# Explaining Escalating Fines and Prices: The Curse of Positive Selection

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## Abstract

This paper shows that escalating fines emerge in a generalized version of the canonical Becker (1968) model if the authority (i) does not fully credit offender gains to social welfare, and (ii) lacks commitment ability. We demonstrate that the authority has no incentive to increase the fine for repeat offenders because of their positive selection. Instead, escalation is driven by the authority's incentive to reduce the fine for low-value offenders in the future and redistribute additional offender gains to society. Our analysis nests optimal law enforcement with uncertain detection and behavior-based monopoly pricing with imperfect customer recognition.

## Keywords

Escalation, repeat offenders, behavior-based pricing, deterrence

## JEL Classification

D42, L11, L12

# 1 Introduction

Escalating fines for repeat offenders are ubiquitous, but they pose a serious challenge for the theory of optimal law enforcement. Why should the fine for a given offense increase with the number of previously detected offenses? Escalating pricing schemes for repeat customers (e.g., mobile phone subscribers, insurance buyers) pose a similar challenge. Why should loyal customers pay higher prices than new ones? Surprisingly, standard theory struggles with answering these questions when the economic environment does not change over time.

The repeated canonical model of optimal law enforcement (Becker, 1968; Polinsky and Shavell, 2007), for instance, cannot explain escalating fines. Various authors have therefore suggested alternative explanations. For example, if law enforcement is error-prone, accidental and real offenders are more distinguishable when the number of offenses increases; it then makes sense to charge higher fines for repeat offenders (Stigler, 1974; Rubinstein, 1979; Chu et al., 2000; Emons, 2007). Similarly, if repeat offenders learn how to avoid detection, escalating fines may keep notorious offenders deterred (Baik and Kim, 2001; Posner, 2007).[1] Finally, if conviction carries a negative social stigma, escalating fines may be needed to keep up deterrence for previously convicted offenders (Rasmusen, 1996; Funk, 2004; Miceli and Bucci, 2005).[2] Interestingly, none of these explanations addresses the underlying inter-temporal fine discrimination problem.

In this paper, we view a fine as a price (Gneezy and Rustichini, 2000) and study a generalized offender model that nests the canonical Becker (1968) model of optimal law enforcement and behavior-based monopoly pricing (Armstrong, 2006; Fudenberg and Villas-Boas, 2007) as special cases. We show that, contrary to what intuition might suggest, escalation is driven by *decreasing* fines for low-value offenders rather than increasing fines for high-value offenders. The result arises from the following logic: If the authority (i) does not fully credit offender gains to welfare, and (ii) lacks commitment ability, it has an incentive to lower the fine for first-time offenders in the future and redistribute additional offender gains to society. Consequently, some forward-looking offenders strategically delay their offense to benefit from lower fines in the future, which drives a wedge between the optimal fine and the intertemporally indifferent type (cutoff) for first-time offenses.

[1] Some authors have argued, though, that declining penalty schemes are optimal if law enforcement becomes more effective in pursuing notorious offenders (e.g. Dana, 2001, Mungan, 2009). Similarly, wealth constraints may make decreasing fines optimal (e.g. Anderson et al., 2017), or lead to falling fines for first offenses over time, but constant ones for repeat offenses (Polinsky and Shavell, 1998).

[2] See Miceli (2013) for a survey of the relevant literature.

This wedge is the source of the fine increase for repeat offenders, as the cutoff for repeat offenders is optimally kept constant because of their positive selection (Tirole, 2016). Put differently, escalating fines cannot be explained by an incentive to ratchet up (Freixas et al., 1985) the fines for repeat offenders. This "curse" of positive selection is arguably the reason why the theory of optimal law enforcement has struggled to explain escalating fines.

We develop our line of argument in a simple two-period model. Following Polinsky and Shavell (2007), we assume that private offender gains are continuously distributed and fixed, and we suppose that the authority and offenders share the same discount factor.[3] In period 1, forward-looking offenders self-select into offenders and non-offenders, and both offenders and non-offenders may commit the offense in period 2. The authority detects offenses with exogenous probability.[4] This implies that, in period 2, the authority can distinguish two groups of offenders: repeat offenders recognized from detected previous offenses, and non-recognized offenders who either did not offend in period 1 ('true' first-time offenders) or were not detected as offenders in period 1 ('false' first-time offenders). The authority can set three fines for detected offenders: The fine for first-time offenders in period 1, the fine for (true and false) first-time offenders in period 2, and the fine for recognized repeat offenders in period 2.

We derive three key results. First, with commitment the authority can do no better than set all fines equal to the optimal static fine. The well-known result that it is optimal not to discriminate prices with commitment (Stokey, 1979; Hart and Tirole, 1988; Acquisti and Varian, 2005; Fudenberg and Villas-Boas, 2007) thus not only extends to settings with imperfect customer recognition, but also to optimal law enforcement. It is worth noting that setting all fines equal to the optimal static fine is not uniquely optimal: falling fines for repeat offenders may also be optimal. Yet, it is never optimal to choose escalating fines, if the authority has the ability to commit. Second, without commitment optimal fines for repeat offenses escalate if and only if optimal fines for first-time offenses decrease. Put differently, escalation (if any) is generated by decreasing fines for low-value offenders rather than increasing fines for repeat offenders with identifiable high types. Escalation is thus explained by the effect that Coasian dynamics (Coase, 1972; Hart and Tirole, 1988) have on the optimal fine for first-time offenses. Third, optimal fines for repeat offenders do indeed escalate if the authority cannot commit to future fines and gives less than full

[3]We will relax this assumption in subsection 5.1.

[4]That is, law enforcement is uncertain (Polinsky and Shavell, 2007), or consumption is subject to payment evasion (Buehler et al., 2017). Examples for payment evasion include digital piracy, shoplifting, fare dodging, etc.

weight to offender gains. In contrast, if the authority gives full weight to offender gains, it maximizes standard social welfare, sets all expected fines equal to the social cost of the offense, and has no incentive to lower the fine for first-time offenders.

Our paper makes a twofold contribution. First, we add to the theory of optimal law enforcement (Polinsky and Shavell, 2007) by providing a novel explanation for escalating fines that builds on behavior-based price discrimination. We develop our explanation in a generalized version of the canonical offender model where offender gains are not necessarily fully credited to welfare. The assumption that offender gains are fully credited to welfare has long been criticized on the grounds that it is difficult to see why illicit individual offender gains should add to social welfare (Stigler, 1974; Lewin and Trumbull, 1990). Our analysis relaxes this assumption and shows that it has prevented the canonical model from addressing escalation in repeated settings, as standard welfare maximization forces expected fines down to the social cost of an offense. Our model brings the analysis closer to the distributive view of justice, which suggests that the optimal punishment "appropriately distributes pleasure and pain between the offender and victim" (Gruber, 2010, p. 5).

