ANTITRUST AGENCIES AND HARD-CORE CARTELS: A GAME THEORETIC PERSPECTIVE

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Abstract: This article studies the strategic interactions between cartelists and the antitrust agency in two theoretical game settings. In the simultaneous game, the numerical results show that it becomes harder for the firms to sustain collusion, but easier for the antitrust agency to detect collusion as the damage multiplier and the effectiveness of leniency program increase. In addition, inelastic demand can also lead to higher detection probability. Therefore, the cartel's collusive price can be reduced when the antitrust agency increases the damage multiplier, and/or implements the leniency program more efficiently. In the sequential game where the cartel decides its collusive price in the first stage, the equilibrium collusive price is higher, and antitrust agency's budget allocation on cartel detection is smaller than in the simultaneous game. And the probability of detection is 5% higher in the sequential game.

JEL classification: K21, L00, L12

Key words: Cartel, Simultaneous Game, Sequential Game, Antitrust, Detection

1. INTRODUCTION

The focus of most studies of business cartel behavior has been on the economic and financial incentives present in market conditions that facilitate cartel activity (as., Stigler, 1964; D'Aspremont et al., 1983; Donsimoni et al., 1986; Haltiwanger and Harrington, 1991; Bryant and Eckard, 1990; Bernheim and Whinston, 1990; Shaffer, 1995; Raith, 1996; Bagwell and Staiger, 1997; Levenstein, 1997; Connor, 2001, 2003, 2004, 2005, 2006; Spagnolo, 2000; Evenett et al., 2000; Posada, 2001; Harrington, 2004, 2005; Aubert et al. 2006). Of course, firms collude to obtain greater market coordination and increased profits in oligopoly markets usually involving homogeneous or nearly homogeneous products. As Connor (2003) correctly points out, without strong detection behaviour from government antitrust agencies, cartels likely would have dominated most world economies. Historically, this was observed before the 1890 Sherman Act in the United States, before 1945 in Germany, and before 1956 in the United Kingdom (Connor 2003).

A survey collected by the Competition Committee of the Organization for Economic Co-operation and Development (OECD) in October 2001 showed that domestic cartels had existed for decades in those countries where the enforcement of antitrust was lax (see details in OECD 2002). Connor (2003) points to reductions in the U.S. agency budgets from 1981 to 1992 as a prime factor in allowing many illegal cartels to flourish in the U.S. during that time period. For obvious reasons, cartels are commonly considered harmful to domestic and world economies. Furthermore, because cartel behavior is a criminal act that has a menu of consequences if discovered, [52] sophisticated cartelists usually set the price lower than the monopoly price in order to avoid suspicions. Therefore, for the antitrust agencies, detection of collusive behavior can be difficult and building a legal case sufficient for courts to act is even more challenging.

In the context discussed by Harrington (2005), it is useful to consider the relationship between the antitrust agency that polices cartel behavior and the firm members of a cartel. This chapter provides such an application in a game theoretic setting. In particular, I study the interactions between two agents: an incumbent cartel and an antitrust agency as both parties try to maximize their one-shot expected payoff. The model characterizes sanctions against illegal collusive behavior by linking the outcomes to account for the probability of cartel detection. The fact that the antitrust agency and the cartel operate with conflicting objectives regarding detection, the strategic interactions and findings provide for a useful and revealing foundation for improved policies.

The studies of strategic interactions between multiple agents in a static game framework have covered a wide range of topics including the well-known prisoners' dilemma, the Bertrand model of price competition, the Cournot model of quantity competition, the first price sealed-bid auction (Milgrom and Weber 1982; Kagel and Levin 1993), and the business location decisions (Carlton 1983; Guimaraes et al. 2003) to name several. I begin with a model in which an incumbent cartel chooses its price to avoid being detected and at the same time to maximize its collusive profit; and an antitrust agency decides its budget level to discern the cartel when the cartel members collude in one commodity market and at the same time to maximize its expected payoff.

The interactions between a cartel and an antitrust agency are very complicated in practice. Thus, instead of finding specific quantitative solutions for the two parties, the qualitative results obtained by the simple static models in this chapter are used to shed some light on a couple of policy issues faced by the antitrust authorities. First, what is the effect of the multiplier of damages on the collusive price and antitrust budget? Second, how does the leniency program affect the collusive price and the antitrust budget allocation? Third, what kind of market feature can affect the detection probability? What will be the outcome when one party moves first?

