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ECONOMIC CONDITIONS ON EXCHANGE OF TECHNOLOGY AND INFORMATION: COURNOT'S MODEL APPLIED TO DEMAND INFORMATION RISK IN CHINA*

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Abstract

A foreign firm is confronted with a demand information risk in the emerging Chinese market, resulting from information disparity between a foreign firm and a Chinese firm. This study analyzes such demand information risk and uses microeconomic theory to derive a management strategy.

There are two main conclusions. Firstly, whether each firm adopts the demand information collection depends on the cost incurred in collecting its information. Furthermore, only one firm will collect the demand information if the gap in the demand information collection costs between both firms is considerable. Secondly, given that only the Chinese firm collects demand information, information sharing is enabled solely by a transaction involving information and technology, rather than information and money. We prove that each firm would be able to utilize the other's advantage if the variance of demand uncertainty were appropriate, not too small or large. Furthermore, we confirm that the possibility to realize such transaction increases when the expected Chinese market size and the technology gap between the foreign and Chinese firms are considerable.

Keywords: Information, Technology, Risk, Cournot's Model, Chinese Market

I. *Introduction*

China is a huge country encompassing 56 races, 1.3 billion people and 9.6 million square kilometers of land, and this sheer market size thus causes considerable variation in the

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consumption pattern of China's consumers. The regional economic gaps arising from the differing economic policies of each local government and the geographical environment that exist throughout the Chinese economy have been growing at a remarkable pace in recent years. This expanding disparity gap among regions is now a major problem. The most typical example of regional disparity is the gap in income and education levels. Regional disparity leads to varying consumption in China and a diversified consumption structure. Thus, we can see that regional disparity complicates the Chinese market.[1]

On the other hand, firms have to collect demand information correctly and quickly in order to improve market competitiveness, since it is vital for product development and brand establishment. However, unsurprisingly, market data in China are either limited or non-existent, given the fact that it remains at a nascent and immature stage. For instance, it is difficult for firms to obtain demand information such as the amount of product sales in the past.[2] Under such circumstances, the Chinese firm, as a local entity, might possibly obtain demand information at a lower cost compared with a foreign equivalent. In other words, the Chinese firm has an advantage in terms of the collection of demand information. If this advantage is relatively large, the Chinese firm will have more demand information than the foreign firm, in which case, there will be asymmetric demand information between the Chinese firm and foreign firm and the foreign firm may be unable to compete against the Chinese firm based on such demand information asymmetry.[3] Therefore, the foreign firm should develop strategies to deal with the demand information risk.

The remainder of this study is organized as follows. Section 2 introduces the economic model that analyzes demand information risk. The possibility for information sharing using the advanced technology is discussed in Section 3, followed by concluding remarks in Section 4.

II. *Economic Modeling and Analysis of Demand Information Risk*

1. The Model

There are two firms: firm F (foreign firm) and firm C (Chinese firm). Assume both are faced with demand uncertainty and both lack accurate demand information unless they collect demand information by monitoring.[4]

To analyze such a situation, we set out the following game, based on the models of Basar and Ho (1974), Ponssard (1979), and Sakai (1990, Chapter 3). In the initial stage, both firms decide whether to engage in information collection. It is possible to obtain exact demand information by monitoring. However, we presume that executing the information collection requires a constant cost. k_C denotes the cost of information collection for firm C and k_F denotes the same for firm F. Moreover, we assume $0 \leq k_C \leq k_F$, because the information

[1] METI (2005) stated that differences in income levels diversified the pattern of Chinese consumption. Moreover, METI (2006) pointed out that the expansion of regional disparities will possibly accelerate the distortion of consumption patterns in China.

[2] See Oliver and Coulter (2004).

[3] For example, Walters and Samiee (2003) provided a case study about the marketing strategy of a foreign firm when it competes with local Chinese firms in an asymmetric information situation.

[4] In contrast, Levine and Ponssard (1977) and Vives (2002) analyzed the market under cost uncertainty.

collection of firm C, which is a local, is more efficient than that of firm F. Furthermore, firms only have random demand quantities if they do not undertake information collection.