Second, we contribute to the literature on behavior-based price discrimination by adding two new ingredients to the analysis. The first ingredient is imperfect customer recognition, which allows us to extend the analysis to settings in which the seller cannot perfectly track the purchase histories of its customers and is thus unable to distinguish a true from a false first-time consumer in period 2. The paper closest to ours is Conitzer et al. (2012). These authors study the extreme cases of either no recognition or full recognition in a two-period model with repeat purchases. We consider a setting in which customer recognition is imperfect and allow for the full range from no recognition to full recognition. In a recent paper, Belleflamme and Vergote (2016) study imperfect customer identification in a monopoly setting without repeated purchases. Our paper is also related to Villas-Boas (2004) who studies a setting in which an infinitely-lived firm faces overlapping generations of two-period-lived consumers and cannot distinguish 'young' from 'old' first-time consumers.

The second ingredient that we add is non-profit maximization by the seller. As discussed above, we find that a welfare-maximizing seller does not want to discriminate prices, irrespective of commitment. The reason is that payments amount to costless money transfers if full weight is given to offender gains. The seller thus cannot do better than setting prices equal to the social cost of consumption. With less weight given to individual gains, the seller's profit motive kicks in, and prices are optimally being discriminated. As one might expect, prices are highest if no weight is given to individual gains and the seller acts as a profit-maximizing monopolist.

The remainder of the paper is organized as follows. Section 2 introduces the generalized offender model and derives the optimal static fine. Section 3 studies the optimal fines in the two-period version of the generalized offender model, both with and without commitment by the authority. Section 4 discusses the relation to behavior-based pricing problems and shows that the static fine is equivalent to the standard monopoly price if detection is perfect and zero weight is given to offender gains. We further illustrate the connection with two examples from dynamic monopoly pricing. Section 5 considers various extensions. Section 6 offers conclusions and directions for future research.

# 2 Static Model

We build on the canonical model of optimal law enforcement pioneered by Becker (1968) and studied extensively in Polinsky and Shavell (2007). Consider a population of individuals who obtain gain $g \geq 0$ from committing an offense that generates social harm $h \geq 0$. Individual gains are private knowledge and drawn independently from a distribution with density function $z(g)$ and cumulative distribution function $Z(g)$ on $[\underline{g}, \bar{g}]$, with $\bar{g} > h > \underline{g}$ and $z(g) > 0$ for all $g$, such that neither complete deterrence nor zero deterrence is optimal from a standard welfare perspective. Individuals who commit the act are detected with exogenous probability $\pi \in (0,1]$ and must pay the fine $f \geq 0$. Individuals are risk-neutral, implying that only offenders whose gain exceeds the expected fine, $g \geq \pi f$, choose to commit the act.

The enforcement authority is assumed to maximize social welfare $W$, which is defined as the sum of the gains offenders obtain from committing the harmful act less the harm caused (Polinsky and Shavell, 2007, p. 413),

$$W(f;h,\pi) = \int_{\pi f}^{\bar{g}} (g-h)dZ(g). \tag{1}$$

Note that the fine $f$ imposed on detected offenders is a socially costless transfer of money from offenders to the enforcement authority, as the offenders' gains are fully credited to social welfare. It is well known that, in this canonical setting, the optimal fine $f^*(h,\pi) = h/\pi$ implements the first-best outcome (see, e.g., Polinsky 2007): Only individuals whose private gain exceeds the social harm ('efficient offenders') commit the harmful act, while all other individuals ('inefficient offenders') are deterred.

The assumption that 'illicit' offender gains are fully credited to welfare has long been criticized in the literature (Stigler, 1974; Lewin and Trumbull, 1990; Polinsky and Shavell, 2007). We relax this assumption and let the authority maximize a weighted sum of surplus, with weight one given to expected income from fine payments net of social cost, and weight $\alpha \in [0,1]$ given to offenders gains. The authority's objective function is then given by

$$\Omega(f;h,\pi,\alpha) = \int_{\pi f}^{\bar{g}} (\pi f - h) dZ(g) + \alpha \int_{\pi f}^{\bar{g}} (g - \pi f) dZ(g), \tag{2}$$

which is equivalent to (1) if the authority gives full weight to offender gains, $\alpha = 1$, and thus maximizes standard welfare. For $\alpha < 1$, offender gains are not fully credited to social welfare, as the authority gives relatively more weight to net income from fine payments. When $\alpha = 0$, the authority focuses exclusively on net redistribution from offender payments.

Our first result characterizes the optimal static fine for the generalized canonical offender model.

**Proposition 1** (static fine)**.** *Suppose the authority's objective function* $\Omega(f;h,\pi,\alpha)$ *is strictly quasi-concave and offender gains are weighted with* $\alpha \in [0,1]$*. Then, the optimal static fine satisfies*

$$f^*(h,\pi,\alpha) = \frac{h}{\pi} + \frac{(1-\alpha)[1-Z(\pi f^*)]}{z(\pi f^*)\pi}, \tag{3}$$

*with* $df^*(h,\pi,\alpha)/d\alpha \leq 0$*.*

*Proof.* Using Leibniz's rule, differentiating $\Omega(f;h,\pi,\alpha)$ with respect to $f$ yields the first-order condition

$$(1-\alpha)[(1-Z(\pi f^*)] - (\pi f^* - h) z(\pi f^*) = 0.$$

Solving for $f^*$ yields the optimal static fine $f^*(h,\pi,\alpha)$. The comparative-statics effect of an increase in $\alpha$ on $f^*(h,\pi,\alpha)$ is readily determined by applying the implicit function theorem to the first-order condition and noting that the cross-partial derivative satisfies $\Omega_{f\alpha} = -[1-Z(\pi f)] \leq 0$. □

Proposition 1 shows the optimal static fine depends on the weight that the authority gives to offender gains. If offender gains are not fully credited to welfare ($\alpha < 1$), the optimal fine exceeds the first-best level $h/\pi$, such that some efficient offenders with types $g > h$ are deterred. The optimal fine now reflects the enforcement authority's interest in redistributing illicit offender gains to society. Note that complete deterrence is not optimal, even if offender gains are not credited to welfare at all ($\alpha = 0$). The reason is that the authority still benefits from the net income from fine payments. Figure 1 illustrates the generalized static offender model with three different values for $\alpha$. The shaded area corresponds to the authority's surplus if $\alpha = \frac{1}{2}$.

