

# Prosecutorial Risk Attitudes, Time Constraints and Plea Bargaining\*

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January 22, 2009

## Abstract

This paper studies multistage plea bargaining procedures when a prosecutor cannot bring every case to trial. I introduce two prosecutorial features which so far have been neglected: risk attitudes and time constraints. The analysis suggests that the choice between plea settlements and going to court primarily depends on (i) the risk attitudes of all parties and (ii) the accuracy of the judicial process. The prosecutor's risk attitude around the highest sentence acceptable to any defendant turns out to be crucial. If she displays little or no risk tolerance around this point, then time constraints play no role and the plea process can be at most partially revealing. On the other hand, sufficient risk tolerance around this sentence renders time constraints relevant, and allows the plea process to reveal the truth about all defendants. The impact of time constraints on such prosecutors further depends on the prosecutor's risk tolerance at the separating sentence. A prosecutor who exhibits little or no risk tolerance around this sentence chooses the fully revealing strategy if time constraints are absent. However, without time constraints a sufficiently risk acceptant prosecutor, in particular one whose risk tolerance is stronger than the defendants' risk aversion, brings everyone to trial without verifying their types first.

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\*I am grateful my advisor David Austen-Smith for his constant guidance throughout this project. I also thank Bard Harstad, Wojciech Olszewski, Kris Ramsay, Adam Meierowitz, and William Rogerson for their invaluable suggestions.

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# 1 Introduction

A large percentage of criminal convictions in the US is achieved by plea bargaining. The systematic adoption of this practice is attributed to various reasons including costly trials and the defendants' willingness to avoid the risks associated with these trials. However the literature so far has not accounted for two characteristics that can explain why and how plea bargains are used: prosecutorial risk attitudes and time constraints interpreted to capture the prosecutor's caseload and court time.<sup>1</sup> First, courts are congested and prosecutors are state officials with heavy caseload and they simply do not have the time to bring every case to court. Second, from the prosecutor's standpoint, going to trial involves the risk of losing the case whereas a plea settlement is a sure way of securing a conviction. This paper explores these two dimensions that define the prosecution while imposing risk aversion on the defendants. The results reveal that the prosecutor's choice between plea settlements and going to court primarily depend on the risk attitudes of all sides and the accuracy of the judicial process, which is also related to the reliability of the evidence gathered. It turns out that time constraints play important yet subsidiary roles.

A purely career oriented prosecutor has to close multiple cases by either plea bargaining or bringing a case to court. However, she is constrained by the number of cases that she can bring to trial.<sup>2</sup> By going to court, the prosecutor can only strengthen her case against a defendant. The plea process with every defendant continues for a finite number of stages, after which a trial commences. The risk attitudes of all actors along with the accuracy of the trial process narrow down the strategies the prosecutor picks

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<sup>1</sup>Alshuler (1968) and Bibas (2004) both point out the importance of prosecutorial attributes on plea bargaining.

<sup>2</sup>As suggested by Landes (1971), Miceli (1990), Reinganum (2000), Bar-Gill and Gazal Ayal (2006) among others, career concerns of the prosecutors induce them to maximize expected punishments. Moreover, Boylan (2005) provides empirical evidence to support the claim that the length of prison sentences as opposed to the number of convictions advance the career motives of attorneys.

from. The accuracy of the trial process is captured by the probabilities of committing type I (convicting an innocent defendant) and type II (acquitting a guilty defendant) errors. The prosecutor's returns from pursuing trials are determined by the probabilities of making these errors. The probabilities of type I and type II errors also affect the highest plea sentences the prosecutor can successfully impose on *any* defendant and *only* on the guilty defendant, respectively. The stronger the defendant's risk aversion is, the higher are these sentences. Furthermore, the prosecutor's valuation of these sentences depend on her risk attitude.

The prosecutor's risk attitude around the highest sentence acceptable to all is crucial. If she is not sufficiently risk tolerant around it, then time constraints play no role and the plea process can be at most partially revealing. The latter statement holds because, such a prosecutor will not find it in her best interest to punish the guilty severely by bringing the innocent to trial. Risk attitudes that render time constraints irrelevant encompass strict risk aversion and weak risk tolerance (especially, weaker than the defendants' risk aversion). When the prosecutors exhibit little or no such local risk tolerance, they engage in three types of plea tactics. The first one involves settling with all defendants out of court at this highest punishment that none rejects. With the second strategy, the prosecutor tries to negotiate the highest plea sentence with as many defendants as she can without violating her time constraints. All but the guilty reject the high sentence thereby making this strategy partially revealing. Finally, by employing the third tactic, the prosecutor shuns pretrial screening altogether and uses all her time to go to court. Comparing the payoffs from each of these strategies can be reduced to evaluating their payoffs for each case separately and consequently, time restrictions play no role.

If the prosecutor is sufficiently risk tolerant around the highest sentence agreeable to all, then the prosecutor's choices are substantially different. First, time constraints become relevant and second, the plea process can reveal the truth about all defendants. Risk attitudes with this local feature subsume adequately high risk tolerance

(especially, stronger than the defendants' risk aversion). Prosecutors who display this risk behavior resort to three types of strategies. Two of these are the partially revealing strategy and the tactic of aggressively pursuing trials mentioned above. The third one is the fully revealing strategy. When the prosecutor screens every defendant via the plea process, the guilty defendants settle on higher penalties earlier on, whereas the innocent defendants either receive lower plea sentences or go to court. Local risk tolerance around the sentence agreeable to all ensures that separation is incentive compatible: only such prosecutors are willing to go to trial despite their low chances of winning. Time restrictions are relevant because, they influence the prosecutor's decisions differently depending on her strategy: the effect is direct with all but the separating strategy and indirect with the separating strategy.

Relaxing the time constraint increases the payoffs from all strategies which potentially end in court. When time constraints matter, however, their effect on the prosecutor's decisions is ambiguous and requires further specifications on risk attitudes. For instance, a prosecutor, not sufficiently risk tolerant at the highest sentence acceptable only by the guilty, chooses the fully separating strategy in the absence of time constraints. On the other hand, without any constraint, a prosecutor with a sufficiently strong risk tolerance brings every defendant to trial without first verifying his type.

This paper also studies caseloads that involve alleged crimes which are related and of different severities. Such instances arise when several defendants are suspected to be complicit in illegal activities to various degrees. Examples include all organized crimes and certain kinds of felony murder. Rather than tilting the prosecutor's choice in favor of one strategy, these heterogeneities determine which cases go to trial whenever the prosecutor decides to go to court. As a result, the uncertainty over who will go to trial is significantly less than when cases are identical and unrelated.

There are several papers which study plea bargaining that involves several defendants. However as far as I know, none of them explicitly recognizes the time constraints that the responsibility for multiple cases imposes on prosecutors, and how

those constraints interact with the other aspects of the prosecution. The examples include the seminal paper by Landes (1971)<sup>3</sup> and Kobayashi (1992), where resource constraints are not an issue. In a less formal setting where prosecutorial attributes are not modeled, Bar-Gill and Gazal Ayal (2006) argue that the legal lower bounds on the plea offers may lead career oriented prosecutors to dismiss those cases that involve lower probabilities of conviction in favor of those cases that have higher such probabilities. However, in their model, prosecutors can choose their caseload and they are aware of the strength of each case *ex ante*.

There is work on the risk attitudes of parties to a civil litigation, namely the plaintiffs and the defendants, and a review can be found in Cooter and Rubinfeld (1989). In various environments, Polinsky and Shavell (1979), Grossman and Katz (1983), and Kobayashi and Lott (1996) underline the importance of differential rates of risk aversion in the calculation of fines and sentences.<sup>4</sup> This paper demonstrates the importance of prosecutors' risk attitudes in determining their approach to closing cases.

