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Cartel Stability with Subjective Detection Beliefs

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Cartel stability with subjective detection beliefs.

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Abstract

The condition is derived for Friedman's trigger strategy to sustain a collusive market equilibrium as a noncooperative Nash equilibrium given subjective beliefs as to the antitrust authority's ability of succesfully disolving the illegal cartel.

Key words: Cartel stability, trigger strategy, subjective beliefs.

JEL Classification: L12, L41

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1 Introduction

Ever since Friedman [1971] introduced his "trigger strategy" it is used in many studies to characterize collusive behaviour as a noncooperative Nash equilibrium, although the implied harsh punishment scheme is sometimes questioned as to its practical validity.[1]

In this note we introduce a new generalization of the condition under which the trigger strategy sustains collusive behaviour as a noncooperative Nash equilibrium. In particular we explicitly model the probability that the cartel is discovered by antitrust authorities as perceived by individual cartel members. If the cartel is discovered, it is also broken up and members have to pay a fine.

A paradoxical finding is that the longer is the period of limitation for violating antitrust laws (that is, the longer are antitrust authorities allowed to prosecute cartels after they have collapsed), the less likely it is that individual cartel members will defect from the collusive agreement. This is due to defection becoming less profitable the longer the threat of prosecution and concomitant fine payment is present.

2 The model

Consider a group of firms that has reached an agreement to jointly set prices at the beginning of some period 1. From that moment on each cartel member is endowed with some private belief as to the detection of the cartel by the antitrust authorities. Let $p_i \in [0, 1)$ be the per-period detection probability as perceived by firm i, and assume that detection implies not only that the antitrust authorities have discovered the cartel, but were also able to provide all necessary legal proof for it to be dismantled.

If the cartel is broken up all firms will behave independently for ever after and firms have to pay a fine $F \in [0, \overline{F}]$. The upper bound on fine payments is given by law and for an individual firm is typically defined as a percentage of gross annual per-firm revenue in the last year of the cartel's existence.[2]

Let π_i^C be single-period non-collusive firm profit and let π_i^{cartel} be single-period collusive firm profit. The latter can be anything, ranging from zero in perfectly competitive markets to noncooperative Cournot profit. Without loss of generality let $\pi_i^C \leq \pi_i^{cartel}$. In Figure 1 the expected pay-off of joining

[1] The literature on noncooperative collusive behaviour is vast and ever growing. For a recent overview of this literature see Martin [2002, Chapter 10].

[2] See Article 15 of EU Council Regfulation 17 for details of the EU practise; see Chapter 2 of the DoJ Antitrust Resource Manual (the "Sherman Act") for details of the US practise.