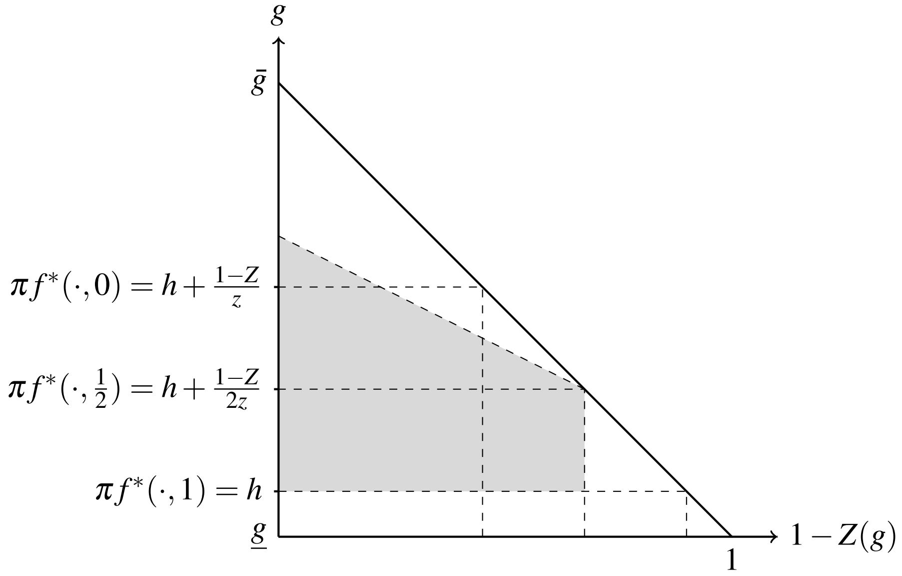



**Figure 1:** Static model

**Notes:** The figure shows the optimal expected fine $\pi f^*(\cdot,\alpha)$ in the generalized offender model with a linear demand for $\alpha \in \{0, \frac{1}{2}, 1\}$. The shaded area indicates the authority's surplus $\Omega$ for $\alpha = \frac{1}{2}$.

# 3 Dynamic Model

Let us now consider the repeated version of the generalized offender model with two periods $t = 1,2$. Suppose that the authority and offenders share the same discount factor $\delta \in (0,1)$,[5] and assume that the authority can set three fines $\mathbf{f} = \{f_1, f_2, \hat{f}_2\}$ that are imposed on detected offenders: $f_1$ for first-time offenders in period 1, $f_2$ for first-time offenders in period 2, and $\hat{f}_2$ for repeat offenders in period 2. Finally, assume that offenders are forward-looking and cannot commit to future offense decisions.

## 3.1 Skimming Property

Since higher types have higher gains, the skimming property (Fudenberg et al. 1985, Cabral et al. 1999, Tirole 2016) ensures that higher-type offenders make their purchases no later than lower-type offenders. Specifically, if a type $g$ chooses to offend in period $t$, then so does a higher type $g' > g$. To see how the skimming property works in our setting, consider the gain of an offender with type $g$ from offending in period 1 and period 2 vs.

[5]We will relax this assumption in Section 5.1.

the gain from offending in period 2 only. For this individual to offend in period 1, we must have that the gain from offending in period 1 and period 2,

$$\phi_1(g) \equiv g - \pi f_1 + \delta[\pi(g - \pi \hat{f}_2) + (1-\pi)(g - \pi f_2)],$$

exceeds the gain from offending in period 2 only,

$$\phi_2(g) \equiv \delta(g - \pi f_2).$$

It is straightforward to see that

$$\phi_1(g') - \phi_1(g) > \phi_2(g') - \phi_2(g), \text{ for } g' > g,$$

which implies that there exists a unique cutoff $g_1^*(\mathbf{f})$ which splits the type set into offenders and non-offenders in period 1. Similarly, in period 2 we have that $g' - \pi f_2 > g - \pi f_2$ and $g' - \pi \hat{f}_2 > g - \pi \hat{f}_2$, so that in each period and each segment there exists a unique cutoff.

By choosing the menu of fines $\mathbf{f}$, the authority induces individuals to self-select into different offender segments. In doing so, the authority may or may not be able to commit to the menu of fines at the beginning of period 1. We consider each case in turn.

## 3.2 Commitment

Suppose that the authority is able to commit to the full menu of fines $\mathbf{f}$ at the beginning of period 1. In this case, the fines $f_2$ and $\hat{f}_2$ applied in period 2 are not conditioned on the offenders' behavior in period 1. The next proposition establishes that under commitment it is optimal *not* to vary the fines in the generalized offender model. This result is reminiscent of classic findings in the price discrimination literature, which show that it is optimal not to price discriminate under commitment if consumer types are fixed and the seller and individuals share the same discount factor (Stokey 1979, Hart and Tirole 1988, Acquisti and Varian 2005, Fudenberg and Villas-Boas 2007).[6]

**Proposition 2** (commitment)**.** *Suppose the authority can commit to the full menu of fines at the beginning of period 1. Then, it can do no better than set all fines equal to the optimal static fine, that is,* $f_1^* = f_2^* = \hat{f}_2^* = f^*(h, \pi, \alpha)$.

*Proof.* Consider high-valuation individuals with $g' \geq g^*$ and low-valuation individuals with $g < g^*$, where $g^*$ is the optimal static cutoff. For all high-valuation individuals to reveal themselves in period 1, fines must be chosen such that the cutoff in period 1 satisfies

[6]We discuss the relation of the generalized offender model to dynamic pricing models in section 4.

$g_1^* \leq g^*$. Similarly, for all low-valuation individuals to reveal themselves, we must have $g_1^* \geq g^*$. This immediately implies that $g_1^* = g^*$. In addition, it cannot be optimal to choose a cutoff $g_2^* \neq g_1^*$ whenever $g_1^* = g^*$, as the authority could do better by setting $g_2^* = g_1^*$. Therefore, the unique optimal policy is to set the fines such that the cutoffs are equal, $g_1^* = g_2^* = g^*$. By Proposition 1, optimality requires that $g_2^* = \pi f_2^* = \pi f^*(h, \pi, \alpha) = g_1^*$. The indifference condition $\phi(g_1^*) = \phi(g_2^*)$ then simplifies to $g_1^* - \pi f_1 + \delta\pi(g_1^* - \pi\hat{f}_2) = 0$, which is satisfied for $f_1^* = f_2^* = \hat{f}_2^* = f^*(h, \pi, \alpha)$. $\square$

Proposition 2 shows that the authority can do no better than achieve the optimal static outcome in both periods: With commitment, it is optimal to set the optimal static fine $f^*$ for all offenders and thus abstain from inter-temporal discrimination ($f_1 \neq f_2$) or behavior-based discrimination ($f_2 \neq \hat{f}_2$). It is worth noting that constant fines are not uniquely optimal. Decreasing fines for repeat offenders that implement equal cutoffs, $g_1^* = g_2^*$, such that only detected repeat offenders benefit from the lower fine period 2, whereas previously non-detected repeat offenders face the optimal static fine in period 2, may also be optimal. Yet, the authority cannot do better with decreasing rather than constant fines. Escalating fines, in turn, cannot be optimal, because individuals cannot be coerced to offend at arbitrary fines.

The result clarifies why the literature on optimal law enforcement has struggled to explain escalating fines in the repeated canonical framework: if the authority can commit to fines, it is simply not optimal to escalate fines if the economic environment does not change over time. Next, we consider the case where the authority lacks commitment ability.

## 3.3 Non-Commitment

Consider a setting in which the authority lacks commitment ability. The authority will then want to condition the fines in period 2 on the offenders' observed behavior in period 1 (i.e., whether or not they were previously detected as offenders). As a result, optimal fines in period 2 must account for both *right*-truncation for first-time offenders and *left*-truncation for repeat offenders, as the cutoff in period 1, $g_1^*$, separates the type set into non-offenders $[\underline{g}, g_1^*]$ and offenders $[g_1^*, \bar{g}]$, respectively.