Introducing time constraints to the study of plea procedures is novel as well as allowing multiple rounds of plea bargaining with each defendant.<sup>5</sup> As short as two rounds enable the time constrained prosecutor to screen all defendants by observing their responses. I do not model other types of resource constraints, such as criminal defense expenditures or costs of assembling a jury for trial. These are serious considerations and studied in various settings. Rhodes (1976) finds that an increase in prosecutors' budgets lead to increases in trials. However, the analysis here suggests that an observation of fewer trials associated with a prosecutor can also be explained by risk attitudes. The single-stage, costless plea processes of Kobayashi and Lott (1996) are succeeded by costly trials where both the defendant and the prosecutor try to manipulate the probabilities of conviction. In a model with risk neutrality and

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<sup>3</sup>Rhodes (1976) builds on this model and provides an empirical study.

<sup>4</sup>A comprehensive review of the economic theory of public enforcement can be found in Polinsky and Shavell (2000).

<sup>5</sup>Work on the dynamics of plea bargaining has been scant. Pretrial bargaining in civil litigation, on the other hand, has received more attention, an example can be found in Spier (1992).

essentially one round of plea negotiations, Baker and Mezetti (2001) study the impact of the interaction between resource constraints and information revelation. Mongrain and Roberts (2009) study the frequency of plea bargains when prosecutors have resource constraints; however their model does not incorporate certain features of plea processes including case strengths and prosecutor types.

Full information revelation implies that those who go to trial are innocent, and this has been a staple result in the game theoretic approach to plea bargaining. The seminal papers by Grossman and Katz (1983), and Reinganum (1988), both of which do not model prosecutorial resource constraints, have this sorting feature.<sup>6</sup> Although this feature of the separating equilibria may sound unfair, Easterbrook (1992) argues that this is due to the imperfections of the adjudication process, not problems inherent in the plea bargaining. I show that the sorting sentence depends on not only the type-dependant expectations of trial outcomes, but also the probability of going to trial that is determined by the prosecutorial time constraints, risk attitudes, and the reliability of the evidence collected. For instance, a separating outcome cannot be an equilibrium under a very risk averse or a very risk acceptant prosecutor with no constraints.

In the next section I introduce the model. In Section 3, I solve the plea bargaining game when the defendant types are independent and all crimes are identical. In Section 4, I relax the independence assumption and allow for crimes that differ in their severities. Section 5 discusses some extensions of the baseline model. Section 6 concludes. All proofs are relegated to the Appendix.

## 2 Setup and Preliminaries

A prosecutor is assigned  $N \geq 2$  cases and she is legally bound to close every case by either a plea agreement or bringing the case to trial. There are two rounds of plea bargaining (results are robust to any finite number of rounds). At the end of the second

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<sup>6</sup>The possibility that the innocent can be convicted in trial even when the prosecutor is certain of the defendant's innocence may strike unfair. However, this is a necessary condition to inflict a more severe punishment on the guilty since the prosecutor's threat of bringing a defendant to trial has to be credible.

round all open cases go to trial. The number of rounds is common knowledge and there is no discounting from one stage to the next.

At the beginning of each round, the prosecutor decides for each open case whether to make a plea offer or to send the defendant to trial. If a defendant pleads guilty by accepting the offer, then his case is closed and both parties collect their payoffs. If a defendant rejects the plea offer, then the prosecutor makes similar decisions regarding the defendant's case in the next round. If a defendant rejects all his plea offers, or if he never receives a plea offer, then his case goes to trial. However, bringing a case to trial in court requires time. The time constraint is defined as the maximum number of cases the prosecutor brings to trial, and is given by  $m : 1 \leq m < N$ . In other words, at most  $m$  open cases can go to trial. As long as this constraint is met, there is no additional cost to a trial and equivalently, there are no savings from not expending these resources.  $N$  and  $m$  are common knowledge.<sup>7</sup>

Each case involves a defendant, or suspect,  $i$ , whose type is represented by  $\theta_i : \theta_i = 1(0)$  if the defendant  $i$  is guilty (innocent). Let  $\alpha = \mathbb{P}(\theta_i = 1)$  denote the prior probability that defendant  $i$  is guilty. The evidence gathered has incriminatory power:  $\alpha > 1/2$ . Also,  $e_i \in \{e_L, e_H\}$  describes the strength of the case against  $i$ , where  $e_H > e_L$ . At the beginning of the plea process, the strength of the case against every defendant is the same:  $e_i = e_L$  all  $i$ . There is a possibility that by bringing a defendant to trial (and only by doing so) the prosecutor can strengthen her case against him, that is, attain  $e_H$  (by uncovering more evidence, finding a witness to testify against the defendant, facing a jury with a predisposition more favorable to the prosecution, etc.). However, due to time constraints the prosecutor can build a stronger case against  $m$  defendants at the most. Moreover, in the process of collecting evidence during trial, the following

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<sup>7</sup>Allowing  $m$  to be privately known by the prosecutor does not alter the model's qualitative predictions.

plausible monotonicity conditions are assumed:

$$\mathbb{P}(e_i = e_H | \theta_i = 1) > \mathbb{P}(e_i = e_H | \theta_i = 0) \geq 0; \quad (1)$$

$$\mathbb{P}(e_i = e_L | \theta_i = 0) > \mathbb{P}(e_i = e_L | \theta_i = 1) \geq 0. \quad (2)$$

The probability of conviction in a trial is given by  $\mathbb{P}(\theta_i = 1 | e_i)$ .<sup>8</sup> Then a defendant of type  $\theta_i$  expects to be convicted in a trial with probability

$$\rho_{\theta_i} \equiv \mathbb{P}(e_i = e_H | \theta_i)\mathbb{P}(\theta_i = 1 | e_i = e_H) + \mathbb{P}(e_i = e_L | \theta_i)\mathbb{P}(\theta_i = 1 | e_i = e_L). \quad (3)$$

Given (1) and (2), we have  $\rho_1 > \rho_0$ .<sup>9</sup> Note that  $\rho_0$  and  $1 - \rho_1$  are the expected probabilities of committing a type I error (falsely convicting an innocent defendant) and type II error (failing to convict a guilty defendant), respectively. Therefore, the prosecutor's prior belief of convicting a defendant in trial is equal to her belief that a defendant is guilty:

$$[(1 - \alpha)\rho_0 + \alpha\rho_1] = \alpha. \quad (4)$$

Let  $s_i \geq 0$  denote the length of the jail sentence defendant  $i$  serves. If  $i$  is convicted in court, then he serves the full sentence associated with his crime denoted  $\bar{s}_i$ . Initially I posit that each alleged crime is equally severe,  $\bar{s}_i = \bar{s}$  for all  $i$ , and  $\bar{s}$  is common knowledge. If  $i$  is acquitted, then  $s_i = 0$ . However, the negotiated plea sentences can take any value. All defendants have identical preferences:  $i$ 's preference over  $s_i$  can be represented by  $u$ , where  $u(0) = 0$  and  $u', u'' < 0$ .<sup>11</sup> The prosecutor's utility is given by

$\sum_{1 \leq i \leq N} v(s_i)$ , where  $v(0) = 0$  and  $v' > 0$ .<sup>12</sup> At this point, we leave  $v''$  unspecified, the sign

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<sup>8</sup>The trial process is taken to be exogeneous and conviction depends solely on the evidence presented against the defendant.

<sup>9</sup>Note that by (3)  $\rho_0 = 0 \Leftrightarrow \rho_1 = 1$ . Also,  $\rho_0$  and  $\rho_1$  can be changed in any direction without manipulating  $\alpha$ .

<sup>11</sup>In other words, I assume that each defendant is equally risk averse. Grossman and Katz (1983), and Kobayashi and Lott (1996) involve models where defendants can differ in their degree of risk aversion.

<sup>12</sup>This approach to model prosecutor preferences can also be viewed as strengthening the deterrence value of criminal justice system (Kobayashi (1992)), or expected sentences can be regarded as the cost of



of  $v''$  plays a crucial role in shaping plea bargaining outcomes.

Let  $s_i^t \in [0, \infty)$  denote the prosecutor's plea offer to each defendant  $i$  whose case is unresolved by the start of stage  $t$ . Any  $s_i^t > \bar{s}$  can be interpreted as the prosecutor's disinclination to settle with  $i$  at stage  $t$ , and  $s_i^t = 0$  can be understood as the dismissal of the charge against  $i$ . In the beginning of every stage  $t$ , the prosecutor makes these  $N$  plea decisions simultaneously. I impose that the defendants cannot communicate with one another, and the prosecutor cannot inform a defendant  $j$  about another defendant's plea decision. In Section 5, I discuss the implications of relaxing the assumptions of simultaneous offers and the privacy of individual plea outcomes.

