# 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) conditions optimal fines on offender histories, and (ii) does not fully credit offender gains to social welfare. We demonstrate that escalation is driven by decreasing fines for first-time offenders rather than increasing fines for repeat offenders. The authority can gain from lowering the fine for first-time offenders with a clean history, thereby redistributing additional offender gains to society. In contrast, the authority cannot gain from increasing the fine for repeat offenders because of their positive selection (Tirole 2016). 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

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# 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? Theory struggles with answering these questions when the economic environment does not change over time.[1]

In this paper, we study a generalized version of the canonical offender model pioneered by Becker (1968) and demonstrate that the (repeated) canonical model cannot explain escalating fines. Our analysis shows that the canonical model's inability to explain escalating fines stems from the standard assumption that 'illicit' offender gains are fully credited to social welfare. We relax this assumption and allow for the possibility that the authority gives less than full weight to offender gains, such that fine payments redistribute offender gains to society. The generalized offender model reveals that, contrary to what intuition might suggest, escalation (if any) is driven by decreasing fines for first-time offenders rather than increasing fines for repeat offenders. The result arises from the following logic: If the authority (i) conditions optimal punishment on offender histories, and (ii) does not fully credit offender gains to social welfare, it has an incentive to lower the fine for first-time offenders with a "clean" history, thereby redistributing additional offender gains to society. Some forward-looking offenders will then strategically delay their offense to benefit from lower fines in the future, which drives a wedge between the (static) expected fine in the first period and the gain of an individual that is indifferent between offending and non-offending. This wedge causes fines to escalate for repeat offenders.

We argue that a monetary fine may be viewed as a price (Gneezy and Rustichini, 2000) and show that the generalized canonical offender model nests both the Becker (1968) model of optimal law enforcement with history-based fine discrimination and behavior-based monopoly pricing (Armstrong, 2006; Fudenberg and Villas-Boas, 2007) as special cases. In particular, we show that the generalized canonical offender model and the standard behavior-based monopoly pricing model are formally equivalent if the authority gives zero weight to offender gains and detects offenses with probability one. We demonstrate that escalating fines cannot be explained by an incentive to increase the

[1] In a recent interview on `www.thepolitic.org` (August 4, 2018), Avinash Dixit suggests that the formal modelling of graduated punishments is "one of those unresolved research problems."

fines for repeat offenders for the same reason that price increases in the number of past purchases are suboptimal: the authority cannot gain from excluding previous offenders from the set of repeat offenders. Increasing the fine for the set of 'positively selected' (Tirole, 2016) repeat offenders cannot be beneficial, given that these types were optimally chosen in the first period by setting the first-period fine. This "curse" of positive selection is the reason why it is difficult to explain escalating fines.

We develop our line of argument in a simple two-period model. Following Polinsky and Shavell (2007), we assume that offender gains are continuously distributed and fixed, and we suppose that the authority and offenders share the same discount factor.[2] In period 1, forward-looking individuals 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.[3] This implies that, in period 2, the authority can distinguish two groups of offenders with different histories: 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, if the authority does not condition fines on offender histories (i.e., with commitment), it is never optimal to choose escalating fines. This finding is reminiscent of the classic result that it is optimal not to discriminate prices with commitment when types are fixed (Stokey, 1979; Hart and Tirole, 1988; Acquisti and Varian, 2005; Fudenberg and Villas-Boas, 2007). Specifically, we show that with commitment the authority can do no better than set all fines equal to the optimal static fine. It is worth noting that this is not uniquely optimal: falling fines for repeat offenders may also be optimal. Second, optimal fines for repeat offenders escalate if and only if the authority conditions punishment on offender histories (i.e., without commitment) and does not fully credit offender gains to social welfare. In this case, the authority optimally lowers the fine for first-time offenders with a clean history in order to redistribute additional offender gains to society.[4] Third, if the authority gives full weight to offender gains, it

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

[3] 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.

[4] Note that this result should not be interpreted as different penalties for 'young' and 'old' first-time offenders, since all individuals have the same age (but may commit the first offense in different periods).

maximizes standard social welfare and therefore sets all expected fines equal to the social cost of the offense, irrespective of its commitment ability. These results show that, in the generalized canonical model, escalating fines for repeat offenses (if any) are generated by falling fines for first-time offenses rather than increasing fines for repeat offenders. 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. In a well-known earlier paper, Polinsky and Shavell (1998) also argue that optimal fines for first-time offenders with a clean history are decreasing if the authority conditions punishment on offender histories ("rewarding good behavior"). However, they do *not* obtain escalating fines for repeat offenders and hypothesize that "penalizing bad behavior could be optimal" (Polinsky and Shavell, 1998, p. 313) in more general models. Our analysis shows that escalation is indeed optimal in a generalized version of the canonical offender model if the authority has an incentive to redistribute offender gains to society.