To understand how left- and right-truncation affect the setting of fines, consider the optimal fine $\hat{f}_2$ for repeat offenders in period 2. Left-truncation at $g_1^*$ implies that the optimal expected fine for repeat offenders must be at least as large as the cutoff in period 1, $\pi\hat{f}_2^* \geq g_1^*$, as all previously detected offenders must have types $g \geq g_1^*$ (otherwise they would not have offended in period 1). This immediately implies that it cannot pay off to strategically offend in period 1: a loss incurred in period 1 cannot be recouped in period 2, as the optimal fine for repeat offenses cannot fall. Strategic delay is thus the only way in which individuals may benefit from non-myopic behavior, which implies that the cutoff in period 1 must satisfy $g_1^* \geq \pi f_1^*$. Note that right-truncation at $g_1^*$ does not eliminate all types $g \geq g_1^*$ from the pool of first-time offenders in period 2. The reason is that a share $(1-\pi)$ of the individuals with types $g \geq g_1^*$ who offend in period 1 go undetected.

We now proceed to characterize optimal individual behavior conditional on types.

**Proposition 3** (self-selection)**.** *Suppose that the authority lacks commitment ability. Then, individuals optimally condition their behavior on types as follows:*

*(i) Types $g < \min\{\pi f_1, \pi f_2\}$ never offend.*

*(ii) Types $g \geq \pi \hat{f}_2$ always offend.*

*(iii) For $f_2 \geq f_1$, individuals behave as if they were myopic, such that types $g \in [\pi f_1, \pi \hat{f}_2)$ offend in period 1 and types $g \in [\pi f_2, \pi \hat{f}_2)$ offend in period 2 if not previously detected.*

*(iv) For $f_2 < f_1$, types $g \in [\pi f_1, g_1^*)$ strategically delay the offense in period 1 and offend in period 2; types $g \in [g_1^*, \pi \hat{f}_2)$ offend in period 1 and offend in period 2 if not previously detected; types $g \in [\pi f_2, g_1^*]$ offend in period 2.*

*Proof.* We consider each statement in turn.

(i) If $f_1 \leq f_2$, offenders act as if they were myopic. For types $g < \pi f_1$ it is not profitable to offend in period 1, and at best equally unprofitable in period 2. If $f_1 > f_2$, types $g < \pi f_2$ do not find it profitable to offend in period 2, and thus even less so in period 1.

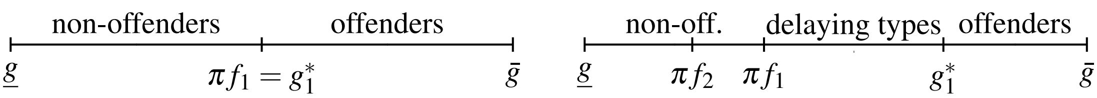
(ii) For types $g \geq \pi \hat{f}_2$ it is always profitable to offend, even at the expected fine $\pi \hat{f}_2 \geq g_1^*$ in period 2, and thus also at the expected fine $\pi f_1 \leq g_1^*$ in period 1.

(iii) For $f_2 \geq f_1$, strategy delay is not profitable by assumption, and individuals thus behave as if they were myopic. Therefore, all types $g \geq \pi f_1$ offend in period 1, and all types $g \geq \pi f_2$ that were not previously detected offend in period 2. The result follows from noting that types $g \geq \pi \hat{f}_2$ always offend by (ii).

(iv) For $f_2 < f_1$, it is profitable for types $g \in [\pi f_1, g_1^*)$ to strategically delay offending in period 1 by construction, and to offend in period 2 by assumption. Similarly, it is profitable for $g \in [g_1^*, \pi \hat{f}_2)$ to offend in period 1 by construction. In period 2, optimal behavior is myopic, and offending is profitable only if not previously detected ($\pi f_2 < g_1^* \leq \pi \hat{f}_2$).

□

Proposition 3 characterizes how individuals optimally self-select based on their types. Essentially, two cases need to be distinguished. First, if the fine for first-time offenses increases, $f_2 \geq f_1$, forward-looking offenders cannot gain from strategic delay and behave as if they were myopic. The cutoff in period 1 is then given by $g_1^* = \pi f_1$. This case is illustrated in panel a) of Figure 2. Second, if the fine for first-time offenses decreases, $f_2 < f_1$, some forward-looking agents strategically delay the offense to benefit from the lower fine in period 2. The cutoff in period 1 then exceeds the myopic level, $g_1^* > \pi f_1$, as illustrated in panel b) of Figure 2.




**(a)** $f_1 \leq f_2$: myopic

**(b)** $f_1 > f_2$: strategic delay

**Figure 2:** Self-selection in period 1

**Notes:** The figure illustrates how individuals with different types optimally self-select in period 1. Panel (a) shows the case of weakly increasing fines for first-time offenses. Panel (b) shows the case of decreasing fines for first-time offenses.

Next, we study how the authority optimally chooses fines, accounting for optimal self-selection by individuals.

### 3.3.1 Optimal Fines in Period 2

We first consider the optimal fine for repeat offenders in period 2, $\hat{f}_2^*$. This fine must maximize the authority's surplus generated by previously detected repeat offenders with types $g \in [g_1^*, \bar{g}]$,

$$\hat{f}_2^* = \arg\max_{\hat{f}_2 \in \hat{F}_2} \left\{ (\pi \hat{f}_2 - h) \frac{1 - Z(\pi \hat{f}_2)}{1 - Z(g_1^*)} + \alpha (g - \pi \hat{f}_2) \frac{1 - Z(\pi \hat{f}_2)}{1 - Z(g_1^*)} \right\}, \tag{4}$$

where $\hat{F}_2 \equiv \{\hat{f}_2 : \pi \hat{f}_2 \geq g_1^*\}$ is the set of fines for which the expected fine for repeat offenders exceeds the cutoff $g_1^*$. Our next result shows how the optimal fine is determined.

**Proposition 4** (repeat offenders)**.** *Suppose that the authority lacks commitment ability. Then,* *(i) if $g_1^* < \pi f^*(h,\pi,\alpha)$, the optimal fine for repeat offenders in period 2 equals the optimal static fine, $\hat{f}_2^* = f^*(h,\pi,\alpha)$.*

*(ii) if $g_1^* \geq \pi f^*(h,\pi,\alpha)$, the optimal fine for repeat offenders in period 2 keeps the cutoff constant, $\pi \hat{f}_2^* = \hat{g}_2^* = g_1^*$.*

*Proof.* We consider both statements in turn.

(i) For $g_1^* < \pi f^*(h,\pi,\alpha)$, it is optimal for the authority to set $\hat{f}_2^* = f^*(h,\pi,\alpha)$ by Proposition 1, as individual behavior is myopic in period 2.

(ii) For $g_1^* \geq \pi f^*(h,\pi,\alpha)$, the surplus in (4) is maximized at the lower bound after left-truncation, $\pi \hat{f}_2^* = \hat{g}_2^* = g_1^*$.