At each stage  $t$ , any defendant  $i$  whose case is pending decides whether to accept  $s_i^t$  or not. His response to  $s_i^t$  is denoted by  $r_i^t \in \{A, R\}$ , where  $A(R)$  means he accepts (rejects) the offer. Once  $r_i^t = A$  at some round  $t$ ,  $i$ 's case is closed and the prosecutor has no further interaction with  $i$ . If  $r_i^t = R$  for all  $t$ , then  $i$  goes to trial.

Let  $H^t$  be the set of all possible histories up to stage  $t = 1, 2$ , where the null history is denoted by  $h^0$ ,  $h^1 = \{(s_1^1, r_1^1), \dots, (s_N^1, r_N^1)\} \in H^1$ , and  $\{(s_1^1, r_1^1), \dots, (s_N^1, r_N^1); (s_1^2, r_1^2), \dots, (s_N^2, r_N^2)\} \in H^2$ . Although  $h^t$  is observed by the prosecutor,  $i$  can observe neither the plea offers ( $s_j^t$  for  $j \neq i$ ) nor the responses of the others ( $r_j^t$  for  $j \neq i$ ). Let  $h_i^t$  be the portion of  $h^t$  observed by defendant  $i$ .

The prosecutor's strategy prescribes  $s^t = (s_1^t, \dots, s_N^t)$  for any possible history  $h^{t-1}$ , and is given by  $s = (s^t(h^{t-1}))_{t=1,2}$ . Defendant  $i$ 's strategy is given by his response to any feasible  $h_i^t$  and is denoted by  $r_i = (r_i^t(h_i^t, \theta_i))_{t=1,2}$ .

We assume that if rejection or acceptance of a plea offer leaves defendant  $i$  equally well off, then  $i$  accepts the offer. The reservation utility of  $i$  at the final stage is his expected utility from a trial and is equal to  $u(z_{\theta_i})$ , where  $z_{\theta_i}$  is the certainty equivalent of the trial:

$$u(z_{\theta_i}) = \rho_{\theta_i} u(\bar{s}). \quad (5)$$

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destroying community resources (Landes (1971)). In the benchmark case the prosecutor is not concerned by prosecuting an innocent defendant. This assumption is plausible with career oriented prosecutors. Section 5.2 discusses the consequences of relaxing this assumption.

Observe that  $z_1 > z_0$  and any  $s_i^t > z_{\theta_i}$  is unacceptable to  $i$ . Since the prosecutor has to guarantee that at most  $m$  cases go to trial,  $s_i^t \leq z_{\theta_i}$  for at least  $N - m$  defendants in some, not necessarily the same, round  $t$ . In the first stage,  $i$  accepts  $s_i^1$  if and only if he does not anticipate a more lenient plea sentence.

Let  $\delta_p^t(i) = \mathbb{P}(\theta_i = 1|h^t)$  denote the prosecutor's belief at the end of stage  $t$  that defendant  $i$  is guilty, given the plea process through that stage.  $\delta_i^t(j) = \mathbb{P}(\theta_j = 1|h^t)$  denotes the posterior belief of  $i$  at stage  $t$  that  $j$  is guilty. Since  $\theta_1, \dots, \theta_N$  are independent, there is no communication between the defendants, and all alleged crimes are punished equally,  $\delta_i^t(j) = \delta_i^t(k)$  for any  $i \neq j \neq k$ . Moreover, let  $\delta_k^t = (\delta_k^t(j))_{j \neq k}$  and  $\delta = \left( (\delta_k^t(j))_{j \neq k} \right)_{k \in \{p, 1, \dots, N\}; 1 \leq t \leq T}$ . Notice that  $\delta_j^0(i) = \alpha$  for all  $j \neq i$ .

### 3 Plea Bargaining with Independent and Homogenous Crimes

A perfect Bayesian equilibrium of the plea bargaining process is given by the equilibrium strategy profiles  $(s^*, r^*)$  and the posterior beliefs  $\delta^*$ . From now on, the defendants' beliefs will be suppressed since no defendant can acquire information about the progress of another defendant's case,  $(\delta_i^t)^*(j) = \alpha$  for  $i \neq j$ . Moreover,  $s_i^*$  denotes  $i$ 's equilibrium sentence. If  $r_i^1 = r_i^2 = R$ ,  $i$  goes to trial and  $s_i^* \in \{0, \bar{s}\}$ . Otherwise,  $s_i^* = (s_i^1)^*$  when  $(r_i^1)^* = A$ , or  $s_i^* = (s_i^2)^*$  when  $r_i^1 = R$  and  $r_i^2 = A$ . A plea sentence above  $z_1$  is rejected by any defendant type, therefore no plea agreement exceeds  $z_1$ ; similarly, a plea offer below  $z_0$  is accepted by any defendant type and therefore, is strictly dominated by  $z_0$  for the prosecutor. Consequently,

$$\text{if } s_i^* = (s_i^t)^* \text{ for some } i \text{ and } t, \text{ then } (s_i^t)^* \in [z_0, z_1]. \quad (6)$$

There are essentially two kinds of pooling strategies that the prosecutor can use. In one, she avoids trials and settles with every defendant out of court, and in the other, she brings as many defendants as she can to court. The first type of strategies and the ensuing equilibria are labeled as “settlement”, and the second type of pooling strate-

gies and their associated equilibria are named as “indifferent”. If there is a pooling equilibrium suggesting that the prosecutor has no intention of sorting the defendants, then the number of stages is irrelevant.

In any settlement equilibrium all defendant types accept the same offer. Since the highest plea sentence that no defendant can reject is  $z_0$ , we record the following result.<sup>13</sup>

**Lemma 1** *In any settlement equilibrium of the plea bargaining game, every case is settled by a plea bargain and  $s_i^* = z_0$  for all  $i$ .*

In an indifferent equilibrium, the prosecutor brings exactly  $m$  defendants to trial, and she settles with the remaining  $N - m$  defendants. When each case is ex ante identical for the prosecutor as in this section, her picks can be regarded as random. The prosecutor offers  $z_0$  to any defendant she settles with and a sentence greater than  $z_1$  to any defendant she brings to court.<sup>14</sup>

A pooling equilibrium can be implemented in a single stage. However, the next result establishes the nonexistence of fully revealing equilibria in single-stage plea processes. This finding can be explained by the interaction between the two kinds of temporal constraints the prosecutor faces. To update her beliefs about a defendant’s type, the prosecutor needs to observe each defendant’s response to a uniform offer higher than  $z_0$  (this indirect effect is formally proved in Lemma 2). However, updating all cases is infeasible in a single stage because the prosecutor can afford at most  $m$  rejections. The most the prosecutor can manage is to offer  $z_1$  to  $m$  defendants as  $z_1$  is the highest acceptable sentence for a guilty defendant. From now on, we label this strategy that renders partial revelation of types feasible as the “semiseparating” strategy.

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<sup>13</sup>A possible set of strategy profiles that supports the settlement outcome is one where the prosecutor chooses to offer  $s_i^t = z_0$  for all  $i$  and  $t$ , and all defendants plead guilty if and only if the plea offer is less than  $z_0$ :  $r_i^t = R(A)$  if  $s_i^t > (\leq) z_0$  for all  $i$  and  $t$ .

<sup>14</sup>One set of strategy profiles that supports the indifferent outcome is as follows. At each stage the prosecutor offers  $z_0$  to the same  $N - m$  defendants and a sentence strictly greater than  $z_1$  to the remaining  $m$  defendants. Each defendant rejects any offer at any stage if and only if it exceeds  $z_0$ .