The article is organized as follows. Sections 2.1 and 2.2 present the basic model and the Nash equilibrium resulting from the interaction between the cartel and the antitrust agency in a simultaneous move game. Section 2.3 examines how damage multiplier, the effectiveness of leniency program and the slope of the market demand affect the probability of cartel detection respectively. Section 2.4 studies the interaction between the two parties in a sequential move game. And the results obtained in the sequential game are compared with those obtained in the simultaneous move game. Section 3 concludes.

2 THE BASIC MODEL

2.1 MODEL SETUP

I begin with a basic model in which a cartel is operating in the market and an

[52]If found guilty, substantial financial penalties could put the firms out of business, and the responsible company executives might pay huge personal fines and possibly face prison sentences.

antitrust agency is trying to detect the cartel's operation by allocating the antitrust budget. Both the cartel and the antitrust agency are assumed to be risk-averse. The cartel as a whole chooses its collusive price p. The collusive price is some value between the competitive price p^c and the monopoly price p^m, i.e., $p^c \le p \le p^m$. In order to gain more profits, the cartel is willing to set a high collusive price, but higher price brings more suspicion from the antitrust authority, and hence higher detection probability. So the optimal collusive price is determined by weighing the two. The antitrust agency chooses its budget amount B to detect the incumbent cartel. When the cartel is in operation, the cartel members enjoy the increased collusive profits. At the same time, the antitrust agency receives the loss in consumer surplus due to cartel actions.

The probability of detecting the cartel is given by $\theta(p,B)$, which is a function of the antitrust agency's budget B and the collusive price p. $\theta(p,B)$ is assumed to be twice differentiable. It increases as the collusive price increases, i.e., $\partial\theta(p,B)/\partial p > 0$. And it increases with the antitrust agency's budget level, but with decreasing marginal returns, i.e., $\partial\theta(p,B)/\partial B > 0$ and $\partial^2\theta(p,B)/\partial B^2 < 0$. In addition, the probability of cartel detection is 0 if the antitrust agency allocates no resources in detecting cartels or the collusive price set by the cartel is 0, and it is close to 1 if the agency allocates an enormous amount of budget in cartel detection, i.e., $\theta(p,0) = 0$, $\theta(0,B) = 0$ and $lim_{B\to\infty}\theta(p,B) = 1$.

For simplicity, I assume that the marginal production cost is zero and the firms are engaged in Bertrand competition in price. So the competitive price is zero in this setting, i.e., $p^c = 0$. If the cartel is detected, the whole cartel has to pay a penalty fine in the amount of F and earn the competitive profit which is zero. And the antitrust agency will collect the penalty fine F. In practice, the penalty fine amount F charged by the antitrust authorities is a multiple of the difference between the collusive profit π and the competitive profit π^c, i.e., $F = r\pi$ because $\pi^c = 0$, where r is the multiplier set by the antitrust agency.

2.2 FINDING NASH-EQUILIBRIUM

The demand function facing the firms is given by the following linear form:

$$D(p) = a - bp \qquad (1)$$

where a is the intercept and b is the slope. In the one shot Nash game, with probability $1-\theta(p,B)$, the cartel is not detected, the cartel firms continue to enjoy collusive profit π. And with probability $\theta(p,B)$, the cartel is detected, the cartel firms pay a penalty fine F which is $r\pi$. The cartel tries to maximize its expected payoff by choosing the collusive price p. Following Zhuang and Bier (2007), let $\theta(p,B) = \dfrac{pB}{B+k}$, where $k > 0$ is a constant representing the effectiveness of the leniency program. As k increases, the leniency program is not well implemented, so the cartel detection becomes more difficult for the antitrust agency, and hence the probability of detection decreases. When the leniency program is implemented efficiently, k decreases and the cartel detection becomes easier for the antitrust agency. This functional form of the detection probability satisfies all the assumptions defined before about $\theta(p,B)$. So the cartel's maximization problem is:

$$max_p(1-\frac{pB}{B+k})(ap-bp^2)-\frac{pB}{B+k}rp(a-bp) \quad (2)$$

Similarly, with probability $1-\theta(e^a,e^c)$, the cartel is not detected, the antitrust agency receives the loss in consumer surplus due to the cartel collusion behavior. And with probability $\theta(e^a,e^c)$, the cartel is detected, the antitrust agency collects the penalty fine. The antitrust agency is trying to maximize its own expected payoff by choosing its budget level B:

$$max_B(1-\frac{pB}{B+k})(\frac{p^2}{2b}-\frac{a}{b}p)+\frac{pB}{B+k}rp(a-bp)-B \quad (3)$$