□

Proposition 4 states that the optimal fine for repeat offenders in period 2 equals the optimal static fine if the cutoff in period 1 is below the optimal static cutoff. The intuition for this result is straightforward: since individuals are myopic in period 2 and the left-truncation at $g_1^*$ does not prevent the authority from reaching the static optimum, it is best to choose the optimal static fine. This finding might suggest that escalation occurs if the initial cutoff is lower than the static optimum. However, as will become clear below, it cannot be optimal for the authority to induce a cutoff $g_1^*$ that is below the static optimum, since this would induce a loss that cannot be recouped in period 2. Henceforth, we therefore focus on the case where $g_1^*$ exceeds the optimal static cutoff.[7]

Proposition 4 further demonstrates that if $g_1^*$ exceeds the optimal static cutoff, the optimal cutoff for repeat offenders in period 2 must equal the cutoff from period 1, $\hat{g}_2^* = g_1^*$. That is, the optimal fine for repeat offenders in period 2 does not exclude previous offenders. This result reflects Tirole's (2016) insight in the context of dynamic pricing that the set of inframarginal consumers is invariant to left-truncation under positive selection. At first glance, the result may seem surprising as cutoff invariance obtains even though exit (i.e., no offense) is not absorbing in our setting. Note, however, that the cutoff invariance result holds *only* for repeat offenders with types above the cutoff level $g_1^*$ who must have committed the offense in period 1 by construction. Therefore, exit is indeed absorbing for repeat offenders.[8] Exit is clearly not absorbing, though, for offenders with types below the cutoff level $g_1^*$.

[7] Mueller and Schmitz (2015) analyze a setting in which the initial fines for first-time offenders are exogenously restricted.

[8] Put differently, individuals cannot self-select into the set of repeat offenders after exit in period 1.

The result sheds further light on why the literature on optimal law enforcement has struggled to explain escalating fines: The notion that repeat offenders should pay higher monetary fines in period 2 than first-time offenders in period 1 *because of identifiably higher private gains* turns out to be incorrect. In a fixed economic environment with a given type distribution, the authority can induce the optimal cutoff $g_1^*$ by the appropriate choice of fines right from the start and does not benefit from the identification of individual offenders over time.

Next, we determine the optimal fine for offenders in period 2 that were not previously detected, $f_2^*$. This fine maximizes the authority's surplus generated by true first-time offenders in period 2 with types $g \in [\pi f_2, g_1^*]$ and false first-time offenders who are in fact repeat offenders with types $g \in [g_1^*, \bar{g}]$ that were not previously detected,

$$
\begin{aligned}
f_2^* \quad &= \quad \arg\max_{f_2} \left\{ \left[ \int_{\pi f_2}^{g_1^*} (\pi f_2 - h) dZ(g) + \alpha \int_{\pi f_2}^{g_1^*} (g - \pi f_2) dZ(g) \right] \right. \\
&+ \quad (1-\pi) \left. \left[ \int_{g_1^*}^{\bar{g}} (\pi f_2 - h) dZ(g) + \alpha \int_{g_1^*}^{\bar{g}} (g - \pi f_2) dZ(g) \right] \right\}.
\end{aligned}
\tag{5}
$$

The next result shows that the optimal fine for first-time offenders in period 2 is lower than the optimal static fine if the authority does not maximize standard welfare.

**Proposition 5** (first-time offenders)**.** *Suppose that the authority lacks commitment ability. Then, the optimal fine for first-time offenders in period 2 satisfies*

$$
f_2^*(g_1^*; h, \pi, \alpha) = \frac{h}{\pi} + \frac{(1-\alpha)[Z(g_1^*) - Z(\pi f_2^*) + (1-\pi)[1 - Z(g_1^*)]]}{z(\pi f_2^*)\pi}. \tag{6}
$$

*If the authority gives less than full weight to offender gains, $\alpha < 1$, this fine is lower than the optimal static fine, $f_2^*(g_1^*; h, \pi, \alpha) < f^*(h, \pi, \alpha)$.*

*Proof.* Using Leibniz's rule, maximizing the surplus in (5) with respect to $f_2$ yields $f_2^*$ in (6). For $\alpha < 1$, we must have $f_2^*(g_1^*; h, \pi, \alpha) \leq f^*(h, \pi, \alpha)$ by construction. However, $f_2^*(g_1^*; h, \pi, \alpha) = f^*(h, \pi, \alpha)$ requires complete deterrence ($g_1^* = \bar{g}$) in period 1 by Proposition 1, which cannot be optimal because of $h < \bar{g}$ by assumption. □

Two comments are in order. First, if the authority gives full weight to offender gains ($\alpha = 1$), the optimal fine for first-time offenders in period 2 equals the standard welfare-maximizing fine, $f_2^* = h/\pi$. This finding is intuitive, as standard welfare maximization forces the expected fine down to the social cost of the offense. Second, if the authority gives less than full weight to offender gains ($\alpha < 1$), the optimal fine is strictly smaller than the static optimal fine. To understand the intuition for this result, consider the extreme case where the cutoff is at the upper bound of the type set, $g_1^* = \bar{g}$, and note that $f_2^*(\bar{g};h,\pi,\alpha) = f^*(h,\pi,\alpha)$. Next, consider a marginal reduction in the cutoff value $g_1^*$. This reduction eliminates offenders with types just below the cutoff level from the pool of true first-time offenders and adds them to the pool of false first-time offenders, but with probability less than one. For a cutoff level $g_1^* < \bar{g}$, the optimal fine must therefore be lower than the optimal static fine.

### 3.3.2 Establishing Escalation

We now establish the conditions under which escalation occurs. To do so, we determine the cutoff level $g_1^*(\mathbf{f})$ in period 1 using the indifference condition which equates an offender's utility from consuming in period 1 and period 2 with the utility from consuming in period 2 only. Specifically, the indifferent type $g_1^*$ must satisfy the condition

$$g_1^* - \pi f_1 + \delta[\pi(g_1^* - \pi\hat{f}_2) + (1-\pi)(g_1^* - \pi f_2)] = \delta(g_1^* - \pi f_2), \tag{7}$$

where the left-hand side accounts for the fact that an offender in period 1 faces two possible outcomes: with probability $\pi$ the offense in period 1 is detected, in which case the repeat offender faces the expected fine $\pi\hat{f}_2^*$ in period 2; with probability $(1-\pi)$ the offense is not detected, and the repeat offender faces the same expected fine $\pi f_2$ as a true first-time offender in period 2. Now, since $g_1^* - \pi\hat{f}_2 \leq 0$ by Proposition 4, a previously detected offender will either not offend (if $g_1^* - \pi\hat{f}_2 < 0$), or get a zero surplus from offending (if $g_1^* - \pi\hat{f}_2 = 0$) in period 2. In both cases, the second term is zero, such that the indifference condition simplifies to