**Proposition 1** *In any single-stage plea bargaining game the prosecutor can learn the true types of at most  $m$  defendants.*

In a multi stage plea process the prosecutor learns a defendant's type through his response to certain sentences. I now develop the characterization of the separating (fully revealing) equilibria in a series of steps. The next result demonstrates two intuitive properties of these equilibria. First, if there are several defendants who have accepted higher sentences than  $z_0$ , then those sentences should be the same. Second, the defendants' threshold strategies imply that any equilibrium can be either fully informative or completely uninformative.

**Lemma 2** (i) *If there exist  $s_i^* = (s_i^t)^*$ ,  $s_j^* = (s_j^r)^* > z_0$  for some  $i \neq j$ ,  $t$ , and  $r$ , then  $s_i^* = s_j^*$ .* (ii)  $(\delta_p^t)^*(i) \in \{0, \alpha, 1\} \forall i, t$ .

In a separating equilibrium, all guilty defendants accept higher plea offers than  $z_0$  and their offers are identical by Lemma 2. The prosecutor brings as many innocent defendants as possible to trial. If it turns out that there are more innocent members than she can bring to trial, the prosecutor settles with the rest. However, bringing an innocent defendant to trial imposes an incentive compatibility constraint on the prosecutor and this constraint cannot be met by risk averse prosecutors. Once a defendant's innocence is revealed to a risk averse prosecutor, the prosecutor prefers to strike a suitable plea deal rather than go through a very risky trial which she loses with probability  $1 - \rho_0$ .

The next result formally depicts the separating equilibrium strategies and beliefs. Less formally, each defendant is made an offer of  $z^S$  either in the first or in the second stage. Since the prosecutor cannot renegotiate with the defendants who reject  $z^S$  in the second stage, they all go to trial. Therefore, to make sure that no more than  $m$  defendants refuse her proposal in the final stage, at least  $N - m$  defendants are offered  $z^S$  initially. If the number of refusals exceeds  $m$ , then the prosecutor proposes  $z_0$  to the minimum number of those who rejected  $z^S$  in the first stage.

**Proposition 2** (1) *In any separating equilibrium:*

$$\begin{aligned}
z_1 &\geq (s_i^1)^* \equiv z^S > z_0 \text{ for at least } N - m \text{ such } i, \text{ and } (s_i^1)^* > z_1 \text{ for the rest.} \\
(s_i^2)^* &= z^S \text{ for all } i \text{ such that } (\delta_p^1)^*(i) = \alpha; \\
(s_i^2)^* &= z_0 \text{ for any } \max\{|x^1(z^S) - (m - x^2(z^S))|, 0\} \text{ of the defendants where} \\
(\delta_p^1)^*(i) &= 0, \text{ and } (s_i^2)^* > z_0 \text{ for the rest.} \\
(\delta_p^1)^*(i) &= 1 \text{ if } (r_i^t)^*((s_i^t)^*, 1) = A \text{ for any } (s_i^t)^* > z_0 \text{ and } (\delta_p^1)^*(i) = 0 \text{ otherwise,}
\end{aligned}$$

where  $x^t(z) = \{i : (r_i^t)^*(z, \theta_i) = R\}$ . For  $t = 1, 2$

$$\begin{aligned}
(r_i^t)^*((s_i^t)^*, 1) &= A \Leftrightarrow (s_i^t)^* \leq z^S, \\
(r_i^t)^*((s_i^t)^*, 0) &= A \Leftrightarrow (s_i^t)^* \leq z_0.
\end{aligned} \tag{7}$$

(2) *If the equilibrium is separating, then  $\rho_0 \geq \frac{v(z_0)}{v(\bar{s})}$ .*

The sorting sentence  $z^S$  is calculated so that a guilty defendant has no incentive to turn  $z^S$  down and feign innocence. Consider a guilty defendant who pretends to be innocent while the other defendants adhere to their separating strategies. He can be sentenced to  $z_0$  if the number of innocent defendants exceeds  $m$  and the prosecutor approaches him again to offer  $z_0$ , otherwise he faces trial. Therefore, he avoids a trial with probability

$$\lambda(m) = \sum_{m \leq k \leq N-1} \binom{N-1}{k} (1 - \alpha)^k \alpha^{N-1-k} \frac{k + 1 - m}{k + 1}. \tag{8}$$

So  $z^S$  is derived as to satisfy

$$u(z^S) = \lambda(m)u(z_0) + [1 - \lambda(m)]u(z_1). \tag{9}$$

The prosecutor's bargaining power is embodied by  $[1 - \lambda(m)]$ , which is an increasing function of  $m$ . Initial high plea offers are credible if and only if at least one guilty

defendant risks going to trial once he rejects this offer. If  $1 \leq m < N$ , then  $\lambda(m) \in (0, 1)$  and  $z_0 < z^S < z_1$ . If  $m = N$ , then  $\lambda(m) = 0$  and  $z^S = z_1$ , that is, the guilty receives the highest expected plea sentence. If  $m = 0$ , then  $\lambda(m) = 1$  and  $z^S = z_0$ , which renders the separating strategy infeasible.

To summarize, the settlement, indifferent, the semiseparating, and the separating strategies are the only options that the prosecutor would employ in any equilibrium.<sup>15</sup> Put differently, the prosecutor can choose not to use any of her resources by utilizing the settlement strategy; she may use her limited ability to go to court as a bargaining device when engaging in the separating strategy; she may use the semiseparating strategy to impose the highest possible sentence on as many defendants as her constraints allow; or she may choose to go to court relentlessly if she picks the indifferent strategy. From now on I make the following tie breaking assumption. If a prosecutor's payoffs from two strategies are the same, she chooses the strategy that achieves the most separation between the defendants. The ordering of the strategies from the most informative to the least is as follows: the separating, the semiseparating, the indifferent, and the settlement.

All equilibria are ex ante outcome equivalent for an innocent defendant. However, a guilty defendant fares the best in a settlement equilibrium. He suffers only as much as an innocent defendant:  $u(z_0)$ . His utility is lowest in the separating equilibrium:  $u(z^S)$ . A guilty defendant's expected payoffs from the indifferent and semiseparating strategies are the same and equal to  $\frac{N-m}{N}u(z_0) + \frac{m}{N}u(z_1) \in (u(z^S), u(z_0))$  since  $\frac{N-m}{N} > \lambda(m)$ . Also note that when trials involve neither type I nor type II errors and there are no time constraints, then all except the settlement strategy are outcome equivalent. Under these "ideal" circumstances, all innocent defendants are exonerated and all guilty defendants receive the full penalty associated with their crimes ( $z^S = \bar{s}$ ). However, to find the prosecutor's strategy when there are frictions in the

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<sup>15</sup>When there are no time constraints, the semiseparating strategy does not exist.

judicial system, let

$$A(m) = \sum_{m+1 \leq k \leq N} \binom{N}{k} \alpha^{N-k} (1-\alpha)^k (k-m)$$

represent the expected additional number of innocent defendants above  $m$ . Moreover,  $\frac{v(z)}{v(\bar{s})}$  represents the prosecutor's normalized utility from settling at  $z$  by dividing it by the highest payoff associated with conviction in trial.