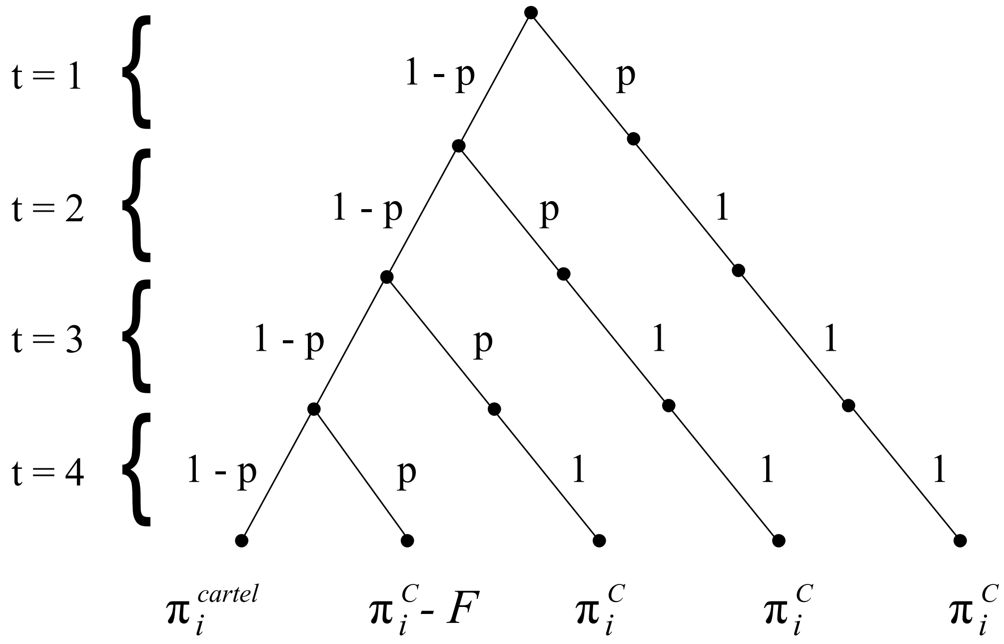

Figure 1: Development over time of expected cartel pay-off; $V_4^{cartel} = (1 - p_i)^4\pi_i^{cartel} + \sum_{t=1}^{4} p_i(1-p_i)^{t-1}\pi_i^C - p_i(1-p_i)^3 F$.

the cartel is illustrated as it evolves over time.

If future period cash flows are discounted with rate r, the expected value at period 1 of being in the cartel during period T equals:[3]

$$V_T^{cartel} = \frac{1}{(1+r)^{T-1}}\left[(1-p_i)^T\pi_i^{cartel} + [1-(1-p_i)^T]\pi_i^C - p_i(1-p_i)^{T-1}F\right]. \tag{1}$$

Observe that V_T^{cartel} is decreasing both in time and per-period detection probability.

The present discounted value at period 1 of staying in the cartel T periods is then given by:

[3]All formulae, in particular the closed-form solutions of series, are numerically checked. The GAUSS procedures with which these checkes are carried out are available upon request.

$$
\begin{aligned}
V^{cartel}(T) &= \sum_{t=1}^{T} V_t^{cartel} \\
&= \frac{(1-p_i)\left[(1+r)^T-(1-p_i)^T\right]}{(r+p_i)(1+r)^{T-1}}\pi_i^{cartel} \\
&\quad +\frac{p_i[(1+r)^{T+1}-1]-r[1-(1-p_i)^{T+1}]}{r(r+p_i)(1+r)^{T-1}}\pi_i^C \\
&\quad -\frac{p_i\left[(1+r)^T-(1-p_i)^T\right]}{(r+p_i)(1+r)^{T-1}}F,
\end{aligned}
\tag{2}
$$

with $V^{cartel}(0)=0$.

3 Cartel stability

If a firm defects from the cartel agreement at the beginning of some period D it earns during this period defection profits π_i^{defect} with perceived probability $(1-p_i)$. It is natural to assume that $\pi_i^{defect} \geq \pi_i^{cartel} \geq \pi_i^C$. During the same period the defecting firm can still be found guilty of having participated in the illegal cartel. This happens with probability p, in which case it earns π_i^C only while having to pay the fine F.[4] The present value at period 1 of expected defection profits earned during the defection period D then equal:[5]

$$
V_D^{defect} = \frac{1}{(1+r)^{D-1}}\left[(1-p_i)^D\pi_i^{defect}+[1-(1-p_i)^D]\pi_i^C-p_i(1-p_i)^{D-1}F\right]. \tag{3}
$$

Defection does not mean however that the antitrust authorities immediately end their investigations. Indeed, both in the US and the EU violating antitrust laws is an offence that comes with a particular period of limitation. This means that antitrust authorities have the legal right to continue to prosecute illegal cartels after their last period of existence. If the antitrust authorities investigate then the cartel for another k periods after the defection period, the present discounted value at period 1 of the expected fine payment *after* the defection period D equals:

[4]Assuming that the defecting firm earns π_i^{defect} with probability $(1-p_i)$ only is for computational convenience; assuming that the defecting firm earns π_i^{defect} with certainty does not affect any of our conclusions stated below.