The first order condition to equation (2) for the cartel is given by:

$$[\frac{B}{B+k}(3+3r)b]p^2-[\frac{B}{B+k}(2a+2ra)+2b]p+a=0 \quad (4)$$

Equation (4) has a solution only when $[\frac{B}{B+k}(2a+2ra)+2b]^2-4a[\frac{B}{B+k}(3+3r)b]\geq 0$. And the first order condition to equation (3) for the antitrust agency is given by:

$$\frac{pk}{(B+k)^2}[arp-brp^2+\frac{ap}{b}-\frac{p^2}{2b}]-1=0 \quad (5)$$

Equation (5) has a solution only when $ar-brp+\frac{a}{b}-\frac{p}{2b}>0$.

Then the best response function of the cartel is:

$$\hat{p}=\frac{\frac{B}{B+k}(2a+2ar-abr)+2b-\sqrt{[\frac{B}{B+k}(2a+2ar)+ab]^2-\frac{12ab(1+r)B}{B+k}}}{6b(1+r)\frac{B}{B+k}} \quad (6)$$

Similarly, the best response function of the antitrust agency is given by:

$$\hat{B}=\sqrt{pk(arp-brp^2+\frac{ap}{b}-\frac{p^2}{2b})}-k \quad (7)$$

Combining the best responses by the two parties, $\hat{p}(B)$ and $\hat{B}(p)$, we can obtain the equilibrium collusive price level by the cartel and the budget level by the antitrust agency (p^*, B^*). Instead of solving equations (6) and (7) simultaneously to yield the Nash equilibrium because of the computational difficulty, I provide a numerical solution by specifying the values of the parameters a, b, r and k. Let $a=b=1$, $r=3$ and $k=0.01$ which is the base case. With $a=b=1$, the collusive price is 0 and the monopoly price is 0.5, so the collusive price is between 0 and 0.5. The best response functions of the cartel and the antitrust agency are shown in the following figure:

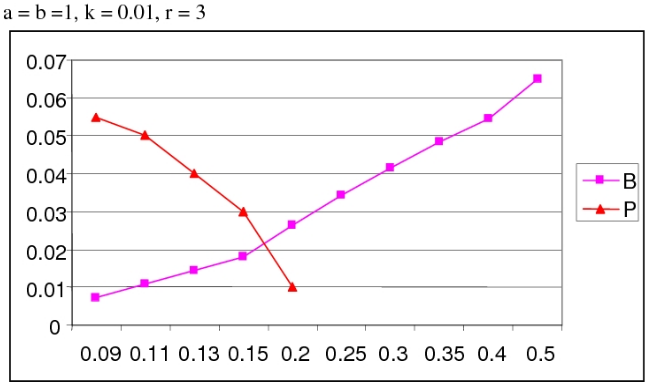


Figure 1. Equilibrium solution for the collusive price and the antitrust budget when $r = 3$.

From Figure 1, the equilibrium solution is $p^* \approx 0.15$ and $B^* \approx 0.021$. So, in the equilibrium, the cartel sets the collusive price at $0.15 which is lower than the monopoly price, and the antitrust agency allocates $0.021 billion for cartel detection.

2.3 COMPARATIVE STATICS ANALYSIS

The antitrust agency has the right to adjust the multiplier and uses the leniency program to affect the equilibrium solution. By increasing the damage multiplier r by 10%, the effect on the equilibrium collusive price and the antitrust budget is displayed in Figure 2.

