# The Maximal Damage Paradigm in Antitrust Regulation: Is it Something New?

It is well known that cartels are harmful for consumers. To counteract cartels, cartel formation is by law an economic crime with the antitrust authority (AA) as its crime fighter. Recently, Harrington (2004, 2005) studied a general model of cartel formation and its pricing based upon profit maximization. In this article, we discuss the novel approach in Houba et al. (2009), who take the maximal damage for consumers as the key criterion. Some developments of this approach are introduced and related to the literature.

## Introduction

Despite a large literature on enforcement against individual illegal behavior, the theory of regulation is still in its infancy when it comes to enforcing market competition. Illegal anti-competitive behavior is much more complicated since it typically is a concerted illegal action performed within an ongoing relationship over time, called a cartel. Any theory of regulation therefore requires a dynamic setting, for example an infinitely-repeated oligopoly model with grim trigger strategies.

In this article, we discuss an innovative but unconventional approach in which we study the maximal-sustainable cartel price in a repeated oligopoly model, i.e., the largest cartel price for which the equilibrium conditions for sustainability hold. This differs from the standard approach in which the cartel maximizes profits. The main reason for doing so is that experimental economics establishes that economic agents often behave differently from standard microeconomic theory. Also, there is empirical evidence in support of Baumol's (1958) hypothesis that managers of large corporations seek to maximize sales rather than profits. Sustainability of cartel behavior offers a more robust criterion that does not depend on the cartel's objective. Then, the characterization of consumers' maximal damage can be regarded as a worst-case scenario for consumers. It is therefore natural to apply this new approach to regulation and compare the main results with those obtained for a profit-maximizing cartel in Harrington (2004, 2005).

This article is organized as follows. Section 2 introduces the maximal-sustainable cartel price in a benchmark model without regulation. In section 3 we analyze the impact of AA enforcement on the maximal-sustainable cartel price. In section 4, we compare, by means of an example, our approach to the one in Harrington (2004, 2005). Section 5 concludes the analysis.

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## The Benchmark Model

Consider an oligopoly market where $n \geq 2$ symmetric firms compete in prices with either homogenous or heterogeneous products over infinitely many periods. All firms have a common discount factor $\delta \in (0,1)$ per period. Since we deal with symmetric outcomes, we simplify $(p,\ldots,p) \in \mathbb{R}^n_+$ to $p \in \mathbb{R}_+$. We adopt the following notation:

- $p^N$ and $p^M$ denote the competitive (Nash) equilibrium price, respectively, the maximal collusive price.
- $\pi(p)$ is the profit function of an individual firm in any period. $\pi(p)$ is continuous and strictly increasing for $p \in [p^N,p^M]$.
- $\pi^{opt}(p)$ is a firm's profit from unilateral deviation against the cartel when all the other cartel members set their prices at $p$. $\pi^{opt}(p)$ is continuous and $\pi^{opt}(p)>\pi(p)>0$ for $p \in [p^N,p^M]$.
- $\lambda(p)$ is the degree of cartel stability and it is defined as

$$\lambda(p) = \begin{cases} \pi(p) \,/\, \pi^{opt}(p), & \text{for } p \in (p^N, p^M], \\ 1, & \text{for } p = p^N. \end{cases}$$

$\lambda(p)<\lambda(p^N)\equiv 1$ for all $p \in (p^N,p^M]$ is decreasing for all $p \in (p^N,p^M]$.

The degree of cartel stability is a new concept. Standard intuition implies that a higher $\lambda$(p) means less incentives for cartel members to deviate and a stabler cartel. Furthermore, a higher cartel price implies a higher incentive for each cartel member to deviate. Since the function $\lambda$ might be discontinuous at $p=p^N$, as Example 2 illustrates, we introduce

$$\underline{\lambda} = \lim_{\varepsilon \to 0^+} \lambda(p^N + \varepsilon) \le 1 \quad \text{and} \quad \overline{\lambda} = \lambda(p^M).$$

The above oligopoly model without regulation is a standard infinitely-repeated game. Throughout this article, we focus on grim-trigger strategies to sustain cartel price $p>p^N$ in which any deviation leads to the repetition of the competitive (Nash) price in every period thereafter. The underlying rationale is that cartels are based upon trust and, by the reciprocal nature of humans, all trust is gone after someone cheats. The equilibrium concept is a subgame perfect equilibrium.