In the second stage, both firms commence Cournot competition after making a decision about information collection and both are assumed to be risk-neutral. Subsequently, the expected profits corresponding to the strategy sets are as follows. The left side shows firm F's profit and the right side shows that of firm C. Moreover, denote $E[\bullet]$ as an expected value operator.

{Collection, Collection} : $\{E[\pi_F{}^{11}], E[\pi_C{}^{11}]\}$.

{Collection, No Collection} : $\{E[\pi_F{}^{10}], E[\pi_C{}^{10}]\}$.

{No Collection, Collection} : $\{E[\pi_F{}^{01}], E[\pi_C{}^{01}]\}$.

{No Collection, No Collection}: $\{E[\pi_F{}^{00}], E[\pi_C{}^{00}]\}$.

Furthermore, the demand function faced by both firms is:

$$p=\alpha-q_F-q_C.$$

However, q_F are the sales of firm F and q_C are those of firm C. Moreover, α is assumed to be an intercept of the demand function, which depicts uncertainty in demand. Assume α to be a random variable and $\alpha\sim\phi(\mu, \sigma^2)$. Here, μ is the mean, and σ^2 is the variance (thus, $\mu\equiv E[\alpha]$ and $\sigma^2\equiv E[(\alpha-\mu)^2]$). Furthermore, assume the production cost of both firms to be constant, regardless of output and denote c_F and c_C as the unit production costs of firms F and C, respectively. In addition, $0<c_F<c_C$, which shows that the technology level of firm F exceeds that of firm C.

Based on the above, when the information structure is i, the expected profit function of firm j is as follows:

$$E[\pi_j^i]=(p-c_j)q_j-k_j.$$

2. Cournot Competition

By referring to Sakai (1990, Chapter 3), we classify all possible information structures into four cases and show the expected profit, respectively.

(a) Neither firm conducts information collection:

$$E[\pi_F{}^{00}]=\frac{1}{9}(\mu-2c_F+c_C)^2 \tag{1}$$

$$E[\pi_C{}^{00}]=\frac{1}{9}(\mu-2c_C+c_F)^2. \tag{2}$$

(b) Only firm F conducts information collection:

$$E[\pi_F{}^{10}]=E[\pi_F{}^{00}]+\frac{1}{4}\sigma^2-k_F \tag{3}$$

$$E\left[\pi_C{}^{10}\right]=E\left[\pi_C{}^{00}\right]. \tag{4}$$

(c) Only firm C conducts information collection:

$$E\left[\pi_F{}^{01}\right]=E\left[\pi_F{}^{00}\right] \tag{5}$$

$$E\left[\pi_C{}^{01}\right]=E\left[\pi_C{}^{00}\right]+\frac{1}{4}\sigma^2-k_C. \tag{6}$$

(d) Both firms conduct information collection:

$$E\left[\pi_F{}^{11}\right]=E\left[\pi_F{}^{00}\right]+\frac{1}{9}\sigma^2-k_F \tag{7}$$

$$E\left[\pi_C{}^{11}\right]=E\left[\pi_C{}^{00}\right]+\frac{1}{9}\sigma^2-k_C. \tag{8}$$

3. Deriving the Equilibrium

Based on the results of Cournot competition, we draw the payoff matrix in Figure 1 and determine whether to execute information collection. The expected profits of firms F and C are shown on the left and right sides, respectively. In addition, the row and column strategies describe the strategies of firms F and C, respectively.

FIG. 1. PAYOFF MATRIX

	Collection	No Collection
Collection	π_F^{11}, π_C^{11}	π_F^{10}, π_C^{10}
No Collection	π_F^{01}, π_C^{01}	π_F^{00}, π_C^{00}

The {Collection, Collection} strategy becomes an equilibrium when the information collection costs of both firms are zero (namely, $k_C=k_F=0$). However, the possibility exists for a firm to choose the No Collection strategy if there are costs in collecting information. In this case, whether to choose the No Collection strategy depends on the size of this cost and the cost difference between the two firms. Therefore, we analyze the relationship between the size of the information collection costs and the equilibrium strategy as follows.