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 history-based fine discrimination in the canonical model. We relax the standard assumption that offender gains are fully credited to welfare, which 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). While we are agnostic about the extent to which offender gains are credited to welfare (and therefore consider the whole spectrum from full to no credit), our analysis shows that the standard assumption of full credit has prevented the canonical model from addressing escalation, as standard welfare maximization necessarily 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).

Earlier work in this field has suggested alternative explanations to solve the 'puzzle' of escalating fines (see Hylton (2005) and Miceli (2013) for useful surveys). For example, law enforcement may be error-prone, so accidental and real offenders are more distinguishable when the number of offenses increases (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).[5] Moreover,

[5]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).

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). Finally, if the authority minimizes the sum of harm from offenses and the cost of penalization, escalation may be optimal if the cost of penalization is increasing in the level of fines (Endres and Rundshagen, 2016).

Our analysis shows that (exogenous) changes in the environment are not needed to explain escalating fines if the authority optimally conditions punishment on offender histories. In fact, they may be insufficient to yield escalation even if intuition suggests otherwise. The reason is simple: if fine payments are socially costless transfers of money, the only role of optimal fines is to deter 'inefficient' offenders. Since the set of repeat offenders has already been optimally selected, any fine that does not deter repeat offenders in the second period is optimal. That is, changes in the economic environment require a corresponding increase in the optimal fine only if they increase the optimal deterrence level beyond the first-period cutoff.

Second, we contribute to the literature on behavior-based price discrimination by adding two ingredients to the analysis. The first ingredient is imperfect (probabilistic) customer recognition, which allows us to extend the analysis to optimal law enforcement. The paper closest to ours is Conitzer et al. (2012), which studies deterministic recognition in a two-period model with repeat purchases. 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), which 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. Our analysis differs from much of the customer recognition literature in that we consider a continuous distribution of types. Discrete types may provide another rationale for escalation that is driven by the ability to separate types in the second period (e.g. Acquisti and Varian, 2005; Taylor, 2004). With a continuous type distribution instead, there is no incentive to ratchet up (Freixas et al., 1985) the fine for revealed high types, and escalation is driven by individuals that strategically delay their offense, thereby obfuscating their type.

The second ingredient 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 its commitment ability. The reason is that the seller can do no better than set all 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 static version of the generalized offender model and derives the optimal 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 monopoly pricing. Section 5 considers various extensions, including heterogenous discount factors and relevant changes in the environment. 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 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, $g \geq \pi f$, 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 offender 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 and Shavell (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 expected offenders gains.[6] 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. Two comments are in order. First, if $\alpha < 1$, offender gains are not fully credited to social welfare, and the authority has an incentive to redistribute offender gains to society via fine payments, as it gives relatively more weight to net income from fine payments. Second, if $\alpha = 0$, the authority exclusively focuses on net redistribution and effectively behaves as a monopolist that maximizes expected income from fine payments net of social cost.

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

**Proposition 1** (static fine)**.** *Suppose the objective function $\Omega(f;h,\pi,\alpha)$ has a unique interior maximum for any $\alpha \in [0,1]$. Then, the optimal static fine satisfies*

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

*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 that 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 $h/\pi$, and some efficient offenders with types

[6] As will become clear below, applying the weight $\alpha$ to gross offender gains $g$ (rather than expected offender gains $g - \pi f$) affects the level of the optimal fine, but not the dynamics in the repeated setting.

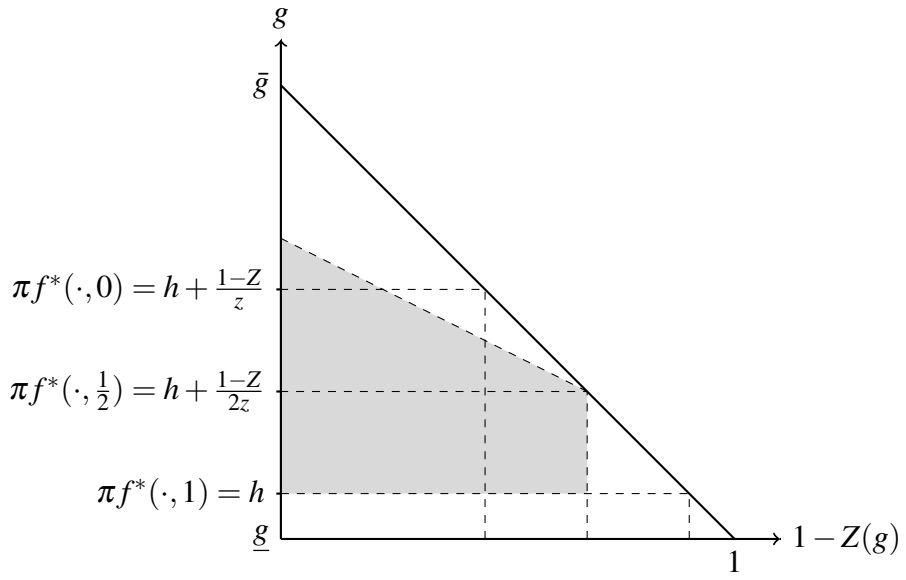


**Figure 1:** Static model

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

$g > h$ are deterred. The optimal fine now reflects the 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 $\alpha = \frac{1}{2}$.