**Proposition 3** *Suppose  $\rho_0 > 0$ , i.e.,  $\rho_1 < 1$ . (A)  $\rho_0 < \frac{v(z_0)}{v(\bar{s})}$  and  $\rho_1 \leq \frac{v(z_1)}{v(\bar{s})}$  : A prosecutor chooses between the semiseparating and settlement strategies, and she picks the semiseparating (indifferent) strategy if*

$$\alpha \frac{v(z_1)}{v(\bar{s})} + (1-\alpha) \rho_0 \geq (<) \frac{v(z_0)}{v(\bar{s})} \quad (10)$$

*(B)  $\rho_0 < \frac{v(z_0)}{v(\bar{s})}$  and  $\rho_1 > \frac{v(z_1)}{v(\bar{s})}$  : A prosecutor chooses between the settlement and indifferent strategies, and she employs the indifferent (settlement) strategy if*

$$\alpha \geq (<) \frac{v(z_0)}{v(\bar{s})}. \quad (11)$$

*(C)  $\rho_0 \geq \frac{v(z_0)}{v(\bar{s})}$  and  $\rho_1 \leq \frac{v(z_1)}{v(\bar{s})}$  : A prosecutor chooses between the semiseparating and separating strategies, and she picks the separating (semiseparating) strategy if*

$$\frac{v(z^S)}{v(\bar{s})} \geq \frac{[A(m) - (N-m)(1-\alpha)] \rho_0}{N\alpha} + \frac{m v(z_1)}{N v(\bar{s})} + \frac{N-m-A(m)}{N\alpha} \frac{v(z_0)}{v(\bar{s})}. \quad (12)$$

*(D)  $\rho_0 \geq \frac{v(z_0)}{v(\bar{s})}$  and  $\rho_1 > \frac{v(z_1)}{v(\bar{s})}$  : A prosecutor chooses between the indifferent and separating strategies, and she employs the separating (indifferent) strategy if*

$$\frac{v(z^S)}{v(\bar{s})} + \frac{[N(1-\alpha) - A(m)] \rho_0}{N\alpha} \geq (<) \frac{m}{N} + \frac{N-m-A(m)}{N\alpha} \frac{v(z_0)}{v(\bar{s})}. \quad (13)$$

Lemma 3 in the Appendix shows that the ratio  $\frac{v(z)}{v(\bar{s})}$  gets smaller as a prosecutor

becomes more risk acceptant. Based on this finding, the inequality  $\rho_{\theta_i} \geq \frac{v(z_{\theta_i})}{v(\bar{s})}$  ( $\rho_{\theta_i} < \frac{v(z_{\theta_i})}{v(\bar{s})}$ ) implies that the prosecutor displays sufficient risk tolerance/acceptance (little or no local risk tolerance/acceptance) around the certainty equivalent sentence of type  $\theta_i$ . These risk attitudes reflect on the prosecutor's choice of strategy in the following way:  $\rho_0 \geq \frac{v(z_0)}{v(\bar{s})}$  indicates that the prosecutor will bring a defendant to trial while being fully aware of his innocence, and  $\rho_0 < \frac{v(z_0)}{v(\bar{s})}$  implies that the prosecutor strictly favors settling at  $z_0$  which makes the separating strategy not incentive compatible. Similarly,  $\rho_1 > \frac{v(z_1)}{v(\bar{s})}$  suggests that the prosecutor definitely brings a guilty defendant to trial if she has the chance and as a result, the indifferent strategy strictly dominates the semiseparating strategy, and  $\rho_1 \leq \frac{v(z_1)}{v(\bar{s})}$  implies that the prosecutor chooses to settle at  $z_1$  instead, in other words, the semiseparating strategy dominates the indifferent strategy. These threshold levels of risk acceptance are defined with respect to (i) the expected probabilities of committing type 1,  $\rho_0$ , and type 2,  $1 - \rho_1$ , errors in the trial process; and (ii) relative intensities of a defendant's risk aversion and the prosecutor's risk acceptance (tolerance).

A prosecutor described by (A) avoids engaging in a separating strategy ( $\rho_0 < \frac{v(z_0)}{v(\bar{s})}$ ). She also prefers the semiseparating option to the indifferent option ( $\rho_1 \leq \frac{v(z_1)}{v(\bar{s})}$ ).<sup>16</sup> A strategy that involves any separation between types is not incentive compatible for a prosecutor depicted in (B); she instead favors bringing the guilty to trial. This leaves the pooling strategies as the prosecutor's only options. On the other hand, the prosecutor described by (C) would prefer to settle with the guilty but bring the innocent to trial and as a result, only the semiseparating and the separating strategies serve her interests. Finally, even the highest certainty equivalent sentence gives the prosecu-

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<sup>16</sup>When  $\rho_0 < \frac{v(z_0)}{v(\bar{s})}$ , the implementation of a semiseparating strategy in (A) requires a temporal restriction. The prosecutor has to make these  $m$  offers of  $z_1$  in the final plea stage. Otherwise, he would retract from bringing to trial those who reject  $z_1$  once he learns that they are innocent, and would offer them  $z_0$  instead. On the other hand, if these offers are made in the last stage, then the plea process is over by the time the prosecutor learns the truth and therefore, she has to bring the defendant to trial. The strategies that support this outcome involve all defendants rejecting any first stage offer that exceeds  $z_0$ , the guilty defendants rejecting second stage offers if and only if they exceed  $z_1$ , and the innocent defendants accepting at most  $z_0$ .



tor described in (D) a lower payoff than an uncertain trial. Therefore, the indifferent strategy is certainly appealing. However, this strategy carries the risk of losing in court given by  $(1 - \alpha)$ . This risk and that the prosecutor has no choice but settle with some defendants, leave room for the separating strategy.

Because the prosecutor's behavior is classified by her risk attitude at two crucial points,  $z_0$  and  $z_1$ , it can be hard to pin down her decision criteria without specifying functional forms for  $v$  and  $u$ . However, the following discussion provides several necessary and sufficient conditions on the prosecutor's and the defendant's risk attitudes which help discern the prosecutorial behavior. For instance, if the prosecutor's risk attitudes are strong or if the defendants' and the prosecutor's risk attitudes hold the same relation to each other throughout the relevant range of sentences, then her decisions are guided by either (A) or (D). Cases (B) and (C) are especially relevant if  $u$  and  $v$  do not belong to the same functional category. The next result provides several general conditions under which a prosecutor can be characterized by one of these four criteria.

When I state that the prosecutor's risk tolerance level/intensity/strength is higher (lower) than that of the defendant's risk aversion, or equivalently, the prosecutor's risk tolerance is stronger than the defendant's, I refer to the fact that  $v$  is more (less) "convex" than  $-u$ .

**Corollary 1** *(I) If the prosecutor's risk tolerance is strictly stronger (weaker) than the defendant's risk aversion, then her decision is described by (A)((D)). If the prosecutor's risk tolerance and the defendant's risk aversion are of equal intensities, then her decision is given by (C).*

*(II) If the prosecutor is risk averse, then her decision is characterized by (A).*

*(III) If the prosecutor is sufficiently risk acceptant, then her decision is described by (D).*

*(IV) A prosecutor sufficiently risk acceptant around  $z_0$  never chooses the settlement strategy.*

(V) *If a prosecutor's decision is guided by (B) or (C), then there exist a range of sentences over which the defendant's risk aversion is stronger than the prosecutor's risk tolerance, and another range in which the opposite is true.*

Time constraints play a role only when the prosecutor considers the separating option. This is because, when sorting the defendants the prosecutor uses her time strategically rather than viewing it merely as a constraint on her pursuit for trials. Examining (10) and (11) tells us that indeed time constraints play no role if the prosecutors are risk averse around  $z_0$ . On the other hand, if the prosecutor is risk acceptant around  $z_0$ , then (12) and (13) reveal that time constraints influence the prosecutor's decisions. The influence of time constraints on the prosecutor's decision is further shaped by her local risk behavior around  $z_1$ . As (12) and (13) also suggest, it may not be possible to extricate the effect of  $m$  unambiguously. However, the following is true. When there are no (or very little) time constraints, those who are risk averse at  $z_1$ , but not around  $z_0$ , exercise caution and choose the separating strategy (plug  $m = N$  in (12)), while those who are sufficiently risk tolerant around both  $z_0$  and  $z_1$  pursue the indifferent strategy of bringing as many cases as possible to trial (plug  $m = N$  in (13)).

The next example applies the results of this section to a standard class of utility functions for the agents that represents decreasing and constant absolute risk aversion. These utility forms cover many practical cases.