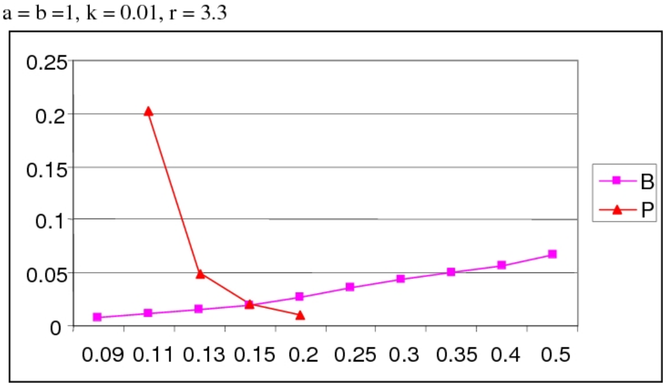
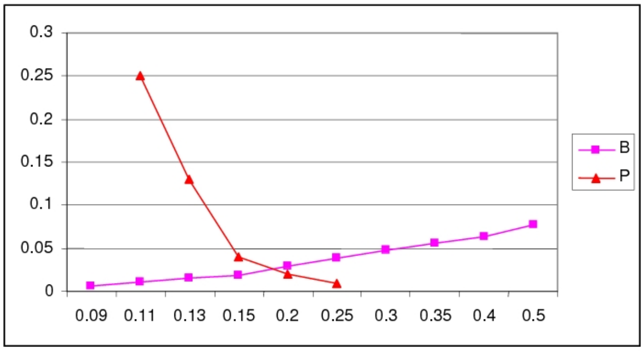


Figure 2. Equilibrium solution for the collusive price and the antitrust budget when $r = 3.3$.

Compared with Figure 1, when the damage multiplier increases by 10%, the equilibrium collusive price decreases to $0.138, and the antitrust budget is also reduced to $0.02 billion. So, the collusive price is reduced by 8%, and the antitrust budget is reduced by nearly 5%. Next, I change the value of k which means the effectiveness of the leniency program varies. The following figure shows the equilibrium solutions when $k = 0.015$ and $k = 0.005$ respectively.

a = b =1, r =3, k= 0.015



a = b =1, r =3, k= 0.005

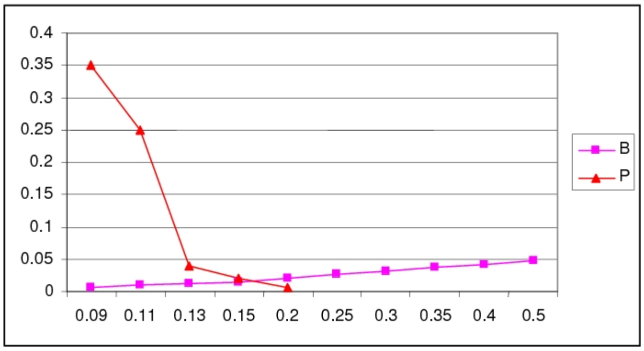


Figure 3. Equilibrium solutions for the collusive price and the antitrust budget when $k = 0.015$ and $k = 0.005$.

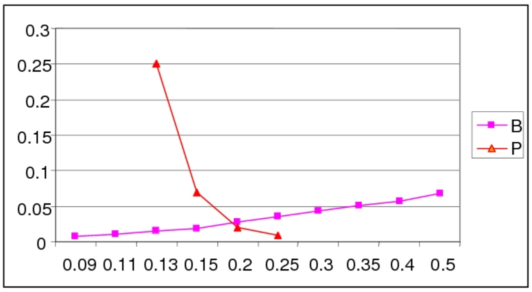
Compared with the base case in Figure 1, when the effectiveness of the leniency program decreases, i.e., k is increased from 0.01 to 0.015, the equilibrium collusive price is increased from \$0.15 to \$0.16 with a growth rate of about 6.7%. And the equilibrium antitrust budget is increased from \$0.021 billion to \$0.026 with a growth rate of 23.8%. However, when the effectiveness of the leniency program increases as k is reduced from 0.01 to 0.005, the equilibrium collusive price is reduced from \$0.15 to \$0.14 with a decrease rate of about 6.7%. And the equilibrium antitrust budget is decreased from \$0.021 billion to \$0.016 with a decrease rate of 23.81%.

If r and k stay the same as in the base case, what will be effect of the demand elasticity on the equilibrium solution? Figure 4 shows the equilibrium cartel price and antitrust budget when $b = 0.9$ and $b = 1.1$.

When we have treble damages and the effectiveness of leniency program is given, the market demand elasticity also has effect on the collusive price and the budget allocation. If the market demand becomes less elastic, the equilibrium collusive price set by the cartel is increased from \$0.15 in the base case to \$0.17 with a growth rate of 13.3%. The budget level is increased from \$0.021 billion to \$0.025 billion with a growth rate of 19%. And if the market demand is more elastic, the equilibrium collusive price decreases from \$0.15 to \$0.14 with a decrease rate of 6.7% and the antitrust budget is about the same as in the base case.

