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Product Differentiation and Cartel Stability With Costs of Collusion

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Abstracts

The stability of collusion has been an interesting phenomena and problem, many of the existing literature focused on the analysis of the stability of collusion without collusion cost, while the real economy and a large number of studies have shown that the collusion cost in collusion between enterprises is very large, this paper analyzes the issue of ease of sustaining collusion with collusion cost under different competition intensity with product differentiation, and modifies the past knowledge about that the collusion is easier to maintain under Cournot competition than under Bertrand competition, and demonstrates that if the collusion cost is above some critical value, the reverse is true. This conclusion provides a more comprehensive perspective in the economic analysis for collusion participants and decision makers.

Key words: Product differentiation; Cournot competition; Bertrand competition; the Stability of Collusion

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INTRODUCTION

The stability of collusion has been an interesting phenomenon and problem. In recent years, there are many economists considering the problem of cartel stability, the not earliest but the most notable is Friedman (1971), his main contribution is to propose the idea of "triggered strategy". Now there are also lots of literatures about product differentiation, competition intensity and collusion stability. The ones focused on the effect of differentiation on departure motivation, Østerdal (2003) analyzed the optimal punishment under Cournot duopoly with product differentiation. Some other literatures focused on factors of the stability of collusion on a given product differentiation. Collie (2006) analyzed the problem of cartel stability under Cournot (Bertrand) duopoly with linear marginal cost, the conclusion is that if the marginal cost is sufficiently increasing in output, the collusion is easier to sustain under Cournot duopoly than under Bertrand for any degree of product substitutability. Poddar & Saha (2010) studied the stability of collusion in the infinitely repeated play of a two-stage game of product innovation and market competition, and showed that competition cooperation in giving R&D efforts is more easily sustained when firms compete in quantity than in price. Matsumura&Matsushima (2012) studied that the relationship between the collusive stability and competitive intensity and showed that the increase in the intensity of competition is not conducive to the stability of collusion. Akinbosoye, Bond&Syropoulos (2012) examined how trade liberalization affects collusive stability in the context of multimarket interactions and found that, when goods are very close substitutes and trade costs are sufficiently high, a marginal reduction in trade costs facilitates collusion, the opposite is true if, for any given degree of product substitutability,trade costs are sufficiently low.

These documents are focused on product differentiation and the stability of collusion, and the analysis of collusion in infinitely repeated duopoly games has generally assumed that cost associated with collusion is 0.There are less documents about collusion stability with collusion cost, which contradicted with the fact that there is huge collusion cost for related collusive firms in the real economy. The collusion costs include the coordination costs, the establishment (in order to sustain collusion, firms need to establish collusion-specific social structure and institution) costs, the monitoring costs, collection costs, and communication costs, and so on. Some studies found that the coordinated conspiracy need to face-to face meeting which would take money, time, and efforts, and so on. As these meetings are illegal, then they face the risk of being spotted[1]. Such as Connor (2001) discussed the difficulty of establishment of collusion in citric acid market. Thomadsen and Rhee (2007) demonstrated that increased product differentiation will make it more difficult to sustain collusion when it is costly to coordinate or maintain collusion.

Through the introduction of collusion cost in analysis of collusion with product differentiation, and the comparison of effects of different competition intensity on collusion with tacit collusion cost or without tacit collusion cost, we can draw some valid conclusions.

2. THE MODEL

Firms' ability of sustaining collusion depends on the comparison of the gain from collusion and the cost to maintain the collusion. If the gain from collusion is greater than the cost of collusion, the collusion is stable, otherwise collusion is unstable. The gain from collusion depends on the profits before and after the collusion, which in turn depend on the method and intensity of competition before they collude (such as they competed in price or in quantity. Generally, it is believed the intensity of quantity competition is weaker than that of price competition). To simplify the analysis, we assume that there is a duopolistic market, in which two firms produce two products and consumers can choose from the two products.