In the absence of regulation, the necessary and sufficient condition to sustain $p \in (p^N,p^M]$ as a cartel price is

$$\pi^{opt}(p) + \frac{\delta}{1-\delta}\pi^{opt}(p^N) \le \frac{1}{1-\delta}\pi(p) \qquad (1)$$
$$\Leftrightarrow \delta \ge 1 - \lambda(p).$$

The socially worst outcome is the maximal-sustainable cartel price that is defined

$$p^C = \max_{p \in [p^N, p^M]} p, \quad \text{s.t.} \quad (1). \qquad (2)$$

Due to the monotonicity of $\pi(p)/(1-\delta)$, the maximal-sustainable cartel price $p^C$ also maximizes the cartel's profit.

A direct approach would solve (1) for $p$ as a function of all parameters, which requires the inverse function $\lambda^{-1}(1-\delta)$. Later, however, this approach is not applicable. Instead, we analyze the properties of the threshold level for $\delta$ as a function of $p \in (p^N,p^M]$ and, then, translate these properties into the maximal-sustainable cartel price as a function of $\delta$ in the $(\delta,p)$-plane. This indirect approach allows for an easier interpretation.

**Proposition 1**

*In the absence of regulation, the maximal-sustainable cartel price $p^C$ is non-decreasing in $\delta \in (0,1)$, and*

$p^C = p^N$, *for* $\delta \in (0, 1 - \underline{\lambda})$,
$p^C \in [p^N, p^M)$, *for* $\delta \in [1 - \underline{\lambda}\,;\, 1 - \overline{\lambda})$,
$p^C = p^M$, *for* $\delta \in [1 - \overline{\lambda}, 1)$,

We conclude this section with a well-known example.

**Example 2**

*Consider a homogeneous Bertrand oligopoly model with linear demand 2−p and 0 marginal costs. Note that $p^N=0$ and $p^M=1$. For all $p \in (p^N,p^M]$, each of the n firms may deviate by slightly undercutting the others to obtain the full cartel profit, i.e., $\lambda(p)=1$ for all $p \in (p^N,p^M]$. Consequently, $\underline{\lambda}=\overline{\lambda}=1/n$. Proposition 1 implies*

$$p^C = \begin{cases} p^N, & \text{for } \delta < 1 - 1/n, \\ p^M, & \text{for } \delta \ge 1 - 1/n. \end{cases}$$

## Antitrust Enforcement

In this section, we examine the impact of regulation. Given $p \in [p^N,p^M]$, the probability that the AA investigates the market outcome in a period and finds the firms guilty of collusion is $\beta(p) \in [0,1)$, where $\beta(p)$ is increasing in $p$ and $\beta(p^N)=0$. Upon being caught, violators will be fined by the amount $k(p)\pi(p)$, where $k(p)$ is increasing and continuous such that $k(p^N)=0$ and $k(p)>0$ for all $p \in (p^N,p^M]$. The function $\beta(\cdot)$ reflects that a higher cartel price attracts suspicions and makes detection more likely. Any cartel takes this negative effect into account when deciding upon the price, see Harrington (2004, 2005).

The AA is a passive player in this model, while firms are the active players. The detection probability $\beta(\cdot)$ is limited by the resources of the authority, and the fine schedule k(·) is limited by legislation. The OECD (2002) reports detection probabilities $1/7 \le \beta(p) \le 1/6$ and penalty schemes $2 \le k(p) \le 3$. These facts imply $2/7 \le \beta(p)\, k(p) \le 1/2$, or an expected penalty roughly between 30% to 50% of the illegal cartel profits. Therefore, the AA may not be able to deter violations. Here, we assume $0<\beta(p)k(p)<1$ for all $p \in (p^N,p^M]$ meaning any cartel is tempted to set its price above the competitive price.

Another aspect is how cartel members react to detection. In some cases, being caught once is sufficient to deter cartel activity in the future. In other cases, the economic sector is notorious for cartel activities despite many convictions (meaning members pay the fines and continue illegal business). $\gamma \in [0,1]$ is the cartel culture parameter that reflects the probability that the firms will behave competitively (i.e. stop illegal business) after each conviction. Notorious implies $\gamma=0$, while $\gamma=1$ means the sector becomes competitive after the first detection. All models in the literature assume either $\gamma=0$ or $\gamma=1$.