In sum, the comparative statistics results are shown in Table no. 1.

a = 1, b= 0.9, r = 3, k = 0.01



a = 1, b= 1.1, r = 3, k = 0.01

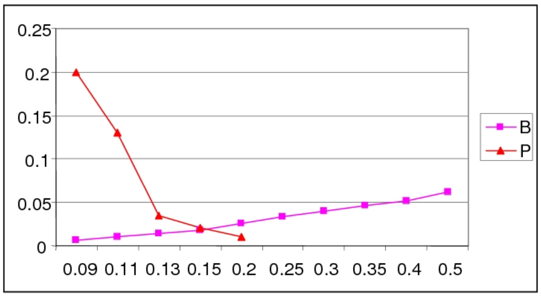


Figure 4. Equilibrium solutions for the collusive price and the antitrust budget when $b = 0.9$ and $b = 1.1$.

Table 1. Simultaneous equilibrium solutions with various parameter values.

a	b	r	k	$p^*(\$)$	$B^*(billion\,\$)$	θ^*
1	1	3	0.01	0.15	0.021	0.1016
1	1	3.3	0.01	0.138	0.020	0.0920
1	1	3	0.015	0.16	0.026	0.1015
1	1	3	0.005	0.14	0.016	0.1067
1	0.9	3	0.01	0.17	0.025	0.1214
1	1.1	3	0.01	0.14	0.021	0.0948

The probability of detection is the highest when the market demand is less elastic. When the effectiveness of the leniency program increases 50%, the detection probability increases by 5.02%.

2.4 FINDING SUB-GAME PERFECT EQUILIBRIUM

Now I consider a sequential game with two stages. In the first stage, the cartel decides the collusive price level. In the second stage, the antitrust agency makes an antitrust budget decision to maximize its expected payoff after seeing the antitrust agency's price level in the previous stage. Throughout the game, I assume sub-game perfect equilibrium. I will start analyzing the equilibrium behavior using backward induction.

In the second stage, the antitrust agency faces the same expected utility maximization problem in equation (3) as in the simultaneous game and the best response function of the cartel is given by $\hat{B}(p)$. In the first stage, the cartel knows that the antitrust agency will make decisions based on its best response strategy $\hat{B}(p)$, so the maximization problem for the cartel is then given by:

$$max_p (1-\frac{pB}{B+k})(ap-bp^2)-\frac{pB}{B+k}r(ap-bp^2)$$
$$s.t.\ B=\sqrt{pk(arp-brp^2+\frac{ap}{b}-\frac{p^2}{2b})}-k \quad (8)$$

The first order condition to equation (8) is:

$$(B+k)^2(a-2bp)-(B+k)B(ap-bp^2+arp-brp^2)-(B+k)Bp(a-2bp+ar-2br)$$
$$=\frac{1}{2}pk(ap-bp^2+arp-brp^2)\frac{2arpk-3brp^2k+\frac{2akp}{b}-\frac{3kp^2}{2b}}{\sqrt{pk(arp-brp^2+\frac{ap}{b}-\frac{p^2}{2b})}}$$

(9)

Solving equations (7) and (9) would yield the sequential equilibrium. Again, a numerical solution is obtained by letting $a=b=1$, $r=3$ and $k=0.01$. The sequential equilibrium is shown in Figure 5. In the sequential game where the cartel moves first, the equilibrium solution is given by $\tilde{p}\approx 0.25$ and $\tilde{B}\approx 0.015$. So the cartel sets the collusive price at $0.25 in the first stage and after seeing the price, the antitrust agency allocates $0.015 billion to detect the collusive behavior. Compared with the simultaneous equilibrium solution when $p^*\approx 0.15$ and $B^*\approx 0.021$, we find that the cartel charges a higher collusive price and the antitrust agency allocates a smaller antitrust budget in the sequential game. The probabilities of detection are $\tilde{\theta}=15\%$ and $\theta^*=10.16\%$ in the sequential game and in the simultaneous game respectively. And the cartel's expected payoffs are 0.0757 in the simultaneous game and 0.075 in the sequential game. Therefore, the cartel is not better off in the sequential game because the detection probability increases along with the collusive price. Although the cartel enjoys the first-mover advantage by being able to set a higher collusive price, the probability of paying penalties once detected and found guilty also increases, so its total expected payoff decreases in the sequential game.