The inverse demand function facing both the firms, which I adopted comes from Ross (1992), is symmetric and linear:

$$p_i=a-q_i-bq_j,\ i, j=1, 2,\ i\neq j \qquad (1)$$

Where b ($b\in(0,1]$) measures the degree of exogenous differentiation between the two goods, if b is close to 0, two goods are completely independent, while if b=1, they are perfect substitutes, which means the differentiation degree decreases as b increases. Both firms have identical cost functions $C_i=f+cq_i$. Without any loss of generality, it will be assumed that $f = 0$ throughout this note. So the firm i 's profit function at each stage of the game is as follows.

$$\pi_i=(p_i-c)q_i \qquad (2)$$

3. CARTEL STABILITY WITHOUT COLLUSION COST

Two firms can repeat games infinitely. According to Friedman (1971), the joint profit maximization collusion can be maintained by Nash trigger strategy, and the result can become a sub-game perfect equilibrium. If the present discount value from the collusion profit(π^C) exceeds profit (π^D) by deviating from collusion and the later Nash equilibrium profit(π^N), the joint profit-maximization collusion is sustainable. If the discount factor exceeds the critical value ρ^* (ρ^* is the necessary critical discount factor which sustains the collusion, the smaller the ρ^* is, the more stable the collusion is), defined as: $\frac{\pi^C}{1-\rho}\geq\pi^D+\frac{\rho\pi^N}{1-\rho}$ => $\rho\geq\rho^*\equiv\frac{\pi^D-\pi^C}{\pi^D-\pi^N}$, the collusion is sustainable, and it must satisfy $\pi^D>\pi^C>\pi^N$ at the same time. In order to better compare the different result, we limit our analysis by considering only the difficulty of sustaining full collusion between firms without any collusion cost in this part.

After the same routine calculations of Collie (2006), we can get the following proposition.

Proposition 1: The needed critical discount factor is more than $1/2$ *under both quantity competition (Cournot behavior) and price competition (Bertrand behavior). If* $b\in(0, 0.96155]$, *it is easier to sustain collusion for the duopolies under Cournot competiton than under Bertrand competition. If* $b\in(0.96155,1]$, *the reverse is true.*

We can see proposition 1 clearly in figure 1. The critical discount factors under Cournot and Bertrand duopoly are plotted in figure 1 as a function of the degree of product substitutability. The minimum required discount factors to sustain collusion, ρ^*, are plotted along the vertical axis and the degree of product substitutability, b , on the horizontal axis.

We can see easily from figure 1 that, for any higher degree of product heterogeneity, it is easier to sustain tacit collusion under Cournot competition than under Bertrand competition, but for any higher degree of product substitutability, the reverse is true, which is in consistent with these traditional ideas of Lambertini and Sasaki (1999) and Collie (2006) and so on.

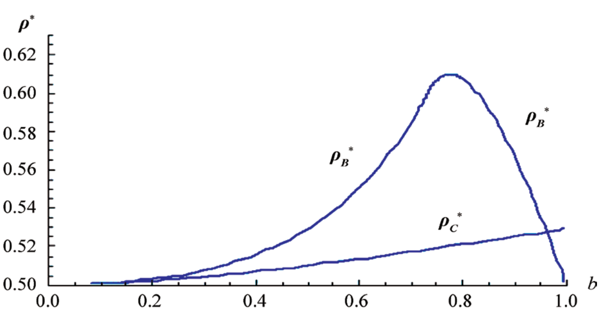

Figure 1
Critical Discount Factors

[1] See Thomadsen and Rhee (2007) for more details on the pervasiveness of presence of collusion cost.

4. CARTEL STABILITY WITH COLLUSION COST

Different from the traditional analysis above, the premise of this part is that there are costs to coordinating and maintaining collusion, the presence of costs of collusion is common in real economy, and numerous studies have demonstrated that the costs of negotiating a collusive outcome are generally large. Thomadsen and Rhee (2007) explained this point well, "One reason is that there is often no focal point for the firms to select as the equilibrium when the firms are asymmetric" (Thomadsen and Rhee (2007, p.661), so here we assume the firms always pay kinds of costs in order to sustain collusion, and we focus on the effect of collusion costs on cartel stability with differentiated products under different kinds of competition.