Let $V(p)$ be the present value of a cartel member's expected profit if the cartel sets price $p \in [p^N,p^M]$ in every period. This value consists of the current illegal gains $\pi(p)$, the expected fine $\beta(p)k(p)\pi(p)$, the expected continuation payoff of a renewed cartel after detection $\beta(p)(1-\gamma)\delta V(p)$, and the expected continuation payoff of not being detected $(1-\beta(p))\delta V(p)$, from which we obtain

$$V(p) = \frac{1-\beta(p)k(p)}{1-\delta[1-\gamma\beta(p)]}\pi(p) < \frac{\pi(p)}{1-\delta}, \quad p \in (p^N, p^M]. \tag{3}$$

So, introduction of regulation reduces the cartel's profitability. Does it also affect sustainability?

The cartel has its own destabilizing forces working from within, because individual cartel members have an incentive to cheat on the cartel. Here, cartel members adopt modified grim-trigger strategies to sustain $p>p^N$:

1 Firms continue to set a price $p>0$ with probability $1-\gamma$ after each conviction (and with probability $\gamma$ set the competitive price $p^N$ ever after).
2 Any deviation by some cartel members leads to the competitive price $p^N$ in every period ever after.

Then, the profit from a unilateral deviation is equal to the short term gain of $\pi^{opt}(p)$ in the current period, followed by the competitive equilibrium with $\pi(p^N)=0$ forever after. Consequently, the necessary and sufficient condition to sustain cartel price $p \in (p^N,p^M]$ is $V(p)\geq\pi^{opt}(p)$, or

$$\lambda(p) \geq \Lambda(p) \equiv \frac{1-\delta[1-\gamma\beta(p)]}{1-\beta(p)k(p)} \tag{4}$$

Under regulation the maximal-sustainable cartel price is given by

$$p^R = \max_{p\in[p^N,p^M]} p, \quad \text{s.t.} \quad (4). \tag{5}$$

where superscript $R$ refers to regulation. Program (5) is a well-defined program since $p \in [p^N,p^M]$, which can be deducted as follows. Since the monotonicity properties of $\Lambda(p)$ (increasing) and $\lambda(p)$ (decreasing) are opposite, the intersection $\lambda(p)=\Lambda(p)$ is unique and coincides with $p^R$. Furthermore, any $p\leq p^R$ can also be sustained by the cartel. So, the range of prices in (4) is a closed subinterval of $[p^N,p^M]$.

Comparing (2) and (5), we observe that $p^N\leq p^R \leq p^C\leq p^M$ meaning that regulation may reduce the maximal-sustainable cartel price in general. Similar to Proposition 1, we derive the thresholds on the discount factor $\delta$. Doing so, (4) can be rewritten as

$$\delta \geq \Delta(p) \equiv \frac{1-\lambda(p)[1-\beta(p)k(p)]}{[1-\gamma\beta(p)]} \geq 1-\lambda(p) \tag{6}$$

The function $\Delta(p)$ is continuous and increasing in $p$, $k(p)$ and $\beta(p)$.

**Proposition 3**

*Under regulation, the maximal-sustainable cartel price $p^R$ is non-decreasing in $\delta \in (0,1)$ and decreasing in $\gamma \in [0,1]$. Furthermore, we have*

$p^R = p^N$, *for* $\delta \in (0, 1-\underline{\lambda})$,
$p^R \in [p^N, p^M)$, *for* $\delta \in [1-\underline{\lambda}, \Delta(p^M))$,
$p^R = p^M$, *for* $\delta \in [\Delta(p^M), 1)$,

*An overall increase in $\beta(p)$ or $k(p)$ shifts $\Delta(p^M)$ and the entire curve to the right.*

"Current regulation is ineffective"

Clearly, inequality (6) is more restrictive than (1) implying that introduction of regulation restricts the set of discount factors for which collusion can be sustained for every possible price $p \in (p^N, p^M]$. This implies that cartel stability is reduced compared to the benchmark case. Moreover, the fact that $\Delta(p)$ is increasing in $p$ implies that the regulation is more effective against collusion on higher prices. When $\Delta(p^M)\leq\delta<1$, the regulation is not effective to deter the cartel from setting its monopoly price.