[5]Here we abstain from the possibility that two or more firms defect simultaneously.

$$F_{D,k} = \frac{1}{(1+r)^{D-1}} \left[(1-p)^D \sum_{t=1}^{k} p(1-p)^{t-1} \right] F = \frac{(1-p)^D \left[1-(1-p)^k\right]}{(1+r)^{D-1}} F. \tag{4}$$

Following Friedman [1971] assume that cartel members complying to the cartel agreement always observe defection and respond by producing the competitive output as of period $D+1$ onward for ever after. This strategy implies that defection by one cartel member induces the cartel to be dismantled for good. Hence, if all cartel members adhere to Friedman's trigger strategy, the present discounted value at period 1 of complying to the cartel agreement for $D-1$ periods and then to defect equals:

$$V^{defect}(T \mid D) = V^{cartel}(D-1) + V_D^{defect} + \sum_{t=D+1}^{T} \frac{\pi_i^C}{(1+r)^{t-1}} - F_{D,k}. \tag{5}$$

The condition under which Friedman's trigger strategy yields a stable cartel under the presence of an active antitrust authority can now be stated.

Proposition 1 *Let $p_i \in [0,1[$ be the per-period cartel detection probability as perceived by firm i, let $F \in [0,\overline{F}]$ be the fine payment after discovery, and let $k \geq 0$ be the number of periods after the defection period that the antitrust authorities continue to investigate the cartel. If future period cash flows are discounted with rate $r \geq 0$, the trigger strategy makes adhering to the cartel agreement more profitable than defecting from it for $T \geq 0$ periods if, and only if,*

$$\frac{\pi_i^{defect} - \pi_i^{cartel}}{\pi_i^{cartel} - \pi_i^C} \leq \min_{p_i} \left\{ \frac{(1-p_i)\left[(1+r)^{T-1} - (1-p_i)^{T-1}\right]}{(r+p_i)(1+r)^{T-1}} - \frac{\widetilde{F}_i}{\pi_i^{cartel} - \pi_i^C} \right\}, \tag{6}$$

where

$$\widetilde{F}_i = \frac{p_i[(1+r)^T - (1-p_i)^T] - (r+p_i)(1+r)^{T-1}\left[1-(1-p_i)^{k+1}\right]}{(1-p_i)(r+p_i)(1+r)^{T-1}} F.$$

Proof. Since expected discounted profits up to the defection period are identical under defection and adherence, assume without loss of generality that defection occurs in period 1. Solving then $V^{cartel}(T) \geq V^{defect}(T \mid 1)$ yields expression (6). ■

4 Discussion

From stability condition (6) a number of inferences can be made. First, since $\widetilde{F}_i$ is decreasing in k, the cartel is more stable the longer the antitrust authorities continue to try and prosecute former cartel members after the defection period. Legislation that provides antitrust authorities with ample authority to prosecute former cartel members thus strengthens rather than weakens the stability of a noncooperative collusive agreement. This paradoxical result is due to defection becoming less profitable the longer the threat of prosecution and concomitant fine payment is present.

Second, although the overall detection probability increases over time, it does not mean that in the long run defection will always be profitable. Taking the time limit in (6) yields:

$$\frac{\pi_i^{defect} - \pi_i^{cartel}}{\pi_i^{cartel} - \pi_i^{C}} \leq \min_{p_i} \left\{ \frac{(1-p_i)}{(r+p_i)} - \frac{(r+p_i)(1-p_i)^k - r}{(r+p_i)\left(\pi_i^{cartel} - \pi_i^{C}\right)} \right\}. \tag{7}$$

Examples thus abound for (6) to hold in the long run.

Third, and finally, note that $\widetilde{F} \mid_{p_i=0} = 0$. In this case stability condition (6) reduces to Friedman's condition for a finite number of periods, as stated by Harrington [1987]. Considering then in addition an infinite number of periods yields the condition as first derived by Friedman [1971].

References

[1] Friedman, J. W., 1971, "A non-cooperative equilibrium for supergames", *Review of Economic Studies*, **38**, pp. 1 – 12.

[2] Harrington, J. E., 1987, "Collusion in multiproduct oligopoly games under a finite horizon", *International Economic Review*, **28**, pp. 1–14.

[3] Martin, S., 2002, *Advanced Industrial Economics* (second edition), Oxford: Blackwell Publishers.