There is a recurring cost, T, of maintaining collusion, so the collusive profits in every period becomes π^C-T. In order to guarantee that the collusion is sustainable under Nash reversion trigger strategy, the profit from tacit collusion must be greater than the gains from cheating, $\frac{\pi^C - T}{1-\rho} \geq \pi^D + \frac{\rho\pi^N}{1-\rho}$, which is equal to: $\rho \geq \rho_T^* = \frac{\pi^D - \pi^C + T}{\pi^D - \pi^N}$.

Under Cournot duopoly, the critical discount factor in the premise of existence of collusion costs is as follows:

$$\rho_{TC}^* = \frac{(a-c)^2(4b^2+4b^3+b^4)+(64+192b+208b^2+96b^3+16b^4)T}{(a-c)^2(b^4+8b^3+8b^2)} \tag{3}$$

Under Bertrand duopoly case we can get the following results about the discount factor:

If $b \in (0, 0.73205)$,

$$\rho_{TB}^* = \frac{(a-c)^2(4b^2-4b^3+b^4)+(64-64b-48b^2+64b^3-16b^4)T}{(a-c)^2(b^4-8b^3+8b^2)} \tag{4}$$

If $b \in [0.73205, 1]$,

$$\rho_{TB}^{**} = \frac{(a-c)^2(b^4-3b^3-b^2+8b-4)+(4b^5-12b^4+16b^2)T}{(a-c)^2(2b^4-3b^3-b^2+8b-4)} \tag{5}$$

From (3), (4) and (5), we can get the proposition 2.

Proposition 2. For any b, with the assumption of the collusion can be sustained, the possible maximum tacit collusion cost, $T_{C.\max}$, under Cournot duopoly is always less than the possible maximum tacit collusion cost, $T_{B.\max}$, under Bertrand duopoly.

Proof: See appendix A.

Compared with Cournot duopoly, firms under Bertrand duopoly will get more profit from deviation from collusion, but it is easier to screen the departure from collusion and is less costly to screen the price-fixing collusive agreement than quantity-fixing collusive agreement, so the possible maximum collusion cost is always higher.

As before, we compare the ease of sustaining collusion under Cournot duopoly case and under Bertrand duopoly with collusion cost. Subtracting (4) or (5) from (3), we obtain:

If $b \in (0, 0.73205)$,

$$\rho_{TC}^* - \rho_{TB}^* = \frac{(a-c)^2(-8b^7)+32b^3(32+32b-24b^2-24b^3+b^4+b^5)T}{(a-c)^2(b^4+8b^3+8b^2)(b^4-8b^3+8b^2)} \tag{6}$$

If $b \in [0.73205, 1]$,

$$\rho_{TC}^* - \rho_{TB}^{**} = \frac{(a-c)^2(b^8+12b^6+16b^5-28b^4-16b^3+16b^2)}{(a-c)^2(2b^4-3b^3-b^2+8b-4)(b^4+8b^3+8b^2)} + \frac{(-4b^9+12b^8+208b^7+192b^6-336b^5-80b^4+896b^3+640b^2-256b-256)T}{(a-c)^2(2b^4-3b^3-b^2+8b-4)(b^4+8b^3+8b^2)} \tag{7}$$

Proposition 3. For any low degree of product substitutability ($0 < b < 0.73205$), if and only if $T > 0.00213(a-c)^2$, tacit collusion is more sustainable under Bertrand duopoly than under Cournot duopoly. For any high degree of product substitutability ($0.73205 \leq b \leq 1$), if and only if $T > 0.00244(a-c)^2$, it is easier to maintain collusion under Bertrand duopoly than under Cournot duopoly.