It is interesting to investigate whether regulation can eradicate the monopoly price for all cartel cultures. Solving $\Delta(p^M)<1$ for $\gamma$ yields

$$\gamma < \{\lambda(p^M)[1-k(p^M)\beta(p^M)]\}/\beta(p^M),$$

where the right-hand side remains positive under $0<\beta(p)k(p)<1$. Hence, industries that are notorious for cartel behavior cannot be eradica-

ted by regulation unless one is willing to adopt regulation that fully takes away the illegal gains (i.e. $\beta(p)k(p)>1$ for all $p \in (p^N, p^M]$).
Another implication is related to the effect of the degree of cartel stability $\lambda(p)$ on sustainability of the monopoly price. Since $\partial\Delta/\partial\lambda<0$, sectors where the degree of cartel stability is higher ($\lambda(p)$ closer to 1) have less restrictive conditions for sustaining consumers´ worst price $p^M$. This makes regulation less effective in these sectors.
The main message is a mixed blessing for regulation. On the one hand, proposition 3 identifies non-empty sets of parameter values for which regulation is effective in reducing the maximal-sustainable cartel price, i.e., $p^R<p^C$. On the other hand, as long as regulation obeys $\beta(p)k(p)<1$, there will remain a large non-empty set of parameter values for which $p^R=p^M$, meaning the regulation is ineffective.
We conclude this section with an example.

**Example 4**
*Reconsider Example 2 and let $\beta(p)=\beta p$ and*

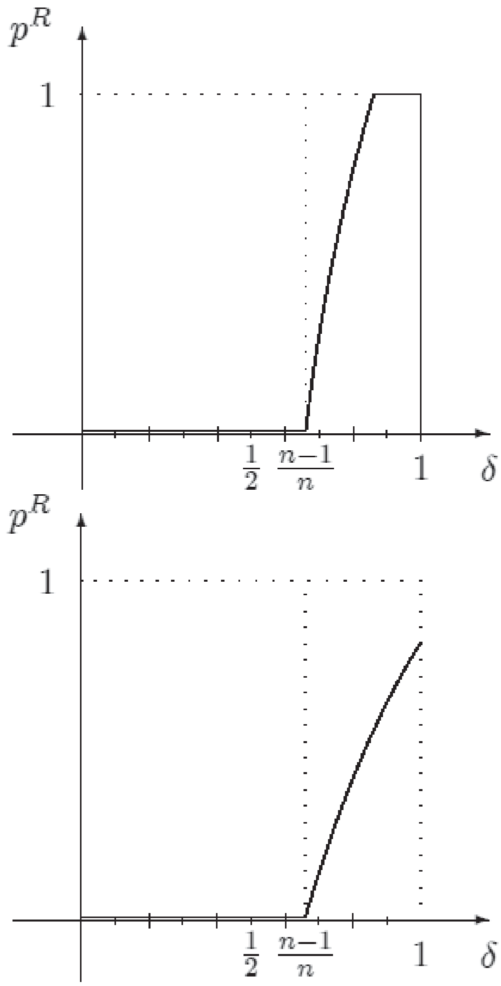


*Figure 1*

*$k(p)=k$, where $k<1$. Then, (5) becomes*

$$p(\delta,\gamma)=\max_{p\in[0,1]} p,\quad \text{s.t.}\quad \frac{1}{n}\geq\frac{1-\delta+\gamma\delta\beta p}{1-k\beta p}.$$

Note that $p=0$ is feasible in the quadratic constraint if and only if $\delta\geq 1-1/n$. The constraint can be rewritten as
$p \leq [1-n(1-\delta)]/[(n\gamma\delta+k)\beta]$,
which is the solution to the problem if it is between 0 and 1. The right hand side is increasing in $\delta$. To summarize, we have

$$p^R=\begin{cases}0, & \text{if } \delta<1-1/n\\ \min\{1,\dfrac{1-n(1-\delta)}{(n\gamma\delta+k)\beta}\}, & \text{if } 1-1/n\leq\delta<1\end{cases}$$

Note that $p^R<p^M=1$ for all $\delta \in (0,1)$ if and only if $(n\gamma+k)\beta>1$. Since $\beta k<1$, this condition can hold only when $n\gamma$ is sufficiently large. For sectors with small numbers of firms and $\gamma$ sufficiently close to 0, the monopoly price will not be eradicated by regulation. Both possible cases, $(n\gamma+k)\beta\leq 1$, respectively, $(n\gamma+k)\beta>1$, are illustrated by figure 1, where the vertical dotted line at $\delta=1-1/n$ represents the discontinuous jump in $p^C$ of Example 2 from $p^N=0$ to $p^M=1$.