**Example 1** *Let  $u(s) = -s^\phi$  be a generic utility function for the defendant, where  $\phi > 1$ . Similarly, let  $v(s) = s^\beta$ , represent a generic utility function of the prosecutor, where  $\beta \geq 0$ . We can use exponential utility forms - such as  $u(s) = -\exp^{\phi s}$  and/or  $v(s) = \exp^{\beta s}$ ,  $\phi, \beta > 0$  - to capture the possibility of constant absolute risk aversion. However, the following results are robust to these functional variations.*

$z_0, z_1$ , and  $z^S$  are then given by the following:

$$\begin{aligned} z_0 &= \rho_0^{1/\phi} \bar{s}; \quad z_1 = \rho_1^{1/\phi} \bar{s}; \quad z^S = \bar{s} [\lambda(m)\rho_0 + (1 - \lambda(m))\rho_1]^{1/\phi}, \\ \frac{v(z_{\theta_i})}{v(\bar{s})} &= \rho_{\theta_i}^{\beta/\phi}. \end{aligned} \tag{14}$$

The inequality  $\beta > \phi$  ( $\beta < \phi$ ) implies that the prosecutor's risk tolerance is strictly stronger (weaker) than the defendant's risk aversion which can be verified by (14). Case (C) occurs only when  $\beta = \phi$ , that is, all players' risk attitudes are of the same intensity, and therefore, case (B) cannot occur.

For any  $\beta < \phi$  (11), a prosecutor chooses the semiseparating (settlement) strategy if

$$\beta \leq \phi - \log_{\rho_0} \left( \frac{1}{1-\alpha} - \frac{\rho_1}{1-\rho_1} \right)^\phi,$$

provided that  $\frac{1}{1-\alpha} > \frac{\rho_1}{1-\rho_1}$ . The above inequality is obtained from (10) by using (4) and taking logarithms of both sides.

## 4 Plea Bargaining with Correlated and Heterogenous Crimes:

In reality, the severity of each crime may vary and the defendants' crimes can be correlated. To investigate these cases within our framework, I assume that the expected trial outcomes depend on not only the defendant's type but also the other defendants' types. Consequently, unlike in the previous section, the prosecutor's bargaining power with any two defendants of the same type is not necessarily the same. It turns out that both the correlation between defendant types and the different degrees of crime severity mitigate the uncertainty over whom the prosecutor chooses to bring to court. In addition, while a positive correlation among defendants allows the prosecutor to extract higher punishments from guilty defendants, a negative correlation has the opposite impact.

Now we briefly discuss these modified plea processes. For simplicity, we maintain the assumption of two levels of case strengths,  $e_L$  and  $e_H$ . (As it is, there will be sufficient heterogeneity generated by the correlations and crime severities). Let  $\alpha_i > \frac{1}{2}$  be the ex ante probability that  $i$  is innocent, and let  $\rho_{\theta_i,i}$  stand for  $i$ 's expected probability of conviction given his type. Not all crimes are of equal severity:  $\bar{s}_i \neq \bar{s}_j$  for some  $i \neq j$ . Consequently,  $z_{\theta_i,i}$  stands for  $i$ 's certainty equivalent of a trial given  $\theta_i$  and  $\bar{s}_i$ . We im-

pose similar monotonicity assumptions to (1) and (2), implying  $z_{1,i} > z_{0,i}$  for all  $i$ . It is plausible to assume that individuals accused of committing related crimes are aware of how serious the other crimes are and hence,  $\bar{s}_i$  for each  $i$  is common knowledge.

The previous analysis suggests that in any settlement equilibrium the plea sentence each defendant receives is equal to  $z_{0,i}$ . Furthermore,  $z_{0,i}$  is also equal to  $i$ 's plea agreement in case the prosecutor settles with him in an indifferent or a semiseparating equilibrium. As expected,  $z_{1,i}$  is the sentence that the prosecutor proposes to each  $i$  of the  $m$  defendants if she selects the semiseparating strategy. The essential difference between this section and the previous one is that the prosecutor is not necessarily indifferent in her choice of defendants to prosecute in court. To be more specific, in any separating, semiseparating, or indifferent equilibrium where the prosecutor chooses  $m$  defendants to bring to trial, she picks those who generate the highest incremental values of going to trial. To be more specific, the prosecutor brings to trial those yielding the highest values of  $\Delta_i(\omega_i)$ , which is her expected payoff from bringing  $i$  to trial minus her payoff from settling with him:

$$\Delta_i(\omega_i) = \omega_i v(\bar{s}_i) - v(z_{0,i}), \quad (15)$$

$$\Delta_i(\alpha_i, \rho_{0,i}) = \alpha_i v(z_{1,i}) + (1 - \alpha_i) \rho_{0,i} v(\bar{s}_i) - v(z_{0,i}) \quad (16)$$

where  $\omega_i = \alpha_i (\rho_{0,i})$  if she employs the indifferent (separating) strategy, and (16) is relevant if the prosecutor adopts the semiseparating strategy. To avoid situations of indifference, each  $\bar{s}_i$  is calibrated to ensure  $\Delta_i(\omega_i) \neq \Delta_j(\omega_j)$  and  $\Delta_i(\alpha_i, \rho_{0,i}) \neq \Delta_j(\alpha_j, \rho_{0,j})$  for any  $i \neq j$ .

The fact that the prosecutor no longer is indifferent impacts the sorting plea sentences in the following way. Let  $z_i^S$  be the sentence that only the guilty type of defendant  $i$  accepts in a separating equilibrium:

$$z_i^S = \lambda_i(m) u(z_{0,i}) + [1 - \lambda_i(m)] u(z_{1,i}),$$

where  $\lambda_i(m)$  denotes the probability with which the prosecutor offers  $z_{0,i}$  to  $i$ :

$$\lambda_i(m) = \sum_{\substack{\theta_{-i} \text{ has } k \text{ zeroes;} \\ m \leq k \leq N-1}} \mathbb{P}(\theta_{-i} \mid \theta_i = 1) \mathbf{1}_{\{\exists \text{ at least } m \text{ defendants among } \theta_j=0 \text{ with } \Delta_j(\rho_{0,j}) > \Delta_i(\rho_{0,i})\}}.$$

The equality above demonstrates that a positive correlation between types enhances the prosecutor’s bargaining position with respect to a guilty defendant. Intuitively, if a defendant’s guilt signals that more of the remaining defendants are guilty, then there is less need for the prosecutor to renegotiate. As a result, a guilty defendant’s chances of settling out of court are lower. The opposite is true if a negative correlation exists. In that case, there are potentially many innocent defendants who would not settle at anything higher than  $z_{0,i}$ . As a result, the gains from deviation are higher for a guilty defendant who expects the prosecutor to be time constrained. However, such correlations are not pertinent for the equilibrium plea sentences under the remaining strategies (apart from determining who goes to court).

## 5 Discussion

In this section I explore two variations of the baseline model in Section 3. The first alternative is constructed by changing the structure of the plea process and the second alteration involves prosecutors with different preferences.

### 5.1 Sequential Plea Offers:

Consider an alternative plea game where the prosecutor makes plea offers to each defendant sequentially. For that purpose, we allow the plea game to last at most  $2N$  rounds during which the prosecutor meets each defendant at least once and at most twice (and not necessarily in a specific order). This game with  $2N$  stages is identical to the one we have studied in Section 3 provided that (a) the outcomes of the previous plea negotiations cannot be learned by any defendant unless they involve him, and (b)

there is no discounting.

However, when the outcome of every plea round (offers and responses) is publicly known, the game reveals interesting results. Common knowledge of plea outcomes affects all defendants whose crimes may be unrelated but whose fates are intertwined, as they compete to escape prosecution in trial. In this game the pooling equilibria are identical to those in Section 3 (although the strategies are different due to the change in game structure) whereas the separating equilibria are substantively different. In particular, the highest sentence acceptable to a guilty defendant is determined by *when* he is approached. To see why, let  $y^t$  and  $t - 1 - y^t$  be the number of closed and open cases by the start of stage  $t$ , respectively. Consider a separating equilibrium where the prosecutor makes her screening offer to each  $i$  when she meets him for the first time. As before, an innocent defendant accepts no plea above  $z_0$ . On the other hand, the highest tolerable sentence for a guilty defendant depends on the number of plea offers accepted prior to his round. The higher the number of guilty pleas entered before a guilty  $i$  is approached for the first time, the higher the sentence  $i$  can expect in equilibrium. This is because, each accepted offer frees the prosecutor to bring an additional case to trial. To illustrate, suppose that all  $N - m$  initial offers are accepted. Then the remaining  $m$  defendants know that they certainly go to trial unless they accept their offers. For that reason, the prosecutor can sentence any remaining guilty defendant to the harshest plea sentence  $z_1$ . Indeed, if  $N - m \leq y^n$  (in other words,  $n$  is any stage after round  $N - m$  where prosecutor is no longer constrained), then the  $n^{\text{th}}$  defendant definitely goes to trial upon rejection.