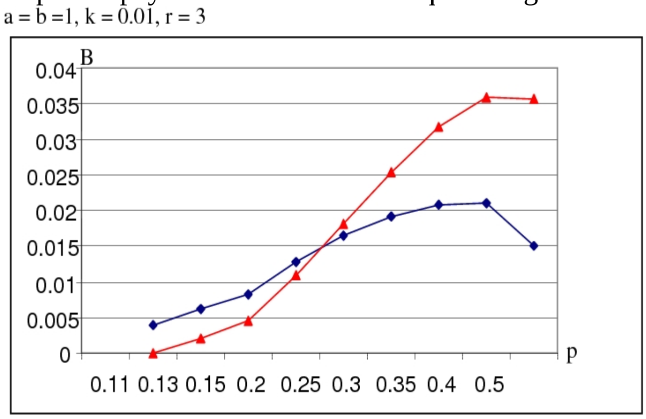


Figure 5. Sequential equilibrium solutions for the collusive price and the antitrust budget.

Keeping $a = b = 1$ and $k = 0.01$, again I increase the damage multiplier r by 10% to 3.3, the new sequential equilibrium is shown in Figure 6. When $r = 3.3$, $\tilde{p} \approx 0.18$ and $\tilde{B} \approx 0.0125$. Compared with the equilibrium solution in Figure 5, the collusive price decreases 28% and the budget amount decreases 16.7% respectively.

a = b =1, k = 0.01, r = 3.3

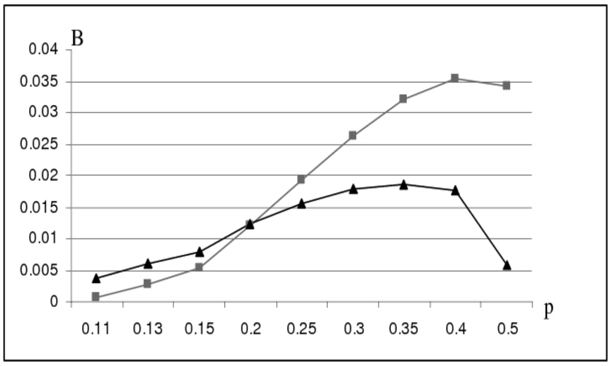
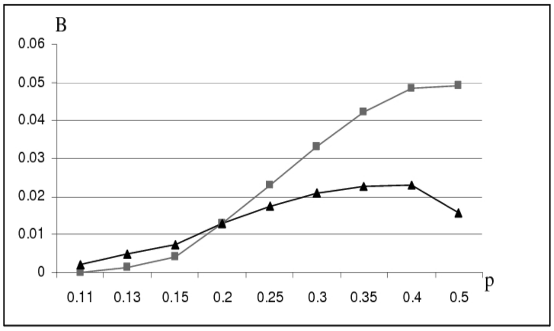


Figure 6. Sequential equilibrium solution when $r = 3.3$.

Then I change the value of the effectiveness of the leniency program k to 0.015 and 0.005 respectively, the sequential equilibrium solution is displayed in Figure 7. When $k = 0.015$, $\tilde{p} \approx 0.175$ and $\tilde{B} \approx 0.0120$. Compared with the equilibrium solution in Figure 5, the collusive price decreases 30% and the budget amount decreases 16.7% as the leniency program becomes less effective. When $k = 0.005$, $\tilde{p} \approx 0.275$ and $\tilde{B} \approx 0.0152$. The collusive price increases 10% and the budget amount increases 1.3% as the leniency program becomes more effective.

a = b =1, k = 0.015, r = 3



a = b =1, k = 0.005, r = 3

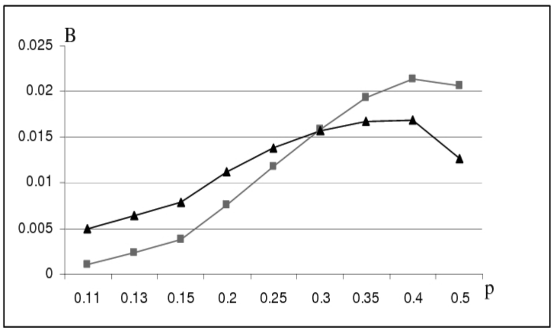


Figure 7. Sequential equilibrium solution when $k = 0.015$ and $k = 0.005$.

Lastly, I change the slope of the market demand b to 1.1 and 0.9 respectively, the equilibrium solution in the sequential game is displayed in Figure 8. When the demand slope $b = 1.1$, $\tilde{p} \approx 0.248$ and $\tilde{B} \approx 0.017$. So the collusive price decreases 0.8% and the budget amount increases 13.3% as the market demand becomes more elastic. When $b = 0.9$, $\tilde{p} \approx 0.175$ and $\tilde{B} \approx 0.014$. The collusive price decreases 30% and the budget amount decreases 6.7% as the market demand becomes less elastic.

