$w_2 - w_1 = \frac{\left(c_2^h - c_2^l\right)\left(1-\mu-\lambda\right)}{2} \quad (23)$$

by equation (23), conclusion one and $c_2^h > c_2^l$

if $\mu + \lambda > 1$, then $w_1 > w > w_2$, whereas if $\mu + \lambda < 1$, then $w_1 < w < w_2$, finally if $\mu + \lambda = 1$, then $w_1 = w = w_2$, so that conclusion two is established.

Conclusion three: The output of D_1 and D_2 is affected by the low cost identification factor and the probability that the cost of D_2 is high when uniform and differential pricing are implemented for intermediate products.

Proof: Take equation (15) minus equation (5), equation (16) minus equation (6), and introduce the low cost identification factor

$$q_{1C} - q_{1T} = \frac{\left(c_2^h - c_2^l\right)\left(1-\mu-\lambda\right)}{3} \quad (24)$$

$$q_{2C}^h - q_{2T}^h = q_{2C}^l - q_{2T}^l = \frac{\left(c_2^h - c_2^l\right)\left(\mu+\lambda-1\right)}{3} \quad (25)$$

by equations (24) and (25), and $c_2^h > c_2^l$

if $\mu + \lambda > 1$, then $q_{1C} < q_{1T}, q_{2C}^h > q_{2T}^h$, $q_{2C}^l > q_{2T}^l$, whereas if $\mu + \lambda < 1$, then $q_{1C} > q_{1T}, q_{2C}^h < q_{2T}^h$, $q_{2C}^l < q_{2T}^l$, finally if $\mu + \lambda = 1$, then $q_{1C} = q_{1T}, q_{2C}^h = q_{2T}^h, q_{2C}^l = q_{2T}^l$, so that conclusion three is established.

Conclusion four: No matter how much value μ and λ are, the group headquarters will make higher profits by adopting differential pricing for intermediate products than by adopting uniform pricing.

Proof: Put $c_1 = c_2^h - \lambda \cdot (c_2^h - c_2^l)$ into equations (10) and (20), and get the profits of the group headquarters under unified pricing and differential pricing. Then subtract the two equations and get

$$\Delta\pi = \pi_{UC} - \pi_{UT} = \quad (26)$$

$$\frac{\left(a - c - c_2^h\left(1-\mu\right) - c_2^l \cdot \mu\right)^2 + c_2^h\left(2+\mu-2\lambda\right) + c_2^l\left(1+\lambda-\mu\right)}{48} > 0$$

That is $\pi_{UC} > \pi_{UT}$, so that conclusion four is established.

Note: To facilitate the distinction between uniform pricing and differential pricing, T and C are added to each parameter to represent the results obtained under uniform pricing and differential pricing, respectively.

5. ANALYSIS OF EXAMPLES

The above is a theoretical analysis of the pricing of intermediate products by transnational corporations with external markets. In order to better explain the decision result and the uncertainty of price and output under unified pricing and differential pricing, the following two specific examples are analyzed and solved.

(1) Suppose there is a multinational enterprise group in the market consisting of upstream and downstream subsidiaries. Upstream subsidiaries sell intermediate products in the final product market. The downstream subsidiary has an external market to compete with it in the final product market, and downstream subsidiaries have a leading position. The demand function of the final product market is $p = 50 - q_1 - q_2$. Upstream subsidiary costs 5 to produce an intermediate unit, and the unit cost for the downstream subsidiary to convert the intermediate product into the final product is 2.5. There is an 80 percent chance that the unit cost of the external market is high cost, and high unit cost is 5, low unit cost is 1.That is $a = 50, \mu = 0.8, c = 5, c_1 = 2.5, c_2^h = 5, c_2^l = 1, \lambda = 0.625$.

Substitute into the above equilibrium results, and the results are shown in Table 1.

Table 1 Comparison of transfer pricing results when $\mu + \lambda > 1$ is satisfied

	Uniform pricing	Differential pricing
Transfer pricing	$w = 25.97$	$\begin{cases} w_1 = 26.25 \\ w_2 = 25.4 \end{cases}$
The output of downstream subsidiaries	$q_{1T} = 11.6$	$q_{1C} = 11.05$
The output of external market	$\begin{cases} q_{2T}^h = 3.71 \\ q_{2T}^l = 5.71 \end{cases}$	$\begin{cases} q_{2C}^h = 4.275 \\ q_{2C}^l = 6.275 \end{cases}$
The Profits of group headquarters	$\pi_{UT} = 329.7$	$\pi_{UC} = 330.18$

Table 2 Comparison of transfer pricing results when $\mu+\lambda<1$ is satisfied

	Uniform pricing	Differential pricing
transfer pricing	$w=26.4$	$\begin{cases} w_1=26.25 \\ w_2=26.7 \end{cases}$
The output of downstream subsidiaries	$q_{1T}=10.1$	$q_{1C}=10.4$
The output of external market	$\begin{cases} q_{2T}^h=4.25 \\ q_{2T}^l=6.25 \end{cases}$	$\begin{cases} q_{2C}^h=3.95 \\ q_{2C}^l=5.95 \end{cases}$
The Profits of group headquarters	$\pi_{UT}=343.47$	$\pi_{UC}=343.605$

(2) With other conditions unchanged, the probability that the unit cost of the external market is high is changed from 0.8 to 0.15. That is $a=50, \mu=0.15, c=5, c_1=2.5, c_2^h=5, c_2^l=1, \lambda=0.625$.
Substitute into the above equilibrium results, and the results are shown in Table 2:
Can be seen from the example, in a multinational enterprise group to the intermediate product adopt the unified pricing and differential pricing study, the internal transfer price and external selling price of the intermediate product, as well as the equilibrium output of the downstream subsidiary and the external market, the corresponding size relation between them is related to the low cost identification factor and the probability that the cost of the external market is high cost. In addition, the profit of the group headquarters on differential pricing of intermediate products is always higher than the unified pricing.

6. CONCLUSION

This paper studies the optimal transfer pricing of intermediate products by enterprise groups when there is incomplete cost information in the final product market. It is found that the transfer price of intermediate products under uniform pricing must be between the internal transfer price and the external selling price of intermediate products under differential pricing. The internal transfer price of intermediate products is not a single fixed size relationship in the case of uniform pricing and differential pricing, and is related to the low cost identification factor and the probability that the cost of the external market is high cost. When relation $\mu+\lambda>1$ is satisfied, the internal transfer price of the intermediate product when differential pricing is implemented is higher than the internal transfer price when uniform pricing is implemented. When relation $\mu+\lambda<1$ is satisfied, the internal transfer price of intermediate products when differential pricing is implemented is lower than the internal transfer price when uniform pricing is implemented. The relationship between the output of the downstream subsidiary and the external market under the unified pricing and differential pricing is also not fixed. Like the price relationship, it is related to the low cost identification factor and the probability that the cost of the external market is high cost. When relation $\mu+\lambda>1$ is satisfied, the output of the downstream subsidiary under the uniform pricing is higher than that under the differential pricing, and the relationship with the external market is opposite. When relation $\mu+\lambda<1$ is satisfied, the output of the downstream subsidiary under the uniform pricing is lower than that under the differential pricing, and the relationship with the external market is opposite. However, no matter what the circumstances, the profit of the group headquarters on differential pricing of intermediate products is always higher than the unified pricing.

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