$$g_1^* - \pi f_1 = \delta\pi(g_1^* - \pi f_2). \tag{8}$$

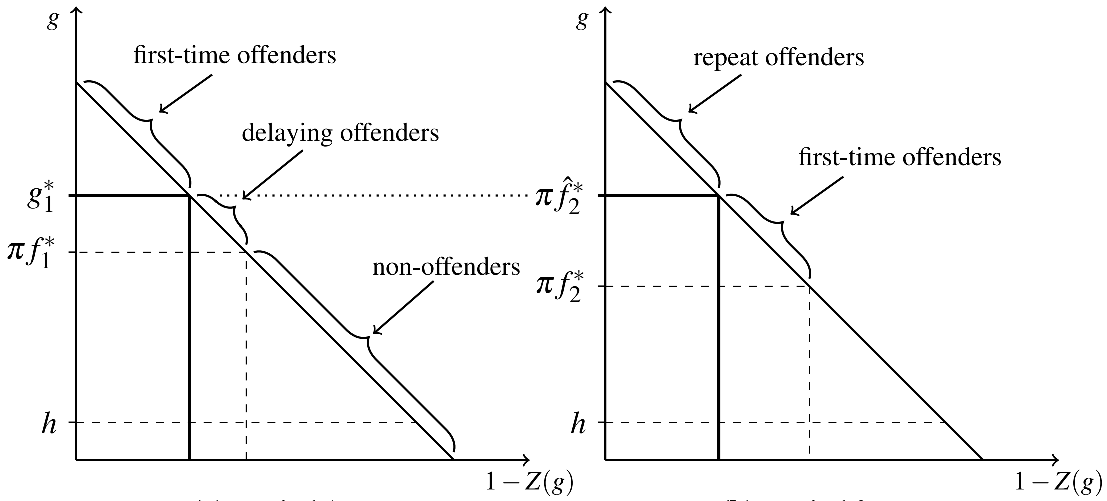
We can now derive the following result.

**Proposition 6** (escalation)**.** *Suppose that the authority lacks commitment ability. Then, optimal fines for repeat offenders escalate, $\hat{f}_2^* > f_1^*$, if and only if the optimal fines for first-time offenders decrease, $f_2^* < f_1^*$.*

*Proof.* Suppose the optimal fines for first-time offenders decrease, $f_2^* < f_1^*$. Then, using (8), we have $g_1^*(f_1^*, f_2^*) > \pi f_1^*$. Since $g_1^* \leq \pi\hat{f}_2^*$ by Proposition 4, we must have $\pi\hat{f}_2^* > \pi f_1^*$ and thus $\hat{f}_2^* > f_1^*$. This establishes sufficiency.

To establish necessity, assume that $\hat{f}_2^* > f_1^*$, and thus $\pi\hat{f}_2^* > \pi f_1^*$. Since the optimal cutoff in period 1 must satisfy $g_1^* \geq \pi f^*(h,\pi,\alpha)$, we must have $\pi\hat{f}_2^* = \hat{g}_2^* = g_1^* > \pi f_1^*$ by Proposition 4. The latter inequality requires $f_2^* < f_1^*$ by (8). $\square$

Proposition 6 highlights that escalating fines for repeat offenders (if any) follow from *decreasing* fines for low-value offenders rather than increasing fines for detected high-value offenders. The prospect of decreasing fines induces some individuals with types above the expected fine to strategically delay the offense, which in turn drives a wedge between the expected fine $\pi f_1^*$ and the cutoff $g_1^*$ in period 1. This is illustrated in panel (a) of Figure 3. The wedge these delaying offenders cause gives rise to escalation, $\hat{f}_2^* > f_1^*$, because by Proposition 4 the cutoff is invariant from period 1 to period 2, $g_1^* = \pi \hat{f}_2^*$, which is illustrated in panel (b) of Figure 3. In contrast, if there is no wedge between the expected fine and the cutoff, $\pi f_1^* = g_1^*$, cutoff invariance yields constant fines $\pi f_1^* = \pi \hat{f}_2^*$.




**(a)**: period 1 **(b)**: period 2

**Figure 3:** Dynamic model without commitment

**Notes:** The figure illustrates the optimal fines and induced inter-temporal cutoff when the authority lacks commitment ability. Panel (a) depicts the first period and shows the wedge between cutoff and expected fine that delaying offenders cause. Panel (b) depicts the second period and shows the resulting escalation in price for repeat offenders.

The following corollary is an immediate implication.

**Corollary 1.** *Suppose that the authority lacks commitment ability and attaches weight $\alpha < 1$ to offenders. Then, optimal fines escalate,*

$$\hat{f}_2^* > f_1^* > f_2^*. \tag{9}$$

*Proof.* By Proposition 5, $f_2^* < f^*(h, \pi, \alpha)$ for $\alpha < 1$. The indifference condition (8) then immediately implies that $g_1^* > \pi f_1^* > \pi f_2^*$. Substituting $g_1^* = \pi \hat{f}_2^*$ by Proposition 4 yields the result. □

The result demonstrates that, without commitment, the authority has an incentive to lower the fine for first-time offenses if it gives less than full weight to offenders gains.

The intuition for this result is straightforward: if full weight is given to offender gains, fine payments are irrelevant for the authority's surplus, and optimal expected fines must reflect the (fixed) social cost of the offense. There is thus no incentive to lower the fine for first-time consumption. However, if less than full weight is given to offender gains, the redistribution motive kicks in, and the authority has an incentive to lower the fine and redistribute additional fine payments in the next period.

# 4 Relation to Monopoly Pricing

We have noted above that the choice of optimal fines by an authority is closely related to profit-maximizing monopoly pricing. To clarify this relation, recall that the authority's static objective function is given by $\Omega(f;h,\pi,\alpha)$. The following corollary is an immediate implication of Proposition 1.

**Corollary 2** (static monopoly price)**.** *Suppose the authority gives zero weight to offender gains and detects offenses with probability one,* $\Omega(f;h,1,0)$*. Then, relabelling the fine as a price,* $f \equiv p$*, the optimal fine is given by the static monopoly price*

$$p^m(h,1,0) = h + \frac{1 - Z(p^m)}{z(p^m)}. \tag{10}$$

Corollary 2 shows that it is natural to view a fine as a price (Gneezy and Rustichini, 2000): the optimal (surplus-maximizing) fine is exactly equal to the monopoly price if the authority focuses on maximizing net income from fines and can perfectly detect offenses.

More generally, the canonical Becker (1968) model and standard monopoly pricing are nested special cases of the generalized offender model that differ in (i) the weight given to offender gains (consumer rents, respectively) and (ii) the probability of detecting an offense (consumption). To illustrate how the results for the generalized offender model carry over to dynamic monopoly pricing, we next consider two well-known examples for dynamic monopoly pricing with $\alpha = 0$ and $\pi = 1$, assuming that individual gains $g$ are uniformly distributed on $[0,1]$.

## 4.1 Behavior-Based Pricing

Armstrong (2006, pp. 6) studies behavior-based monopoly pricing in a two-period model where production is costless, $h = 0$. This setting is a special case of the generalized offender model in which prices $\mathbf{p} = \{p_1, p_2, \hat{p}_2\}$ rather than fines are chosen so as to maximize intertemporal profits.