We remain agnostic regarding the value of $\alpha$ and therefore allow for the entire spectrum from giving no credit to giving full credit to offender gains. Depending on the particular example one may have in mind, some specific values of $\alpha$ may be more reasonable than others. However, our analysis below will show that escalation cannot obtain in the canonical model if there is no desire to redistribute offender gains to society ($\alpha = 1$). It should be clear, though, that escalation may be optimal with $\alpha = 1$ in non-canonical settings in which the optimal deterrence level for repeat offenders increases by construction (e.g., due to accidental offenses, or increasing costs of penalization).

# 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 $\delta \in (0,1)$,[7] 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.

Since higher types have higher gains from committing the offense, the skimming property (Fudenberg et al. 1985, Cabral et al. 1999, Tirole 2016) ensures that higher-type offenders choose to offend 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, observe that for type $g$ to offend in period 1 ($x_1 = 1$), the gain from offending in period 1 plus the continuation value in period 2 must exceed the continuation value in period 2 following a decision not to offend in period 1 ($x_1 = 0$),

$$g - \pi f_1 + \delta V(g, x_1 = 1) \geq \delta V(g, x_1 = 0).$$

where $V(g,x_1)$ denotes the continuation value conditional on type $g$ and offense decision $x_1 \in \{0,1\}$ in period 1. Since type $g$ can always mimic type $g' > g$ in period 2 (irrespective of offense decisions in period 1), we must have

$$g' - g \geq V(g', x_1) - V(g, x_1), \quad x_1 \in \{0,1\}, \tag{3}$$

which implies that there exists a unique cutoff $g_1^*(\mathbf{f})$ that 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.

We now proceed to characterizing optimal individual behavior for any combination of fines that the authority may choose.

**Proposition 2** (self-selection)**.** *Forward-looking individuals optimally condition their offense decisions on types as follows:*

*(i) Types $g < \pi \min\{\mathbf{f}\}$ never offend.*

*(ii) The cutoff satisfies $g_1^* = \pi f_1$ ("quasi-myopia") if $f_1 \leq \min\{f_2, \hat{f}_2\}$ or $f_2 = \hat{f}_2$. Then, types $g \geq \pi f_1$ offend in the first period and offend again in the second if they were not caught and $g \geq \pi f_2$, or if they were caught and $g \geq \pi \hat{f}_2$.*

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

*(iii) The cutoff satisfies $g_1^* \leq \pi f_1$ ("strategic forwarding") if $f_1 > \hat{f}_2$ and $f_2 > \hat{f}_2$. Then, types $g \in [g_1^*, \pi f_1]$ offend in the first period despite incurring a loss and offend again in the second if they were caught, or if they were not caught and $g \geq \pi f_2$.*

*(iv) The cutoff satisfies $g_1^* > \pi f_1$ ("strategic delay") if $f_1 > f_2$ and $\hat{f}_2 > f_2$. Then, types $g \in [\pi f_1, g_1^*]$ delay their offense despite foregoing a gain in the first period and offend in the second period, and types $g \geq g_1^*$ offend in the first period and offend again in the second if $g \geq \pi \hat{f}_2$.*

*Proof.* First, note that the unique cutoff in the first period is determined by the indifference condition $g - \pi f_1 + \delta[\pi(g - \pi \hat{f}_2) + (1-\pi)(g - \pi f_2)] = \delta(g - \pi f_2)$, where each payoff in the second period is bounded below by zero, as offenders may always choose the outside option. We now consider each statement in turn.

(i) Types $g < \pi \min\{\mathbf{f}\}$ make a loss from offending in either period and facing any fine and hence never offend.

(ii) If $f_1 \leq \min\{f_2, \hat{f}_2\}$, by (i) types $g < \pi f_1$ will never offend, while types $g \in (\pi f_1, \pi \min\{\hat{f}_2, f_2\})$ face a loss from offending in period 2 and hence choose the outside option, irrespective of first-period behavior. The indifference condition then simplifies to $g_1^* - \pi f_1 = 0$, which immediately implies $g_1^* = \pi f_1$. Similarly, $f_2 = \hat{f}_2$ implies that the indifference conditions simplifies to $g_1^* = \pi f_1$.

