All-or-nothing verdict as a screening device

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An adversarial model of criminal trial is considered with three verdict choices—innocent, guilty of moderate crime, and guilty of serious crime. Depending on the parties' access to evidence and initial beliefs in the courtroom about the possible crimes, the judge may agree to the defendant's request to eliminate the verdict of moderate crime from jury deliberation if the prosecution brings the charge of serious crime. Though this all-or-nothing verdict choice confers the defendant some manipulative power, it is shown that such verdict choice may also screen out an overstated charge of serious crime. Conditions are derived under which screening is effective and powerful enough to generate (*ex-ante*) efficiency gains.

1. Introduction

The results of several recent trials in the USA, that attracted wide attention of the common public on both sides of the Atlantic, have shown that instructions to include or exclude lesser offenses can have a considerable impact on a jury's verdict. For instance, in the Oklahoma City bombing trial of Terry Nichols, the jury was given the options of several counts of first-degree murder and the lesser-included offense of involuntary manslaughter. The jury turned in the verdict of involuntary manslaughter on eight counts. It is difficult to guess what the same jury would decide under a set of choices excluding the lesser offense of manslaughter. In another trial, Massachusetts vs Woodward, the Middlesex Superior Court Judge Hiller Zobel instructed the jury that they may not consider the lesser charge of manslaughter and instead should focus on charges of first- and second-degree murder. The instruction was prompted by a request from the defendant Louise Woodward and her attorneys. The jury turned in the second-degree murder verdict, but may well have chosen involuntary manslaughter had this option been available. Not all jurisdictions allow for such instructions.[1]

Opinions vary regarding how the decision concerning inclusion or exclusion of lesser offenses should be made. This decision can be considered the defendant's right (which she can waive) or an aid to the prosecution in obtaining a conviction

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[1] See Carpenter (1999) for a survey of various jurisdictions' use of instructions on lesser offenses. Even within the USA, jurisdictions vary considerably in their approach to lesser-included offenses.

(of the lesser, if not the serious crime), or a strategic instrument that both parties can use in their own interests.[2] Earlier research (Andreoni, 1991; Snyder, 1990) made the observation that the jury's decision depends also on the potential penalties, with higher penalties leading to lower probabilities of conviction, given the evidence available. A lesson of their analysis can be summarized by the following thought process, so we conjecture, on the part of the defendant: even if the jury believes it quite likely that the defendant committed the serious crime, the jury would declare her innocent when the lesser offense is excluded if they consider unfair the penalty for the serious crime. Clearly, whether penalties are considered fair or unfair, exclusion of a lesser offense can generate a wrongful acquittal or conviction, which conflicts with trial integrity and its basic objective to find the truth and penalize accordingly. Furthermore, not only possible exclusion of lesser offenses may lead the defendant to gamble for a strategic escape, upholding the defendant's request of exclusion despite objections by the prosecution would violate the principle of mutuality of right.

This is one side of the coin, however. On the other side there are arguments and principles in favor of excluding lesser offenses or giving the parties the option of making a request to this effect. As Carpenter (1999) notes, the principle of party autonomy—the parties' freedom to form their trial strategy without any interference—would stipulate that the defendant be allowed to request exclusion of lesser, uncharged crimes.[3] Also, especially if evidence on the lesser offense is not strong enough to necessarily warrant its inclusion, failure to exclude the lesser offense may generate compromise verdicts based on prejudice or sympathy of fact-finders. In this paper we argue that there is another, less obvious and hitherto unnoticed, potential motive behind allowing defendants in criminal trials to make an all-or-nothing verdict request.

Based on Shin (1998), but applied to criminal trial, we consider an extensive form game representation of the jury trial procedure with four players—the prosecution, the defendant, the jury and the judge. At the beginning the prosecution observes some preliminary evidence with which to charge the defendant for a crime. In addition and at the same time, the prosecution and the defendant each may independently and privately observe a verifiable common signal relevant to the true state, that is, whether the defendant is innocent or guilty of the serious crime

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[2] See Patillo (1998) for a discussion of these views in light of several recent trials and Adlestein (1995) for the potential tension between inclusion of lesser offenses and criminal statutes of limitations.

[3] To quote from Carpenter (1999), '... the trial court ordinarily should not give a jury an instruction on an uncharged lesser-included offense where neither side requests or affirmatively agrees to such instruction. It is a matter of prosecution and defense strategy which is best left to the parties. There is no requirement that the jury pass on each possible offense the defendant could have committed'.

or of the lesser, moderate crime.[4] The judge and the jury are completely uninformed about the signal and private observations of the parties, thus the game is one of three-sided incomplete information. The prosecution moves first by deciding on a charge of moderate or serious crime, based on the disclosed grounds of preliminary evidence (and possibly the privately observed signal). The defendant then adopts a unique stance, say of innocence. If the prosecution charged the defendant of serious crime and the defendant claims innocence, the defendant can request exclusion of the moderate crime from jury deliberation. The judge may agree to the defendant's request or turn it down. Both sides simultaneously submit their respective evidence before the judge and the jury and, finally, given the choices made available by the judge, the jury decides on a verdict. The judge and the jury are motivated by the objective of minimizing the expected social costs from different types of potential errors of verdicts. In the analysis we assume that it is sufficiently costly for the judge to alter, so that he accepts, the jury's verdict. We emphasize, though, that our results continue to hold if the probability that the judge alters the jury's verdict, as the accumulated body of trial experience suggests, is sufficiently small.