With commitment, it is optimal not to discriminate prices and set all prices equal to the static monopoly price $p_1^* = p_2^* = \hat{p}_2^* = p^m = \frac{1}{2}$. This result is a special case of Proposition 2. If the monopolist lacks commitment ability, prices are chosen so as to maximize intertemporal profits

$$\pi_1 + \delta \pi_2 = p_1(1 - g_1^*) + \delta[\hat{p}_2(1 - g_1^*) + p_2(g_1^* - p_2)],$$

where the price for repeat consumers in period 2 is $\hat{p}_2^* = p^m = \frac{1}{2}$ if $g_1^* < p^m$ and $\hat{p}_2^* = g_1^*$ if $g_1^* \geq p^m$, which is in line with Proposition 4. The price for first-time consumers in period 2 must account for right-truncation and is given by $p_2^* = \frac{1}{2} g_1^*$, which is in line with Proposition 5. Using these prices, it is straightforward to solve the indifference condition for the cutoff $g_1^*(p_1) = (2p_1)/(2 - \delta)$. Maximizing over $p_1$ then yields the profit-maximizing prices (Armstrong, 2006)

$$p_1^* = \frac{4 - \delta^2}{2(4 + \delta)}; \quad p_2^* = \frac{2 + \delta}{2(4 + \delta)}; \quad \hat{p}_2^* = \frac{2 + \delta}{(4 + \delta)}.$$

The monopolist thus practices behavior-based price discrimination as analyzed above: profit-maximizing prices for repeat consumers escalate because the monopolist cannot resist the temptation to lower the price for low-type consumers who have not consumed in period 1. The pricing for repeat consumers, in turn, is time-consistent.

## 4.2 Pricing with Positive Selection

Tirole (2016) analyzes dynamic monopoly pricing with positive selection, assuming that production is costly, $h = c$, and that consumers can consume in future periods only if they have consumed in all previous periods (absorbing exit). Consider the two-period version of this setting. Since types $g < g_1^*$ cannot consume in period 2 by assumption, first-time consumption in period 2 is excluded and the monopolist chooses two prices only, $p_1$ and $\hat{p}_2$. This two-period example is a special case of the generalized offender model in which only types above $g_1^*$ stay in the market.

It is shown that, with commitment, it is optimal not to discriminate prices and set all prices equal to the static monopoly price, which assuming a uniform distribution of gains is given by

$$p_1^* = \hat{p}_2^* = p^m = \frac{1 + c}{2},$$

which is in line with Proposition 2. More interestingly, Tirole (2016) shows the result holds even if the monopolist lacks commitment ability. The intuition for this result is as follows: Since exit is absorbing by assumption, all types $g < g_1^*$ below the cutoff are excluded in period 1, such that the monopolist is not tempted to lower the price for non-consumers below the static monopoly price. The profit-maximizing price for the remaining types $g \geq g_1^*$, in turn, is the static monopoly price, which is the lower bound after left-truncation. This is in line with the cutoff invariance result of Proposition 4.

# 5 Extensions

We now consider several extensions. First, we allow for heterogenous discount factors in the fixed-environment setting analyzed above. Second, we discuss changes in the environment that may provide alternative explanations for escalating pricing schemes.

## 5.1 Heterogeneous Discount Factors

So far we have assumed that all decision makers have the same discount factor $\delta$. We now consider settings in which the authority and individuals have different discount factors, $\delta_A \neq \delta_I$. With heterogeneous discount factors, a given surplus arising in period 2 is valued differently by the authority and individuals in period 1. This suggests that it may be beneficial for the authority to shift surplus gained by offenders from one period to the other, while keeping the overall offender surplus constant. For example, if the authority is more patient than individuals, $\delta_A > \delta_I$, the authority can offer them a lower surplus tomorrow in exchange for a higher surplus today by adjusting the prices accordingly. Specifically, the authority has an incentive to *backload* the fines ($f_1 < \hat{f}_2$) when it is more patient than individuals, $\delta_A > \delta_I$, and *frontload* the fines ($f_1 > \hat{f}_2$) when it is less patient, $\delta_A < \delta_I$. The next result establishes that, although heterogenous discount factors may provide an incentive to backload fines, they do not provide a new rationale for escalation.

**Proposition 7** (heterogeneous discounting)**.** *Suppose that the authority and individuals have unequal discount factors, $\delta_A \neq \delta_I$. Then,*

*(i) if the authority lacks commitment ability, escalating fines are optimal for $\alpha < 1$.*

*(ii) if the authority can commit and is more patient that individuals, $\delta_A > \delta_I$, constant fines are optimal.*

*(iii) if the authority can commit and is less patient than individuals, $\delta_A < \delta_I$, optimal fines for repeat offenders are frontloaded and satisfy $f_1^* = f^*(1+\pi\delta_I) > \hat{f}_2^* = 0$.*

*Proof.* Consider the three statements in turn.

(i) Propositions 3-5 continue to apply as they are independent of the discount factors $(\delta_A, \delta_I)$. Proposition 6 relies on the individuals' indifference condition, which now reads $g_1^* - \pi f_1 = \delta_I(g_1^* - \pi f_2)$ rather than (8). As before, this implies that $g_1^*(f_1^*, f_2^*) > \pi f_1^*$, and since Proposition 4 continues to hold, the results of Proposition 6 and Corollary 1 still apply.

(ii) As established in the proof of Proposition 2, with authority commitment the unique optimal policy is to set the fines such that the cutoffs satisfy $g_1^* = g_2^*$. Since offenders cannot commit, optimality requires that $g_2^* = \pi f_2^* = \pi f^*(h, \pi, \alpha) = g_1^*$. The indifference condition then reads $g_1^* - \pi f_1 + \delta_I \pi(g_1^* - \pi \hat{f}_2) = 0$, which is satisfied for $f_1^* = f_2^* = \hat{f}_2^* = f^*(h, \pi, \alpha)$.

(iii) As established in (ii), with authority commitment the cutoffs satisfy $g_1^* = g_2^*$, and $g_2^* = \pi f_2^* = \pi f^*(h, \pi, \alpha)$. If $\delta_A < \delta_I$, the authority can strictly gain by transferring its surplus in period 2 to offenders in exchange for extracting their surplus in period 1. Optimality requires that the authority's period-2 surplus is fully transferred, which immediately implies that $\pi \hat{f}_2^* = 0$. The indifference condition then reads $g_1^* - \pi f_1 + \delta_I \pi g_1^* = 0$, which yields $f_1^* = f^*(1 + \delta_I \pi)$.

□

Proposition 7 shows that heterogeneous discount factors cannot explain escalating fines. Although the authority has an incentive to backload the fines when it is more patient than individuals, our previous results continue to hold regardless of authority commitment. The intuition for this result is straightforward: Since the authority cannot coerce individuals into offending at fines at which they would not voluntarily offend from a myopic perspective in period 2, it cannot gain from lowering fines in period 1 in exchange for increasing fines in period 2. Thus, it can never profitably act on its incentive to backload.