(iii) If $f_1 > \hat{f}_2$, types $g \geq \pi f_1$ face a gain in the second period if they were caught in the first period and face either a loss (and take the outside option) or a gain in the second period if they were not caught. In the first case, the indifference condition simplifies to $g - \pi f_1 + \delta\pi(g - \pi \hat{f}_2) = 0$ which yields $g_1^* < \pi f_1$. In the second case, the indifference condition solves for $g_1^* = \pi(f_1 + \delta\pi(\hat{f}_2 - f_2))$, which yields $g_1^* < \pi f_1$ if $f_2 > \hat{f}_2$.

(iv) If $f_1 > f_2$, types $g \geq \pi f_1$ face a gain in the second period if they were not caught and face either a gain or loss (and take the outside option) in the second period if they were caught. In the first case, the indifference condition solves for $g_1^* = \pi(f_1 + \delta\pi(\hat{f}_2 - f_2))$, which yields $g_1^* > \pi f_1$ when $\hat{f}_2 > f_2$. In the second case, the indifference condition simplifies to $g - \pi f_1 - \delta\pi(g - \pi f_2) = 0$, which yields $g_1^* > \pi f_1$.

□

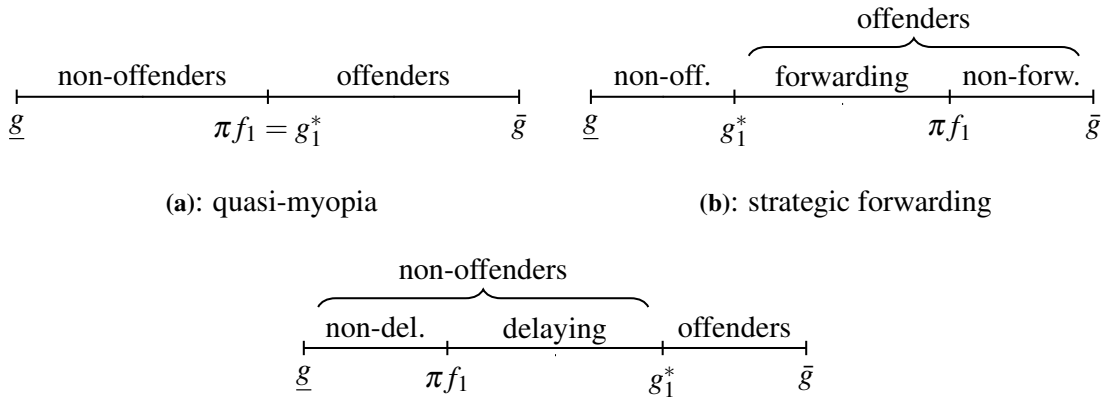


**Figure 2:** Self-selection in period 1

**Notes:** The figure illustrates how individuals optimally self-select in period 1 according to parts (ii)-(iv) of Proposition 2. Panel (a) shows the case of weakly increasing fines for offenses. Panel (b) shows the case of decreasing fines for repeat offenses. Panel (c) shows the case of decreasing fines for first-time offenses.

Proposition 2 characterizes how forward-looking individuals optimally condition their offense decisions on their types for any possible combination of fines. Essentially, three cases (corresponding to parts (ii)-(iv) of Proposition 2) need to be distinguished.

First, if both second-period fines are weakly higher than the fine in the first period, forward-looking individuals behave as if they were myopic and the cutoff is equal to the myopic level, $g_1^* = \pi f_1$ ("quasi-myopia"). That is, in either period individuals only offend if their instantaneous net gain from an offense is weakly positive.[8] Intuitively, individuals cannot gain from strategic forwarding if the fine for repeat offenders exceeds the fine for first-time offenders in the first period. Similarly, individuals cannot benefit from strategic delay because there is no possibility of making up for the foregone utility in the second period if the fine for first-time offenders increases. Strategic behavior is also excluded if the second-period fines for first-time offenders and repeat offenders are equal, since the surplus that can be obtained in the second period then does not depend on first-period behavior and hence the offense decision in the second period is irrelevant for the optimal first-period decision. In addition, since the second period is the final period of the game, all individuals behave myopically when facing second-period fines. This case is illustrated in panel (a) in Figure 2.

[8]Myopic individual behavior, which refers to behavior that is not forward-looking, is sometimes also called 'naivety' in the literature (e.g. in Taylor, 2004).

Second, if the second-period fine for repeat offenders is lower than the first-period fine, some offenders may benefit from strategically moving their offense forward to self-select into the set of repeat offenders in the second period. However, this will only occur if the fine for repeat offenders is lower than the second-period fine for first-time offenders. The cutoff is then below the myopic level, $g_1^* < \pi f_1$ ("strategic forwarding"). This case is illustrated in panel (b) in Figure 2.