The conditions where {Collection, Collection} becomes the equilibrium are:

$$E\left[\pi_F{}^{11}\right]\geq E\left[\pi_F{}^{00}\right] \tag{9}$$

and

$$E\left[\pi_C{}^{11}\right]\geq E\left[\pi_C{}^{00}\right]. \tag{10}$$

Moreover, from the above equalities (7) and (8), we have:

$$E\left[\pi_F{}^{00}\right]+\frac{1}{9}\sigma^2-k_F\geq E\left[\pi_F{}^{00}\right] \tag{11}$$

and

$$E\left[\pi_C{}^{00}\right]+\frac{1}{9}\sigma^2-k_C\geq E\left[\pi_C{}^{00}\right]. \tag{12}$$

Hence, we have $k_F\leq\frac{1}{9}\sigma^2$ and $k_C\leq\frac{1}{9}\sigma^2$.

The conditions where {No Collection, Collection} becomes the equilibrium are:

$$E\left[\pi_F{}^{00}\right]\geq E\left[\pi_F{}^{11}\right] \tag{13}$$

and

$$E\left[\pi_C{}^{01}\right]\geq E\left[\pi_C{}^{00}\right]. \tag{14}$$

Moreover, from the above equalities (7) and (6), we have:

$$E\left[\pi_F{}^{00}\right]\geq E\left[\pi_F{}^{00}\right]+\frac{1}{9}\sigma^2-k_F \tag{15}$$

and

$$E\left[\pi_C{}^{00}\right]+\frac{1}{4}\sigma^2-k_C\geq E\left[\pi_C{}^{00}\right]. \tag{16}$$

Hence, we have $k_F\geq\frac{1}{9}\sigma^2$ and $k_C\leq\frac{1}{4}\sigma^2$.

The conditions where {No Collection, No Collection} becomes the equilibrium are:

$$E\left[\pi_F{}^{00}\right]\geq E\left[\pi_F{}^{10}\right] \tag{17}$$

and

$$E\left[\pi_C{}^{00}\right]\geq E\left[\pi_C{}^{01}\right]. \tag{18}$$

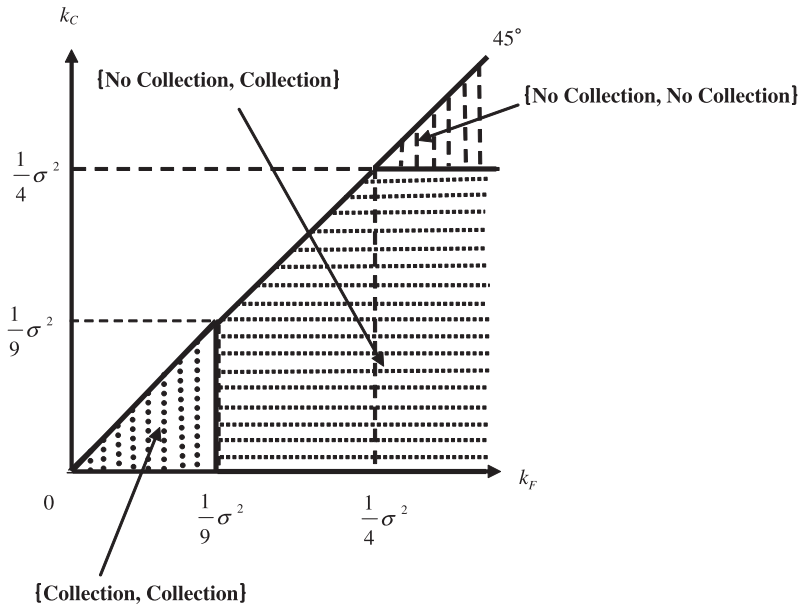
Moreover, from the above equalities (3) and (6), we have:

$$E\left[\pi_F{}^{00}\right]\geq E\left[\pi_F{}^{00}\right]+\frac{1}{4}\sigma^2-k_F \tag{19}$$

and

$$E\left[\pi_C{}^{00}\right]\geq E\left[\pi_C{}^{00}\right]+\frac{1}{4}\sigma^2-k_C. \tag{20}$$

FIG. 2. INFORMATION COLLECTION COST AND EQUILIBRIUM AREA



Hence, we have $k_F \geq \frac{1}{4}\sigma^2$ and $k_C \geq \frac{1}{4}\sigma^2$.[5]

Therefore, we obtain the following proposition from the above analysis.