Proof: See appendix B.

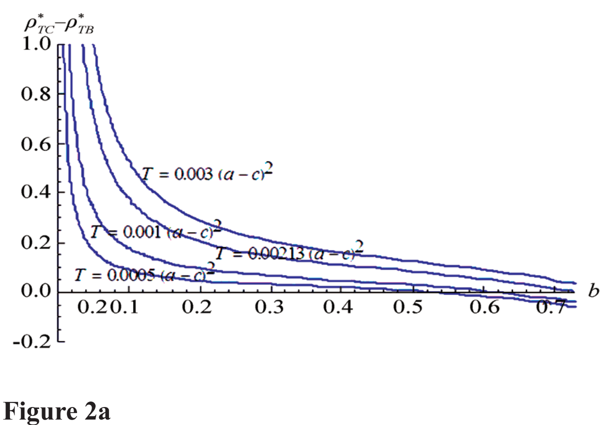

Figure 2a
Differences in Discount Factors with Collusion Cost ($0 < b \leq 0.73205$)

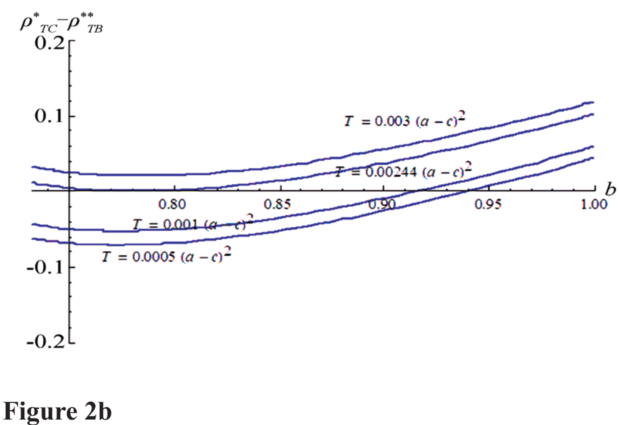

Figure 2b
Differences in Discount Factors with Collusion Cost ($0.732050 \leq b \leq 1$)

Figure 2a and figure 2b have shown us that, with the premise of existence of the tacit collusion cost, the comparison of stability of collusion under Cournot duopoly and Bertrand duopoly becomes more complicated. And we can obtain from figure 2a that, if 0<b<0.73205, under the low degree of product substitutability, if and only if $T > 0.00213(a-c)^2$ the tacit collusion is easier to maintain under Bertrand duopoly than under Cournot duopoly, if $T \leq 0.00213(a-c)^2$, the sign depend on the degree of product substitutability. If $0.73205 < b \leq 1$, if and only if $T > 0.00244(a-c)^2$,the stability of collusion under Bertrand duopoly is superior to under Cournot. If $T \leq 0.00244(a-c)^2$, the sign depend on the value of *b*. So once we consider the existence of collusion cost, the results of the ease of collusion contrast with the previous theoretical literature. The reason is proposition 2, for the same *b*, the possible maximum implicit collusion cost is always less under Cournot competition than under Bertrand competition. The collusive firms have the most to gain from cheating on the collusive agreement, but the collusive firms can easily to screen the departure from price-fixing agreement, and it is also less costly to supervise price-fixing collusive agreement than quantity-fixing collusive agreement. So the effect of these costs is strong enough that collusion becomes harder to sustain under Cournot competition than under Bertrand competition when these costs are large enough. These results contrast with the previous theoretical literature, which shows that, in absence of these costs, Cournot competition can help foster collusion under a wide range of product substitutability.

CONCLUSION

It is a more realistic assumption to introduce the collusion costs. In the absence of these costs, it is easier to maintain tacit collusion under Cournot competition than under Bertrand competition under a wide range of product substitutability, and in the presence of collusion costs, it is difficult to compare the difficulty of the tacit collusion under low cost. Once the cost exceeds the critical value, it is more difficult to sustain tacit collusion under Cournot competition than under Bertrand competition, regardless how much the degree of product differentiation is. This point out the traditional idea that the collusion under Cournot competition is easier to maintain is not always right, which provide a more comprehensive perspective to analyze and identify collusion for participants and policy makers.