Third, if the fine for first-time offenses is falling over time, some offenders have an incentive to strategically delay their offense. However, this will only occur if the second-period fine for first-time offenders is lower than the fine for repeat offenders. In this case, the cutoff exceeds the myopic level, $g_1^* > \pi f_1$ ("strategic delay"), as illustrated in panel (c) in Figure 2.

Next, we study how the authority optimally chooses the menu of fines $\mathbf{f}$, accounting for optimal self-selection by individuals. 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.

## 3.1 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 $\hat{f}_2$ in period 2 are *not* conditioned on observed individual offense histories. The next proposition establishes that under commitment it is optimal not to vary the fines in the generalized offender model.

**Proposition 3** (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.* By the revelation principle, the authority can do no better than choose fines that reveal all types in period 1, which requires setting $g_1^* = g^*$, where $g^*$ is the optimal static cutoff. By Proposition 2 (ii), constant fines ensure that $g_1^* = \pi f_1^*$. By Proposition 1, optimality requires that $g_2^* = \pi f_2^* = \pi f^*(h, \pi, \alpha) = g_1^*$. □

Proposition 3 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 ($f_2 \neq \hat{f}_2$). The result is reminiscent of the classic finding 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).[9] 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 in period 2, whereas previously non-detected repeat offenders face the optimal static fine in period 2, may also be optimal. This corresponds to case (iii) in Proposition 2.[10]

The result clarifies why the literature on optimal law enforcement has struggled with explaining escalating fines. In the canonical offender model, an authority with commitment ability cannot gain from discriminating fines. However, authority commitment is excluded by construction if the authority optimally conditions fines on individual offender histories or if judges have least some discretion when determining punishment (Miceli, 2009). We next consider the case of non-commitment.

## 3.2 Non-Commitment

Consider a setting in which the authority lacks commitment ability and therefore conditions the fines in period 2 on observed offender histories (i.e., whether or not offenders in period 2 were previously detected as offenders). In this setting, optimal fines in period 2 must account for (i) *right*-truncation for first-time offenders, and (ii) *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. The following result shows the implications for the optimal setting of fines.

**Lemma 1** (truncation)**.** *Suppose that the authority lacks commitment ability. Then, it optimally sets the fines such that strategic delay is the only way in which individuals may benefit from strategic behavior, and the cutoff satisfies* $g_1^* \geq \pi f_1$.

*Proof.* For the left-truncated set of repeat offenders $[g_1^*, \bar{g}]$, the authority can do no better than leave no rent to the lowest type, hence $\pi \hat{f}_2^* \geq g_1^*$. For the set of previously undetected first-time offenders in the second period, the authority can do no better than set $f_2^*$ such that $\pi f_2^* \leq g_1^*$. Therefore, we must have that either $\hat{f}_2^* > f_2^*$ or $\hat{f}_2^* = f_2^*$. By Proposition 2, individuals then cannot benefit from strategic forwarding and hence $g_1^* \geq \pi f_1$. □

The intuition behind Lemma 1 is as follows. Since the authority has no incentive to leave any rent to the lowest type in the left-truncated set of repeat offenders in period 2,

[9] We will discuss the relation of the generalized offender model to dynamic pricing models in Section 4.

[10] The possibility of 'frontloading' fine payments for offenders is discussed in more detail in Section 5.1.

and there may be additional offender gains to be redistributed from the right-truncated set of previous non-offenders to society, it must be that $\hat{f}_2^* \geq f_2^*$. Given these second-period fines, Proposition 2 shows that individuals will either behave as if they were myopic (as in case (ii)) or choose to strategically delay consumption (as in case (iv)), depending on the fines chosen. 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 and thus end up in the pool of potential first-time offenders in period 2. We now proceed to characterizing optimal fines in period 2.

### 3.2.1 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 (weakly) 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.[11]

Proposition 4 further demonstrates that if $g_1^*$ exceeds the optimal static cutoff, the optimal cutoff for repeat offenders in period 2 must be equal to 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 that the set of inframarginal types 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.[12] Exit is clearly not absorbing, though, for offenders with types below the cutoff level $g_1^*$. Importantly, the result implies that the common notion that fines for repeat offenders should be escalating because of their (revealed) higher types is not correct. In a fixed economic environment with a continuous type distribution, the authority cannot gain from excluding previous offenders from the set of repeat offenders.