Proposition [1]:

1. If $k_F \leq \frac{1}{9}\sigma^2$ and $k_C \leq \frac{1}{9}\sigma^2$, {Collection, Collection} becomes the equilibrium.

2. If $k_F \geq \frac{1}{9}\sigma^2$ and $k_C \leq \frac{1}{4}\sigma^2$, {No Collection, Collection} becomes the equilibrium.

3. If $k_F \geq \frac{1}{4}\sigma^2$ and $k_C \geq \frac{1}{4}\sigma^2$, {No Collection, No Collection} becomes the equilibrium.

From Proposition [1], it is clear that when both demand information collection costs are low (high), both firms adopt the Collection (No Collection) strategy. If the gap in the demand information collection costs between both firms is high, namely, the demand information collection cost of the foreign firm is high and that of the Chinese firm is low, only the Chinese firm will collect the demand information. Figure 2 shows the areas depicting both firms' strategies and the realized equilibrium.

[5] {Collection, No Collection} never becomes the equilibrium because $0 \leq k_C \leq k_F$.

III. *The Possibility for Information Sharing*

Consider the situation whereby information collection costs are high for firm F and low for firm C, namely, where firm C has an advantage in information collection. In this situation, firm F intends to obtain the information from firm C, rather than collecting its own.[6] Here, we analyze the existence and conditions of such a possibility.

1. Transactions Involving Information and Money

Firstly, we examine whether firm F can obtain the information from firm C through payment. In other words, can firm F purchase the information?

In order to prove this possibility, denote s as the price of the information at which firms F and C can consummate the deal. We can state the expected profits of firm F before and after purchasing the information from firm C as follows:

$$\text{Before purchasing the information: } E\left[\pi_F{}^{00}\right]. \tag{1}$$

$$\text{After purchasing the information: } E\left[\pi_F{}^{00}\right]+\frac{1}{9}\sigma^2-s. \tag{21}$$

In contrast, the expected profits of firm C before and after selling the information to firm F are denoted as follows:

$$\text{Before selling the information: } E\left[\pi_C{}^{00}\right]+\frac{1}{4}\sigma^2-k_C. \tag{6}$$

$$\text{After selling the information: } E\left[\pi_C{}^{00}\right]+\frac{1}{9}\sigma^2-k_C+s. \tag{22}$$

The following conditions should be satisfied in order to realize the transaction of information exchange:

$$E\left[\pi_F{}^{00}\right]+\frac{1}{9}\sigma^2-s\geq E\left[\pi_F{}^{00}\right] \tag{23}$$

and

$$E\left[\pi_C{}^{00}\right]+\frac{1}{9}\sigma^2-k_C+s\geq E\left[\pi_C{}^{00}\right]+\frac{1}{4}\sigma^2-k_C. \tag{24}$$

Inequality (23) is the condition where firm F wants to purchase the information and (24) is the condition where firm C wants to sell the information.

From inequalities (23) and (24), we have $s\leq\frac{1}{9}\sigma^2$ and $s\geq\frac{5}{36}\sigma^2$. Thus, no value of s exists

[6] There has been considerable previous research on information sharing. For example, see Li (1985), Gal-Or (1985), Sakai and Yamato (1989), and Liu and Serfes (2006), who discussed the incentives for information sharing among firms in an oligopolistic market under cost or demand uncertainty. Okada (1982) and Sakai (1985) proposed duopolistic models for information exchange between firms, and analyzed the case where these firms faced uncertainty in their cost functions.

to realize the transaction between the two firms and the transaction does not occur voluntarily. In other words, the price for the information anticipated by the Chinese firm is higher than the foreign firm expects, and it is impossible to satisfy both firms. Maybe it also rarely occurs in reality.