By a similar reasoning, the plea process becomes more favorable to defendants if the prosecutor faces many rejections in the earlier rounds. Any guilty defendant yet to negotiate with the prosecutor knows that he has higher chances of arranging a better deal weakening the prosecutor's bargaining power with the rest of the defendants (see (17)). Also note that since the prosecutor is *ex ante* equally ambivalent about all defendants, the order in which she offers pleas is random. To formalize how publicly

observed plea outcomes affect the subsequent plea offers, let us look at the  $n^{\text{th}}$  defendant the prosecutor approaches under the assumption that  $N - m > y^n$ . The highest acceptable sentence to a guilty  $n^{\text{th}}$  defendant, is denoted by  $z^{S,n}$  and satisfies

$$u(z^{S,n}) = \lambda^n(m)u(z_0) + [1 - \lambda^n(m)]u(z_1),$$

where

$$\lambda^n(m) = \sum_{N-n \geq k \geq m+y^n-n} \binom{N-n}{k} (1-\alpha)^k \alpha^{N-n-k} \frac{k+n-y^n-m}{k+n-y^n}. \quad (17)$$

Observe that, due to the independence of types the expected payoff from each strategy prior to the plea stage is the same as before.

## 5.2 Prosecutors with Different Goals:

It is plausible that the prosecutors may harbor reservations about punishing an innocent defendant, or they may only be interested in punishing the guilty. To investigate these possibilities, we allow the prosecutors to suffer a nonnegative loss from sentencing the innocent. One modified form of prosecutorial utility functions that captures these considerations is:

$$\sum_{i=1, \dots, N} \theta_i v(s_i) - (1 - \theta_i) w(s_i),$$

where  $w(0) = 0$  and  $w' \geq 0$ .

When  $w' = 0$ , the prosecutor cares only about sentencing the guilty but is indifferent to the fate of an innocent defendant. Under these circumstances, the prosecutor always chooses to go to trial. In doing so, if  $\rho_1 \geq \frac{v(z_1)}{v(\bar{s})}$  ( $\rho_1 < \frac{v(z_1)}{v(\bar{s})}$ ), then she uses the separating strategy instead of the indifferent (semiseparating) strategy as long as

$$\frac{v(z^S)}{v(\bar{s})} \geq \frac{N-m}{N} \frac{v(z_0)}{v(\bar{s})} + \frac{m}{N} \rho_1 \left( v(z^S) \geq \frac{N-m}{N} v(z_0) + \frac{m}{N} v(z_1) \right).$$

When the prosecutor's risk tolerance is little, she always chooses the separating strategy.

When  $w' > 0$ , the prosecutor suffers from convicting the innocent. Since the threat of bringing an innocent defendant to trial is not credible, she never adopts the separating strategy. The prosecutor then chooses between the three remaining strategies. The plea agreement with  $N - m$  defendants in a settlement or a semiseparating strategy is denoted by  $z'_0$  and solves:

$$\max_{s \leq z_0} \alpha v(s) - (1 - \alpha) w(s) \quad (18)$$

If  $\rho_1 \geq \frac{v(z_1)}{v(\bar{s})}$  ( $\rho_1 < \frac{v(z_1)}{v(\bar{s})}$ ), then the prosecutor chooses the indifferent (semiseparating) instead of the settlement strategy when

$$\rho_1 v(\bar{s}) - v(z'_0) (v(z_1) - v(z'_0)) > \frac{1 - \alpha}{\alpha} [\rho_0 w(\bar{s}) - w(z'_0)].$$

Thus, the prosecutor chooses the settlement strategy as long as 1) evidence generation is sufficiently inaccurate, 2) trials are sufficiently unreliable (small chances of making type I and II errors), and 3) her guilt from punishing the innocent trumps her gain from punishing the guilty.

## 6 Conclusion

In this paper I propose a comprehensive plea bargaining model which explores the prosecution side in depth. I introduce two prosecutorial features which so far have been neglected : risk attitudes and time constraints. Moreover, as in any situation of bargaining, the characteristics of each negotiating partner are pertinent to predict the final outcomes. In doing so, I provide a rationale for plea bargaining. I find that the prosecutor's decisions are primarily defined by (i) the probabilities of reaching erroneous verdicts in trials, and (ii) the prosecutor's risk attitudes around two sentences, one that is acceptable by all and another acceptable only by the guilty. I find that time constraints are immaterial to the decisions of those prosecutors who are locally risk



averse or little risk tolerant around the sentence which can be successfully imposed on any defendant. This happens, for instance, when prosecutors are risk averse or when their risk tolerance is weaker than the defendants' risk aversion; indeed, with these risk attitudes the prosecutors can even choose to close every case with a plea agreement regardless of time constraints. Separation of the guilty from the innocent can occur and time constraints become relevant if the prosecutors are sufficiently risk tolerant around this sentence. However, when prosecutors are highly risk tolerant, then they may prefer the riskiest option by proceeding to trials without learning the truth. The most informative plea processes take place under prosecutors who are sufficiently risk tolerant at low sentences acceptable to all, but risk averse or little risk tolerant at high ones acceptable only to the guilty.

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## 7 APPENDIX

**Proof of Lemma 2:** (i) Assume  $s_i^* > s_j^*$ , without loss of generality, that is,  $s_i^*$  is the lowest sentence  $i$  can expect in the plea process. But then the prosecutor is strictly better off by setting  $(s_j^1)^* = (s_i^1)^*$  and  $(s_j^2)^* = (s_i^2)^*$ .

(ii) The following four cases cover all the contingencies. (a) If  $s_i^* = (s_i^t)^* > z_0$  for some  $t$ , then  $(\delta_p^t)^*(i) = 1$ . (b) If  $s_i^* = (s_i^t)^* \leq z_0$  or if  $(s_i^t)^* > z_1$  for some  $i$  and  $t$ , then  $(\delta_p^t)^*(i) = \alpha$ . (c) Suppose there exist some  $i, j$ , and  $r$  such that  $z_1 \geq s_i^* = (s_i^r)^* \geq \min_t (s_j^t)^* > z_0$  where  $(r_j^t)^* = R$  for all  $t$ . Then  $(\delta_p^1)^*(j) = (\delta_p^2)^*(j) = 0$  if  $(s_j^1)^* \leq (s_j^2)^*$ ;  $(\delta_p^1)^*(j) = \alpha$  and  $(\delta_p^2)^*(j) = 0$  if  $(s_j^1)^* > (s_j^2)^*$ . (d) Suppose there exist some  $i, j$ , and  $r$  such that  $\min_t (s_j^t)^* > (s_i^r)^* > z_0$  and  $(r_j^r)^* = A$ , then  $(r_j^t)^* = R$  and  $(\delta_p^t)^*(j) = \alpha$  for all  $t$  by (i).

**Proof of Proposition 2:** (1) follows from Lemma 2. (2) follows from the observation that at stage 2, the prosecutor must have the incentive to bring as many defendants as feasible to trial, otherwise no guilty defendant accepts a sentence higher than  $z_0$ :  $\rho_0 v(\bar{s}) \geq v(z_0)$ .