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,

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

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

$$\begin{aligned}\Phi(f_2; g_1^*, \pi, \alpha) &= \int_{\pi f_2}^{g_1^*} (\pi f_2 - h) dZ(g) + \alpha \int_{\pi f_2}^{g_1^*} (g - \pi f_2) dZ(g) \\ &+ (1-\pi) \int_{g_1^*}^{\bar{g}} (\pi f_2 - h) dZ(g) + \alpha \int_{g_1^*}^{\bar{g}} (g - \pi f_2) dZ(g).\end{aligned} \tag{5}$$

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,*

*(i) if the authority maximizes standard welfare, $\alpha = 1$, the optimal fine for first-time offenders in period 2 keeps the cutoff constant, $\pi f_2^* = g_2^* = g_1^* = h$.*

*(ii) if offender gains are not fully credited to welfare, $\alpha < 1$, the optimal fine for first-time offenders in period 2 satisfies $\pi f_2^* < g_1^*$.*

*Proof.* We consider both statements in turn.

(i) For $\alpha = 1$, all types $g \geq h$ must offend to maximize welfare. In period 2, this requires that $f_2^* = h/\pi = f^*(h, \pi, \alpha = 1) = \hat{f}_2^*$. Proposition 2 then implies that $g_1^* = \pi f_1^*$, and by Proposition 4 we know that $g_1^* = \pi \hat{f}_2^*$, which implies $f_1^* = h/\pi$.

(ii) For $\alpha < 1$, we must have $g_1^* > h$, as it cannot be optimal to set fines that yield $g_1^* = h$. Similarly, $g_1^* < \bar{g}$ holds by construction. The authority can then gain from lowering the expected fine for first-time offenders below the cutoff, $h < \pi f_2^* < g_1^*$.

□

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 keeps the cutoff constant and equals the standard welfare-maximizing fine, $f_2^* = h/\pi$. This finding follows since 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 expected fine for first-time offenders in period 2 is lower than the first-period cutoff. The intuition for this result is straightforward: for any first-period cutoff above the social cost of the offense, the authority can gain from lowering the fine, thereby redistributing additional offender gains to society via fine payments.

### 3.2.2 Establishing Escalation

We now establish the conditions under which escalation occurs in the generalized offender model. The following result is an immediate implication of Propositions 2-5.

**Corollary 1** (escalation)**.** *Optimal fines for repeat offenders escalate if and only if the authority lacks commitment ability and attaches weight $\alpha < 1$ to offender gains. Optimal fines for first-time offenders then fall over time, and fines are chosen such that*

$$\hat{f}_2^* > f_1^* > f_2^*. \tag{6}$$

*Proof.* Proposition 3 shows that escalation cannot occur under commitment and thus establishes the necessity of non-commitment. Similarly, Proposition 5 shows that optimal fines are constant with $\alpha = 1$, which establishes the necessity of $\alpha < 1$. To establish sufficiency, note that Proposition 5 demonstrates that when $\alpha < 1$ and the authority lacks commitment, $f_2^* < g_1^*$, while Proposition 4 shows that $\pi\hat{f}_2^* \in [g_1^*, \bar{g}]$, which immediately implies that $f_2^* < \hat{f}_2^*$. Then by Proposition 2 (some) individuals strategically delay their offense, $g_1^* > \pi f_1^*$, and $f_1^* > f_2^*$, which yields the result.

□

Corollary 1 clarifies that two conditions need to be satisfied for escalating fines to be optimal. First, the authority must lack commitment ability and thus condition optimal fines on offender histories. Second, the authority must not fully credit offender gains to social welfare. The result highlights that escalating fines for repeat offenders (if any) follow from the authority's incentive to lower the fines for individuals with a clean history (i.e., no previous offense) in order to redistribute additional offender gains to society. The prospect of decreasing fines induces some individuals 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 $\pi f_1^* = \pi\hat{f}_2^*$.

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 simply reflect the (fixed) social cost of the offense. There is thus no incentive to lower the fine for first-time offenses. However, if less than full weight is given to offender gains, the