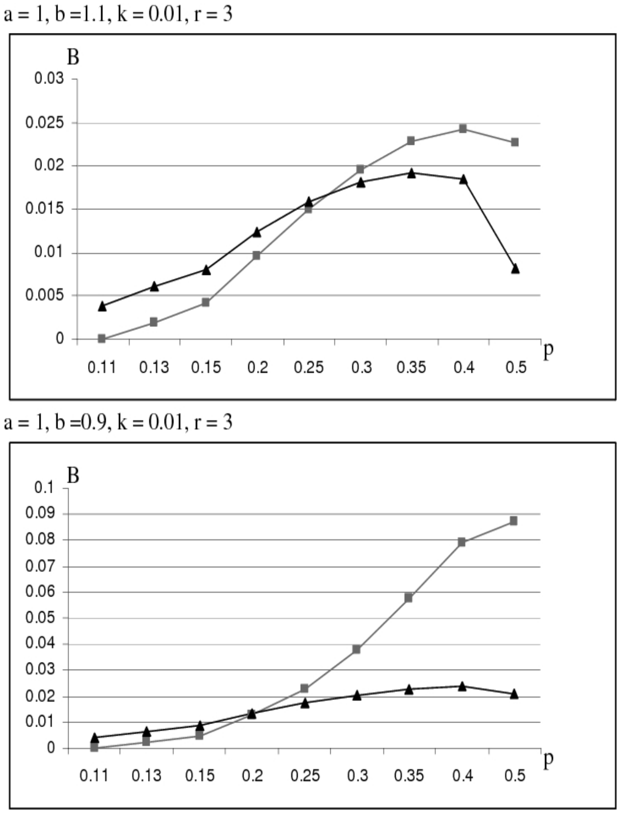


Figure 8. Sequential equilibrium solution when $b = 1.1$ and $b = 0.9$.

In sum, the comparative statics results in the sequential game where the cartel sets the collusive price first are shown in Table 2.

Table 2. Sequential equilibrium solutions with various parameter values.

a	b	r	k	$\tilde{p}(\$)$	$\tilde{B}(billion\,\$)$	$\tilde{\theta}$
1	1	3	0.01	0.25	0.015	0.15
1	1	3.3	0.01	0.18	0.0125	0.10
1	1	3	0.015	0.175	0.012	0.095
1	1	3	0.005	0.275	0.0152	0.1659
1	0.9	3	0.01	0.175	0.014	0.1021
1	1.1	3	0.01	0.248	0.017	0.1561

Comparing Table 2 with Table 1, we find that the collusive prices in the sequential game where the cartel moves first are all higher than in the simultaneous game, and the antitrust agency allocates less budget used to detect the ongoing cartel in the sequential game.

3 CONCLUSIONS

In the first model of the strategic interactions between an ongoing cartel and the antitrust agency in a simultaneous game, my numerical results show that when the damage multiplier and the effectiveness of leniency program increase, the equilibrium collusive price increases and the equilibrium antitrust budget decreases. The equilibrium collusive price in the market with less elastic demand is higher and the budget level made by the antitrust agency is also higher. In the base case, the probability of detection is about 10% and can be increased by improving the effectiveness of the leniency program. And the detection probability is higher in the markets with less elastic demand. From the above results, if the cartel and the antitrust agency are interacting simultaneously, the antitrust agency can increase the damage multiplier to have a lower collusive price. And the agency can decrease the collusive price by improving the leniency program or any other program that can be used to affect the cartel detection probability.

In the sequential game where the cartel decides its collusive price, the equilibrium collusive price is higher than in the simultaneous game, and antitrust agency's budget is smaller than in the simultaneous game. The probability of detection compared to the simultaneous game is 5% higher at 15%. The cartel's benefits from charging a higher collusive price are offset by the higher probability of getting caught and paying penalties in the sequential game. When the damage multiplier set by the antitrust agency, the effectiveness of the leniency program and the slope of the market demand curve change, compared with the simultaneous results, the cartel charges a higher equilibrium collusive price and the antitrust agency allocates less budget spending to detect the incumbent cartel after seeing the cartel's price decision in the sequential game.

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