2. Transactions Involving Information and Technology

In this section, we examine whether firm F can obtain the information from firm C by offering its technology. In other words, can firm F acquire the information using its technology because it has a technological advantage?

Assume that firm C can reduce its unit production cost if it receives technological assistance from firm F. If firm C receives technological assistance, the unit production cost of firm C then changes from c_C to $\underline{c_C}$, where $c_C > \underline{c_C} > c_F$.

The expected profits of both firms before the transaction are shown as follows:

$$E\left[\pi_F{}^{01}\right] = E\left[\pi_F{}^{00}\right] \tag{5}$$

$$E\left[\pi_C{}^{01}\right] = E\left[\pi_C{}^{00}\right] + \frac{1}{4}\sigma^2 - k_C. \tag{6}$$

Namely, from equalities (1) and (2), we have:

$$E\left[\pi_F{}^{01}\right] = \frac{1}{9}(\mu - 2c_F + c_C)^2$$

$$E\left[\pi_C{}^{01}\right] = \frac{1}{9}(\mu - 2c_C + c_F)^2 + \frac{1}{4}\sigma^2 - k_C.$$

In contrast, the expected profits of both firms after the transaction become:

$$E\left[\pi_F{}^{11}\right]' = \frac{1}{9}(\mu - 2c_F + \underline{c_C})^2 + \frac{1}{9}\sigma^2 \tag{25}$$

$$E\left[\pi_C{}^{11}\right]' = \frac{1}{9}(\mu - 2\underline{c_C} + c_F)^2 + \frac{1}{9}\sigma^2 - k_C. \tag{26}$$

Thus, the conditions that realize the transaction involving information and technology are:

$$E\left[\pi_F{}^{11}\right]' \geq E\left[\pi_F{}^{01}\right] \tag{27}$$

and

$$E\left[\pi_C{}^{11}\right]' \geq E\left[\pi_C{}^{01}\right]. \tag{28}$$

Namely,

$$\frac{1}{9}(\mu - 2c_F + \underline{c_C})^2 + \frac{1}{9}\sigma^2 \geq \frac{1}{9}(\mu - 2c_F + c_C)^2 \tag{29}$$

and

$$\frac{1}{9}(\mu-2\underline{c_C}+c_F)^2+\frac{1}{9}\sigma^2-k_C\geq\frac{1}{9}(\mu-2c_C+c_F)^2+\frac{1}{4}\sigma^2-k_C. \tag{30}$$

Hence, we have

$$(c_C-\underline{c_C})(2\mu-4c_F+c_C+\underline{c_C})\leq\sigma^2 \tag{31}$$

and

$$\frac{16}{5}(c_C-\underline{c_C})(\mu+c_F-c_C-\underline{c_C})\geq\sigma^2. \tag{32}$$

Therefore, if there is a value of σ^2 satisfying both inequalities (31) and (32) simultaneously, then the transaction involving information and technology may occur. In other words, if

$$\frac{16}{5}(c_C-\underline{c_C})(\mu+c_F-c_C-\underline{c_C})\geq(c_C-\underline{c_C})(2\mu-4c_F+c_C+\underline{c_C}) \tag{33}$$

is satisfied, the transaction involving information and technology may be realized. From inequality (33), we have

$$2\mu+12c_F-7(c_C+\underline{c_C})\geq 0. \tag{34}$$

Thus, it is clarified that the transaction may be realized under certain conditions. From inequality (34), the larger μ and c_F, as well as the smaller c_C and $\underline{c_C}$, the greater the possibility of a transaction involving information and technology.

Hence, we obtain the following proposition from the above analysis.

Proposition [2]:

1. A transaction involving information and money does not occur voluntarily.
2. When a value of σ^2 is appropriated, a transaction involving information and technology occurs voluntarily between two firms.
3. The larger μ and c_F as well as the smaller c_C and $\underline{c_C}$, the greater the possibility of a transaction involving information and technology.