However, heterogeneous discount factors may yield decreasing fines. If the authority can commit and is less patient than offenders, forward-looking repeat offenders will accept frontloaded fines that compensate them for a loss in period-1 surplus with an appropriate gain in period-2 surplus. As the authority can strictly gain from transferring period-2 surplus to repeat offenders in exchange for a higher period-1 surplus, it will optimally give up its total surplus in period 2, so that repeat offenders effectively pay once for committing the offense twice. As a consequence, the authority charges a fine in the first period that maximizes the total payment for the two periods subject to the constraint that the total surplus of repeat offenders is at least as large as that generated by constant fines.

Finally, note that frontloading is impossible if the authority lacks commit ability. This follows immediately from the fact that offenders are forward-looking. Without authority commitment, offenders will not accept frontloaded fines, as they correctly anticipate that the authority will not want to lower the fine below the optimal static level in period 2 to compensate for the higher fine in period 1.

## 5.2 Changes in the Economic Environment

The preceding analysis has focused on a fixed economic environment. However, there may be scenarios in which optimal fines escalate because of changes in the economic environment. For instance, a number of authors in the literature on explaining escalating fines have considered the effect of a lower detection probability for repeat offenders (e.g. Baik and Kim, 2001). In this section, we consider two exogenous parameter changes that give rise to such changes in the economic environment: (i) an increase in the social cost of offending, and (ii) a decrease in the detection probability as a function of the number of previous offenses.

### 5.2.1 Increasing Social Cost of Consumption

The next result establishes that an increase in the social cost of offending may indeed lead to escalating fines. More interestingly, it also shows that an increase in social cost may eliminate behavior-based discrimination.

**Proposition 8** (increasing social cost)**.** *Suppose the social cost of offending $h$ is known to increase over time, so that $h_2 > h_1$. Then,*

*(i) with authority commitment, the authority can do no better than set the fines equal to the respective optimal static fines, $f_1^* = f^*(h_1, \pi, \alpha)$ and $f_2^* = \hat{f}_2^* = f^*(h_2, \pi, \alpha)$, and hence $f_1^* < \hat{f}_2^* = f_2^*$.*

*(ii) if the authority lacks commitment ability, the increase in social cost reduces the incentive to lower the fine for first-time offenders and eliminates behavior-based discrimination altogether if $\pi f_2^*(h_2, \pi, \alpha) \geq g_1^*$.*

*Proof.* Consider each statement in turn.

(i) With authority commitment, optimality requires that the authority avoids strategic delay by offenders and accounts for the increase in the social cost of offending. By Proposition 1, it is optimal for the authority to set the fines such that $\hat{g}_2^* = g_2^* =$

$\pi \hat{f}_2 = \pi f_2^* = \pi f^*(h_2, \pi, \alpha)$ and $g_1^* = \pi f_1^* = \pi f^*(h_1, \pi, \alpha)$. The result follows from $h_2 > h_1$.

(ii) By Proposition 5, $f_2^*(h, \pi, \alpha)$ is increasing in the social cost of offending $h$. By Proposition 6, behavior-based escalation occurs if and only if $f_2^* < f_1^*$, which is not possible when $\pi f_2^*(h_2, \pi, \alpha) \geq g_1^*$.

□

Proposition 8 shows how an increase in the social cost of offending leads to escalating fines when the authority can commit. Note, though, that the logic is very different from that identified above: with commitment, it is optimal for the authority to charge the optimal static fine in each period. However, since optimal static fines increase mechanically due to the increase in social cost, escalating fines emerge even though the authority can commit.

The result also shows that, if the authority lacks commitment ability, an increase in the social cost may eliminate behavior-based discrimination. If the optimal static fine for first-time offenders in period 2 (i.e., after the increase in social cost) lies at or above the cutoff $g_1^*$, the authority cannot benefit from lowering the fine. This ensures that individuals behave as if they were myopic, since they cannot gain from delaying consumption. In this case, the outcome is the same as under authority commitment: the optimal static fine in period 2 increases mechanically due to $h_2 > h_1$.

#### 5.2.2 Decreasing Detection Probability

Finally, we consider a decrease in the detection probability as a function of the number of detections.

**Proposition 9** (decreasing detection probability)**.** *Suppose the probability of detection is known to decrease in the number of detections, so that $\pi_2 < \pi_1$. Then,*

*(i) with authority commitment, the authority can do no better than set $\pi_1 f_1^* = \pi_2 \hat{f}_2^*$ and hence $f_1^* < \hat{f}_2^*$.*

*(ii) if the authority lacks commitment ability, optimal fines are escalating for $\alpha < 1$.*

*Proof.* Consider the two statements in turn.

(i) Under authority commitment, it must still be that $g_1^* = g_2^* = \pi_1 f_2$. The indifference condition then becomes $g_1^* - \pi_1 f_1 + \delta \pi_1 (g_1^* - \pi_2 \hat{f}_2) = 0$, which as before is satisfied for $\pi_1 f_1^* = \pi_2 \hat{f}_2^*$. With $\pi_1 > \pi_2$, it follows immediately that $\hat{f}_2^* > f_1^*$.

(ii) The change in the detection probabilities does not affect the optimal cutoff values under non-commitment, which give rise to escalating fines for $\alpha < 1$ by Corollary 1. Optimal fines must now compensate for the decrease in the detection probability and thus continue to escalate.

□

Proposition 9 demonstrates that our analysis generalizes naturally to settings in which offenders become more effective at avoiding detection after having been fined for an offense. If the authority is able to commit, it still cannot do better than obtain the optimal static surplus in each period. Yet, because the detection probability for repeat offenders decreases, the fine for repeated consumption must increase to compensate. This is directly in line with the finding in Proposition 8. Similarly, if the authority lacks commitment ability, optimal fines continue to escalate, as they must implement the same cutoff values and therefore increase even more than in the standard setting to compensate for the decrease in the detection probability.

# 6 Conclusion

We have studied how escalating fine schemes emerge in a fixed economic environment in which offender types are private knowledge, the authority imperfectly recognizes previous offenders, and individual offender gains are not necessarily fully credited to welfare.

The key insight of our analysis is that escalation is driven by an incentive to *reduce* the fine for low-value offenders, rather than an incentive to increase the fine for high-value repeat offenders. The intuition for this result is as follows: if the authority cannot commit not to lower the fine in the future, some forward-looking offenders strategically delay offending to benefit from lower fines in the future, which drives a wedge between the optimal fine and the cutoff for first-time offenses. This wedge is the source of the fine increase for repeat offenders, while the positive selection of repeat offenders dictates that the optimal fine for repeat offenders keeps the cutoff constant. In addition, we have illustrated the relations to dynamic monopoly pricing and considered various extensions, including heterogenous discount factors and changes in the economic environment.

Our analysis suggests various avenues for future research. First, one could study how commitment by individuals affects the scope for escalating pricing schemes. Second, one might examine how competition among sellers affects the scope for escalating pricing schemes. Third, it would be interesting to provide systematic empirical evidence on escalating prices. We hope to address these issue in future research.

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