### The profit-maximizing cartel price

In this section, we compare our approach to Harrington (2004, 2005). He defines the endogenous cartel price as the profit-maximizing sustainable cartel price $p^n$:

$$p^n=\arg\max_{p\in[p^N,p^M]} V(p),\quad \text{s.t.}\quad (4). \tag{7}$$

For explanatory reasons, we restrict attention to numerical values $\beta(p)=p/2$ and $k(p)=3$ and $\gamma=2/3$ in Example 4. Then,

$$V(p)=\frac{19-9p}{18-18\delta+2p}\cdot\frac{(2-p)p}{n}.$$

Standard arguments imply $V(p)$ fails both monotonicity and concavity on $[p^N,p^M]=[0,1]$, but this function is single peaked on $[p^N,p^M]$. Checking the second-order conditions can be avoided, because $V(p)$ is monotonically increasing from $p^N$ to its peak and monotonically decreasing from its peak to
$p^M$. So, application of the first-order conditions suffices. In contrast, (5) is a well-defined convex program.
Harrington shows that, in general, (4) is nonbinding for $\delta$ sufficiently close to 1 and we may solve the first-order condition $\partial V(p)/\partial p=0$. In our case, MAPLE returns

$$\hat{P}\equiv\frac{-27(1-\delta)+3\sqrt{65\delta^2-146\delta+81}}{4\delta}\in[0,\frac{3}{4})$$

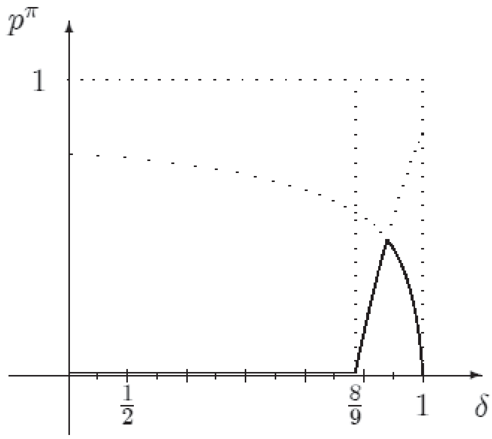


*Figure 2*

for all $\delta \in [0,1]$. Taking also (4) into account implies that the profit-maximizing cartel price $p^n$ is the minimum of $\hat{p}$ and $p^R$. These two price curves intersect at $\delta \approx 0.955$. So, on the interval $[0,0.955]$, the profit-maximizing cartel price $p^n = p^R$, while for the interval $(0.955,1]$ we have $p^n = \hat{p} < p^R$ and the equilibrium condition is nonbinding. Figure 2 illustrates $p^n = \min\{\hat{p}, p^R\}$.
This example offers important insights. Whenever constraint (4) in (7) is binding, the maximal-sustainable cartel price $p^R$ and the profit-maximizing cartel price $p^n$ coincide and our approach is complementary to the analysis in Harrington (2004,2005). Otherwise, i.e., (4) in (7) is nonbinding, these two cartel prices systematically differ. As the figure shows, for $\delta$ close to 1, the profit-maximizing cartel price $p^n$ is close to the competitive price $p^N$ and, therefore, seriously underestimates the potential maximal damage to consumers. Our approach offers a worst case scenario of sustainable cartel behavior.

## Conclusion

In this article, we explore a general infinitely-repeated oligopoly model for the analysis of violations of competition law under regulation. A novel concept is the maximal-sustainable cartel price that reflects consumers´ worst cartel price among those cartel prices that are sustainable, which endogenizes the cartel formation decision and its pricing strategy. This cartel price is related to the discount rate and the novel concepts of type and structure of the industry ($\lambda$) and cartel culture parameter ($\gamma$). Regulation is less effective in sectors where the degree of cartel stability is higher or where the sector´s cartel culture to continue business as usual is more prominent. Stylized facts from OECD countries imply that current regulation is ineffective. Finally, our approach is complementary to Harrington (2004, 2005) in case equilibrium conditions are binding. Otherwise, the profit-maximizing cartel price underestimates the maximal damage to consumers; a bias that might be huge.
Since economic agents often behave differently from standard microeconomic theory, the criterion of sustainability of cartel behavior offers a more robust framework that does not depend on the cartel´s objective function. In this perspective, our approach is a worst-case scenario.

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