This conclusion can be also applied to other cases, e.g. the self-price elasticity is not 1.and we assume the tacit collusion cost is constant, which may be unreal. For example, coordination cost may increase as the product differentiation increase, and more differentiation, more asymmetry between enterprises, and more difficult for them to monitor or identify the departure from the collusion or other deviation behavior and more coordination cost. Endogenous cost is beyond the scope of article, which can be open up to any further study.

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APPENDIX A

Proof:

Under Cournot competition, substituting (3) into $0<\rho_{TC}^{*}<1$ yields the possible tacit collusion cost:

$$T_C < T_{C.\max} = \frac{(4b^3+4b^2)(a-c)^2}{64+192b+208b^2+96b^3+16b^4} \tag{A.1}$$

Similarly, under Bertrand competition, if $b\in(0,0.73205)$,the possible tacit collusion cost is:

$$T_B < T_{B.\max} = \frac{(4b^2-4b^3)(a-c)^2}{64-64b-48b^2+64b^3-16b^4} \tag{A.2}$$

If $b\in[0.73205,1]$, the possible tacit collusion cost is:

$$T_B < T_{B.\max} = \frac{b^4}{4b^5-12b^4+16b^2} \tag{A.3}$$

Subtracting (A.2) or (A.3) from (A.1) yields:

If $b\in(0,0.73205)$,

$$T_{C.\max}-T_{B.\max} = \frac{-512b^3(1+b-b^2-b^3)}{(64+192b+208b^2+96b^3+16b^4)(64-64b-48b^2+64b^3-16b^4)} \text{ p } 0 .$$

If $b\in[0.73205,1]$,

$$T_{C.\max}-T_{B.\max} = \frac{-128b^5(1+b)^2}{(64+192b+208b^2+96b^3+16b^4)(4b^5-12b^4+16b^2)} \text{ p } 0 .$$

Thus for any b, we can always get $T_{C.\max} \text{ p } T_{B.\max}$. Q.E.D.

APPENDIX B

Proof:

(1) If $b\in(0,0.73205)$,a sufficient condition for $\rho_{TC}^{*}-\rho_{TB}^{*}>0$ is that $T > f(b) = \dfrac{(a-c)^2 b^4}{4(32+32b-24b^2-24b^3+b^4+b^5)}$, because then $\dfrac{\partial f(b)}{\partial b} = \dfrac{(a-c)^2 b^3\ (128\ +96\ b-48\ b^2-24\ b^3-\ b^5)}{4(32+32b-24b^2-24b^3+b^4+b^5)^2}>0$, $\rho_{TC}^{*}-\rho_{TB}^{*}>0$ will always hold for any levels of product substitutability ($b\in(0,0.73205)$) if $T>f(0.73205)=0.00213(a-c)^2$.

(2) If $b\in[0.73205,1]$, a sufficient condition for $\rho_{TC}^{*}-\rho_{TB}^{**}>0$ is that

$$T > g(b) = \frac{(a-c)^2(b^8+12b^6+16b^5-28b^4-16b^3+16b^2)}{4b^9-12b^8-208b^7-192b^6+336b^5+80b^4-896b^3-640b^2+256b+256},$$

because if $b\in[0.73205,0.78057)$, $\dfrac{\partial g(b)}{\partial b}>0$, and if $b\in(0.78057,1]$, $\dfrac{\partial g(b)}{\partial b}<0$, so if T>g(0.78057)=0.00244(a-c)^2, $\rho_{TC}^{*}-\rho_{TB}^{**}>0$ will always hold for any levels of product substitutability ($b\in[0.73205,1]$). Q.E.D.

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