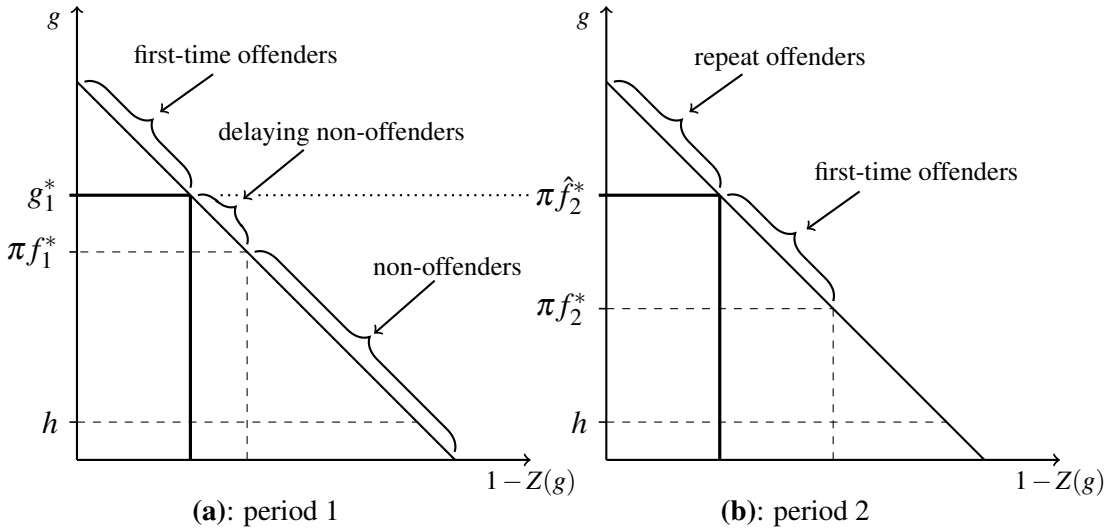


**Figure 3:** Dynamic model without commitment

**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.

redistribution motive kicks in, and the authority has an incentive to lower the fine and redistribute additional fine payments to society 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*

$$p^m(h,1,0) = h + \frac{1-Z(p^m)}{z(p^m)}. \tag{7}$$

Corollary 2 shows that it is quite natural to view a fine as a price (Gneezy and Rustichini, 2000): the optimal (surplus-maximizing) fine is formally equivalent 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 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 3. 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 loyal consumers escalate because the monopolist cannot resist the temptation to lower the price for first-time 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 3. 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 cannot gain from lowering 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 fine 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 6** (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 than 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 2 and 4-5 continue to apply as they are independent of the difference in discount factors $(\delta_A, \delta_I)$. Then, Corollary 1 still applies.

(ii) As established in the proof of Proposition 3, with authority commitment the unique optimal policy is to set the fines such that the cutoffs satisfy $g_1^* = g_2^*$. As before, by Proposition 2 it follows that $f_1^* = f_2^* = \hat{f}_2^* = f^*(h, \pi, \alpha)$ since the indifference condition then reads $g_1^* - \pi f_1 + \delta_I \pi(g_1^* - \pi \hat{f}_2) = 0$.

(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 6 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, irrespective of its ability to commit.

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 commitment 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 ('brute force'). 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 history-based discrimination.

**Proposition 7** (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 behavior 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 Corollary 1 and Proposition 2, behavior-based escalation requires that $f_2^* < f_1^*$, which is not possible when $\pi f_2^*(h_2, \pi, \alpha) \geq g_1^*$.

□

Proposition 7 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 the offense. 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 8** (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 8 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 7. 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. However, note that this requires that $\alpha < 1$ as before. That is, a decrease in the detection probability for repeat offenders is not sufficient to yield escalation on its own. This is because for $\alpha = 1$ fines only serve to deter inefficient offenders. But for the set of repeat offenders, lowering the deterrence level via the fall in the detection probability is of no consequence, since it only contains selected efficient offenders. More formally, for $\alpha = 1$, any $\pi_2 \hat{f}_2 \leq g_1^*$ is optimal.

# 6 Conclusion

We have studied how escalating fine schemes emerge in a generalized version of the canonical offender model 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 lower the fine for first-time offenders rather than an incentive to increase the fine for repeat offenders. The intuition for this result is as follows: if the authority conditions optimal punishment on offender histories and does not fully credit offender gains to social welfare, it has an incentive to lower the fine for first-time offenders with a "clean" history, thereby redistributing additional offender gains to society. Some forward-looking offenders will then strategically delay their offense to benefit from lower fines in the future, which drives a wedge between the expected fine and the gain of an individual that is indifferent between offending and non-offending. This wedge is the source of the fine increase for repeat offenders, as 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 extend the setting to an infinite number of periods. 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 fines and prices. We hope to address these issues in future research.

# References


Acquisti, A. and Varian, H. R. (2005). Conditioning prices on purchase history. *Marketing Science* 24(3), 367–381.

Anderson, L. R., DeAngelo, G., Emons, W., Freeborn, B. and Lang, H. (2017). Penalty structures and deterrence in a two-stage model: Experimental evidence. *Economic Inquiry* 55(4), 1833–1867.

Armstrong, M. (2006). *Advances in Economics and Econometrics: Theory and Applications: Ninth World Congress: volume II*, Cambridge University Press, chap. Recent developments in the economics of price discrimination.

Baik, K. H. and Kim, I.-G. (2001). Optimal punishment when individuals may learn deviant values. *International Review of Law and Economics* 21(3), 271–285.

Becker, G. (1968). Crime and punishment: An economic approach. *Journal of Political Economy* 76, 169.

Belleflamme, P. and Vergote, W. (2016). Monopoly price discrimination and privacy: The hidden cost of hiding. *Economics Letters* 149, 141–144.