**Proof of Proposition 3:**  $V_v^P$  and  $V_v^{SS}$  denote the prosecutor's expected payoffs from employing the settlement and semiseparating strategies, respectively, when she has a utility representation  $v$ . Also recall that  $V_v^S$ , and  $V_v^I$  are her expected payoffs from utilizing the separating, and the indifferent strategies. Clearly,  $V_v^P = Nv(z_0)$ . The separating strategy generates a payoff of

$$\begin{aligned}
V_v^S &= \sum_{0 \leq k \leq N} \binom{N}{k} (1 - \alpha)^{N-k} \alpha^k k v(z^S) + \sum_{0 \leq k \leq m} \binom{N}{k} (1 - \alpha)^k \alpha^{N-k} k \rho_0 v(\bar{s}) \\
&\quad + \sum_{m+1 \leq k \leq N} \binom{N}{k} (1 - \alpha)^k \alpha^{N-k} [m \rho_0 v(\bar{s}) + (k - m)v(z_0)] \\
&= \sum_{0 \leq k \leq N} \binom{N}{k} (1 - \alpha)^k \alpha^{N-k} k v(z^S) + \sum_{0 \leq k \leq N} \binom{N}{k} (1 - \alpha)^k \alpha^{N-k} k \rho_0 v(\bar{s}) \\
&\quad - \sum_{m+1 \leq k \leq N} \binom{N}{k} (1 - \alpha)^k \alpha^{N-k} [(k - m)\rho_0 v(\bar{s}) - (k - m)v(z_0)] \\
&= N\alpha v(z^S) + N(1 - \alpha)\rho_0 v(\bar{s}) - [\rho_0 v(\bar{s}) - v(z_0)] A(m), \tag{19}
\end{aligned}$$

where the penultimate and last equalities are achieved by regrouping the terms and taking expectations of binomially distributed terms. The indifferent and semiseparating strategy payoffs are given below in that order:

$$\begin{aligned}
V_v^I &= (N - m)v(z_0) + \sum_{0 \leq k \leq m} \binom{m}{k} \alpha^k (1 - \alpha)^{m-k} [k\rho_1 + (m - k)\rho_0] v(\bar{s}) \\
&= (N - m)v(z_0) + mv(\bar{s}) [(1 - \alpha)\rho_0 + \alpha\rho_1] \\
&= (N - m)v(z_0) + \alpha mv(\bar{s}) \quad \text{(by (4))} \\
V_v^{SS} &= (N - m)v(z_0) + m [\alpha v(z_1) + (1 - \alpha)\rho_0 v(\bar{s})]
\end{aligned} \tag{20}$$

$V_v^{SS} \geq (<) V_v^P \Leftrightarrow (10)$ . By grouping terms we have  $V_v^I \geq (<) V_v^P \Leftrightarrow (11)$ . Since  $\alpha > \rho_0 \geq \frac{v(z_0)}{v(\bar{s})}$ , the last inequality is sufficient to guarantee (11).

Also we have

$$\frac{v(z_1)}{v(\bar{s})} \geq (<) \rho_1 \Leftrightarrow V_v^{SS} \geq (<) V_v^I. \tag{21}$$

Moreover,  $V_v^S \geq (<) V_v^{SS} \Leftrightarrow (12)$ . Regrouping terms shows that  $V_v^S \geq (<) V_v^I \Leftrightarrow (13)$ . Moreover, by (2) of Proposition 2, the separating strategy is incentive compatible only if  $\rho_0 \leq \frac{v(z_0)}{v(\bar{s})}$ .

**Lemma 3** *Suppose there exist two prosecutors,  $p_1$  and  $p_2$ , whose utility functions are  $w$  and  $v$ , respectively. If  $p_1$  is strictly more risk acceptant than  $p_2$ , then*

$$\forall y > x > 0 : \frac{v(x)}{v(y)} > \frac{w(x)}{w(y)}, \tag{22}$$

and

$$\forall x > 0 : \Delta'(x) > 0 \tag{23}$$

where  $\Delta = w - v$ .

**Proof.** The following definitions of the more-risk-acceptant-than relation are equivalent: (i) for any  $\lambda \in (0, 1] : \lambda v(x) + (1 - \lambda)v(y) < \lambda w(x) + (1 - \lambda)w(y)$ . (ii) There exists an increasing and strictly convex function  $f$  such that  $w = f(v)$ . (iii)  $\frac{v''}{v'} < \frac{w''}{w'}$ .

For any  $x > 0$ , let  $v_x = v(x)$ . Then by (ii), (22) can be equivalently stated as

$$\forall y > x > 0 : \frac{f(v_y)}{v_y} > \frac{f(v_x)}{v_x},$$

which holds since  $\frac{f(v)}{v}$  is an increasing function of  $v$  :  $\left(\frac{f(v)}{v}\right)' = \frac{f'(v)v - f(v)}{v^2} > 0$  by  $f'(v) > \frac{f(v)}{v}$ , which, in turn, is due to  $f', f'' > 0$ .

Next (23) is proved. Suppose  $\lambda = 1$ , then  $\Delta(x) > 0$  for all  $x > 0$  by (i). The positivity of  $\Delta$  and  $\Delta(0) = 0$  imply  $0 = \arg \min \Delta$ . If  $\Delta'(d) = 0$  for some  $d$ , then  $\Delta''(d) > 0$  by (iii). Since 0 is the global minimum, there exists no such  $d$ . Moreover, if  $\Delta'(f) < 0$  for some  $f$ , then  $\Delta'(e) > 0$  for some  $e < f$  due to  $\Delta(0) = 0$  and  $\Delta(x) > 0$  for all  $x > 0$ . But this would imply  $\Delta'(c) = 0$  for some  $c \in (e, f)$ . Contradiction. ■

**Proof of Corollary 1:** (I) Let  $T(\nu) = \nu v(\bar{s}) - v(z_\nu)$ , where  $z_\nu = u^{-1}(\nu u(\bar{s}))$ . Therefore (a)  $T(0) = T(1) = 0$ ; (b) for  $\nu \in (0, 1)$  :  $T''(\nu) = \left(\frac{u(\bar{s})}{u'(z_\nu)}\right)^2 \left[-v''(z_\nu) + v'(z_\nu) \frac{u''(z_\nu)}{u'(z_\nu)}\right] < (\geq) 0 \Leftrightarrow \frac{u''(z_\nu)}{u'(z_\nu)} < (\geq) \frac{v''(z_\nu)}{v'(z_\nu)}$ . If  $\frac{u''(z_\nu)}{u'(z_\nu)} < \frac{v''(z_\nu)}{v'(z_\nu)}$   $\left(\frac{u''(z_\nu)}{u'(z_\nu)} \geq \frac{v''(z_\nu)}{v'(z_\nu)}\right)$  for all  $\nu$ , then given (a),  $T(\nu) > 0$  ( $T(\nu) \leq 0$ ) for  $\nu \in (0, 1)$  (in other words,  $-u$  is less “convex” than  $v$ )

(II) If  $v'' < 0$ , then

$$\forall \theta_i : v(z_{\theta_i}) = v(u^{-1}(\rho_{\theta_i} u(\bar{s}))) > v(u^{-1}(u(\rho_{\theta_i} \bar{s}))) = v(\rho_{\theta_i} \bar{s}) > \rho_{\theta_i} v(\bar{s}).$$

The first inequality is due to  $v'' < 0$  and that lower sentences mean higher payoffs for the defendant and lower payoffs for the prosecutor.

(III) For all  $\nu > 0$  :  $T(\nu) > 0 \Leftrightarrow \frac{v(z_\nu)}{v(\bar{s})} < \nu$ , that is,  $\frac{v(z_\nu)}{v(\bar{s})}$  is sufficiently small which holds if the prosecutor is sufficiently risk acceptant by (22).

(IV) In (A)  $\alpha \frac{v(z_1)}{v(\bar{s})} + (1 - \alpha) \rho_0 > \alpha$ . Then  $\alpha \geq \frac{v(z_0)}{v(\bar{s})}$  implies both (10) and (11) hold.

(V) Consider  $\rho_1 > \frac{v(z_1)}{v(\bar{s})}$  and  $\rho_0 < \frac{v(z_0)}{v(\bar{s})}$  (C):  $T(\rho_1) > 0$  and  $T(\rho_0) < 0$ . Since  $T$  is continuous, there exists  $(a, b)$ ,  $b < \rho_1$  such that  $T(\nu) < 0$  for all  $\nu \in (a, b)$ . Suppose further that  $(a, b)$  is the largest such set (union of open sets is open). It also has to be true that  $T''(y) > 0$  for some subset of  $(a, b)$ ; if not, then  $T''(\nu) < 0$  for all  $y$  at which  $T(\nu) < 0$ , implying there is a “jump” at  $\rho_1$ . Contradiction. (B) can be proved similarly.