The first part of Proposition [2] shows that the additional expected profit of firm F is smaller than the additional expected loss of firm C if a transaction involving information and money occurs. In other words, firm F cannot compensate for the expected loss of firm C in the case of information sharing.

The second part of Proposition [2] shows that, given that the Chinese firm has an advantage in information collection and the foreign firm has an advantage in technology, each firm could utilize the other's advantage if the variance of demand uncertainty is appropriate. However, if this variance is excessive, the expected loss of the Chinese firm in providing the information becomes larger, hence it will be difficult to motivate the Chinese firm to provide

information to the foreign firm. In contrast, if the variance is too small, the expected profit of the foreign firm resulting from the acquisition of information becomes less than the expected loss resulting from transfer of technology. Under these circumstances, it will be difficult to motivate the foreign firm to transfer technology to the Chinese firm.

The third part of Proposition [2] shows that there is a high possibility to realize a transaction involving information and technology when the expected Chinese market is large or when the technology gap between the foreign and Chinese firms is large. In contrast, when the difference of unit production costs is small, namely, the technology gap is small, or when the expected Chinese market is small, the incentive to conduct a transaction involving information and technology also diminishes.

IV. *Concluding Remarks*

1. Summary of Findings

This study analyzed the demand information risk faced by a foreign firm in the emerging Chinese market and derived a management strategy using microeconomic theory. A foreign firm that invests in the developing market of China is confronted with numerous risks. In this study, we discussed certain risks, particularly arising from information disparity between a foreign firm and a Chinese firm, which we referred to as demand information risk. Furthermore, individual and overall analyses of this risk were undertaken and we derived the features of such risk in the Chinese market. The ways to reduce or avoid this risk are also clarified in this study.

The two main results of our analysis can be summarized as follows. (1) When the demand information collection costs of both foreign and Chinese firms are low, both firms will collect demand information individually. In contrast, when their demand information collection costs are high, they will not collect demand information. Furthermore, if the gap in the demand information collection costs between both firms is high, namely, the demand information collection cost of the foreign firm is high and that of the Chinese firm is low, only the Chinese firm will collect demand information. (2) Given that only the Chinese firm collects demand information, information sharing could take place between the foreign and Chinese firms provided certain specific conditions are met. Information sharing is enabled solely by transactions involving information and technology, rather than information and money. We proved that each firm would be able to utilize the other's advantage if the variance of demand uncertainty is appropriate, not too small or large. Furthermore, the possibility to realize transaction involving information and technology increases when the expected Chinese market size and the technology gap between the foreign and Chinese firms are large.

In addition, the results obtained from this study can be effective in explaining actual phenomena. For instance, the cooperation between the Sanyo Group (Japan) and the Haier Group (China) commencing in 2002 is a good example. This cooperation can be a successful strategy in avoiding or reducing risk and maximizing profits by sharing each other's advantage. Namely, the Sanyo Group has high technology and the Haier Group has an advantage in terms of information collection.

Furthermore, these study results can also be applied to analyze such demand information risk and management strategies in other developing markets, such as India and Vietnam. In this

case, it will be fruitful to take into consideration the particular circumstances of each country, such as the level of economic development, population, and so on.

2. Limitations of Study and Future Research

This study has some limitations, of which the critical one is the assumption of only a single foreign firm and Chinese firm in the market respectively. Needless to say, there are far more than this number in the actual market. For example, cases involving multiple foreign firms in the same market with one Chinese firm, one foreign firm with multiple Chinese firms, and multiple foreign firms with multiple Chinese firms can also occur. Furthermore, we assumed quantity competition, namely Cournot competition, between the two firms. However, there are other competition styles, such as Bertrand competition, known as price competition.

Future research should address the above limitations. Moreover it is also necessary to test the hypotheses derived by the model using empirical studies and it is possible to construct a general theory of demand information risk management by expanding the model in this study.

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