Buehler, S., Halbheer, D. and Lechner, M. (2017). Payment evasion. *Journal of Industrial Economics* 65(4), 804–832.

Cabral, L., Salant, D. and Woroch, G. (1999). Monopoly pricing with network externalities. *International Journal of Industrial Organization* 17(2), 199–214.

Chu, C. Y. C., Hu, S. and Huang, T. (2000). Punishing repeat offenders more severely. *International Review of Law and Economics* 20(1), 127–140.

Coase, R. (1972). Durability and monopoly. *Journal of Law and Economics* 15(1), 143–49.

Conitzer, V., Taylor, C. and Wagman, L. (2012). Hide and seek: Costly consumer privacy in a market with repeat purchases. *Marketing Science* 31(2), 277–292.

Dana, D. A. (2001). Rethinking the puzzle of escalating penalties. *Yale Law Journal* 110(5), 733–783.

Emons, W. (2007). Escalating penalties for repeat offenders. *International Review of Law and Economics* 27(2), 170–178.

Endres, A. and Rundshagen, B. (2016). Optimal penalties for repeat offenders—the role of offence history. *BE Journal of Theoretical Economics* 16(2), 545–578.

Freixas, X., Guesnerie, R. and Tirole, J. (1985). Planning under incomplete information and the ratchet effect. *The Review of Economic Studies* 52(2), 173–191.

Fudenberg, D., Levine, D. K. and Tirole, J. (1985). *Infinite-Horizon Models of Bargaining with One-Sided Incomplete Information*, Cambridge, UK and New York, Cambridge University Press. 73–98.

Fudenberg, D. and Villas-Boas, J. M. (2007). *Behavior-Based Price Discrimination and Customer Recognition*, Oxford, Elsevier Science.

Funk, P. (2004). On the effective use of stigma as a crime-deterrent. *European Economic Review* 48(4), 715–728.

Gneezy, U. and Rustichini, A. (2000). A fine is a price. *The Journal of Legal Studies* 29(1), 1–17.

Gruber, A. (2010). A distributive theory of criminal law. *William and Mary Law Review* 52(1).

Hart, O. D. and Tirole, J. (1988). Contract renegotiation and coasian dynamics. *The Review of Economic Studies* 55(4), 509–540.

Hylton, K. (2005). The theory of penalties and the economics of criminal law. *Review of Law and Economics* 1, 175–201.

Lewin, J. L. and Trumbull, W. N. (1990). The social value of crime? *International Review of Law and Economics* 10(3), 271–284.

Miceli, T. J. (2009). *The Economic Approach to Law*. Stanford University Press, second edition ed.

Miceli, T. J. (2013). Escalating penalties for repeat offenders: Why are they so hard to explain? *Journal of Institutional and Theoretical Economics* 168(4), 587–604.

Miceli, T. J. and Bucci, C. (2005). A simple theory of increasing penalties for repeat offenders. *Review of Law and Economics* 1(1), 71–80.

Mueller, D. and Schmitz, P. (2015). Overdeterrence of repeat offenders when penalties for first-time offenders are restricted. *Economics Letters* 129, 116–120.

Mungan, M. C. (2009). Repeat offenders: If they learn we punish them more severely. *International Review of Law and Economics* 30(2), 173–177.

Polinsky, A. M. and Shavell, S. (1998). On offense history and the theory of deterrence. *International Review of Law and Economics* 18, 305–324.

Polinsky, A. M. and Shavell, S. (2007). *Handbook of Law and Economics*, Elsevier, Vol. 1, chap. The Theory of Public Enforcement of Law. 1 ed.

Posner, R. A. (2007). *Economic Analysis of Law*. Aspen Publishers, 7 ed.

Rasmusen, E. (1996). Stigma and self-fulfilling expectations of criminality. *Journal of Law & Economics* 39(2), 519–543.

Rubinstein, A. (1979). *Applied Game Theory*, Physica-Verlag HD, chap. An Optimal Conviction Policy for Offenses that May Have Been Committed by Accident. 406–413.

Stigler, G. J. (1974). *Essays in the Economics of Crime and Punishment*, National Bureau of Economic Research, Inc, chap. The Optimum Enforcement of Laws. 55–67.

Stokey, N. L. (1979). Intertemporal price discrimination. *The Quarterly Journal of Economics* 93(3), 355–371.

Taylor, C. R. (2004). Consumer privacy and the market for customer information. *The Rand Journal of Economics* 35(4), 631–650.

Tirole, J. (2016). From bottom of the barrel to cream of the crop: Sequential screening with positive selection. *Econometrica* 84(4), 1291–1343.

Villas-Boas, J. M. (2004). Price cycles in markets with customer recognition. *RAND Journal of Economics* 35(3), 486–501.