Our main result is that giving the judge the freedom to exclude a lesser offense from jury deliberation on a request from the defendant may serve to screen out unwarranted charges of serious crime. This screening role is likely to be effective when (i) at the outset of the trial prior beliefs are biased in favor of the serious crime, and (ii) the parties, especially the defendant, are likely to have relatively easy access to evidence that supports the true circumstance (serious or moderate crime, or innocence). Under these conditions, if the lesser offense cannot be excluded, the prosecution's charge of serious crime, coupled with the preliminary evidence supporting the charge, may prompt the verdict guilty of serious crime unless the defendant is able to submit evidence to the contrary and make a reasonable case for the lesser crime or innocence. However, if the lesser offense can be excluded and the prosecution brings in an overstated charge of serious crime with the hope of influencing the verdict decision accordingly, he also runs the risk that the judge, on a request by the defendant, drops the moderate verdict from the jury's choice set. Then the jury's choice from the restricted all-or-nothing verdict set may fall far below the prosecution's initial charge and expectation. This risk may induce the prosecution to bring only a genuine charge of moderate crime. Thus, the view that All-or-nothing verdict merely allows the defendant a strategic escape can be misleading. If used properly, it may generate *ex ante* efficiency gains

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[4] Shin (1998), in both judicial and quasi-judicial contexts of arbitration, compare two trial procedures, adversarial and inquisitorial, and considers only two verdict choices, guilty or not guilty. In the adversarial procedure, a plaintiff and a defendant each make their cases to an impartial arbitrator (or judge) based on their respective evidence. In the inquisitorial procedure, the arbitrator adjudicates based on his own investigations. The adversarial procedure is shown to be strictly superior to the inquisitorial procedure.

by preventing an overstated charge, hence a potential wrongful conviction, of serious crime.

Let us now explain briefly why the conditions outlined above are necessary for this result. Prior beliefs at the outset of the trial induced by the preliminary evidence must be biased in favor of the serious crime because only then would an overstated charge of serious crime generate the verdict of serious crime. All-or-nothing verdict, as we show, can effectively eliminate this undesirable outcome. The probability that the prosecution obtains the kind of evidence that strongly supports the true circumstance should not be small, for otherwise there would be little expected gain from screening his information to induce a genuine charge of moderate crime. Finally, the defendant should be expected to relatively easily demonstrate that she is not guilty of the serious crime, provided, of course, this is the truth. Only then will the defendant's failure to do so, coupled with biased prior beliefs and the prosecution's overstated charge of serious crime, generate the verdict of serious crime, an unwanted outcome which All-or-nothing verdict prevents.

Our view that the prosecution may bring in an overstated charge and behave strategically should be considered a reasonable description of most judicial systems, the unpalatable nature of its implications notwithstanding. Demanded by intense media and public pressure to be seen to be tough on crime in general and to see 'justice being done' in high profile criminal cases, it may not be entirely unlikely for the prosecution to find an escapegoat by charging a suspect of high crime despite insufficient evidence (insufficient, if not for admitting the case to trial, but at least for the charge levelled).[5]

Though the primary focus in this paper is on the implications of the all-or-nothing principle in the case of criminal trials, the basic idea can be related more generally, as follows. Usually, limiting the choice set of a decision maker under uncertainty makes the decision maker worse off (or no better off, at best). However, this is true only if the information of the decision maker is invariant to his choice set. If his information varies with the choice set, then it is quite possible that limiting the freedom of choice will improve his expected payoff. The impact on information quality can therefore explain why organizations, especially professional service firms, adopt an 'up or out' rule according to which promotions lead to partnerships whereas non-promoted employees are left to their outside options. A commitment to eliminate the option of retaining the employee at the same level

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[5] An apt indication of such inclinations by the prosecution is the recent fiasco with the teenage boy Damilola Taylor's murder trial at the London's Old Bailey—see 'Damilola: The Flawed Alibi' and other reports in the *Evening Standard*, 26 April 2002. The report quotes the deputy assistant commissioner in charge of London's murder squads, 'We had our own doubts about the quality of the case, that is why we did not charge these young men without reference to the Crown first. We gathered all the evidence, . . . , it was not the strongest case, and we went to the Crown with what we had. It is the Crown prosecution that brings the prosecution, and this is not me trying to pass the buck, I'm simply describing what happened here.'

can be a beneficial screening mechanism: Under incomplete information regarding individual applicants' abilities, firms would offer probationary contracts during which the employee has the opportunity to signal his type. At the end of the probationary contract the organization either retains and promotes the employee or ends the employment relationship (but never takes the middle road of extending it at the same terms). This up-or-out rule, with properly determined wages for the probationary contract, would screen out 'bad' employee types from the beginning of the relationship, just like all-or-nothing verdict decision screens out the prosecution with an unwarranted charge of serious crime. See Bac (2000) for an analysis of the up-or-out mechanism in job screening context.

The rest of the paper is organized as follows. In Section 2, the basic model is outlined. Section 3 studies the adversarial game when the jury is allowed the full set of verdicts. In Section 4, the game is reexamined with restricted jury verdicts, and the outcome is compared with that obtained in Section 3. Section 5 concludes. All the derivations relating to the equilibria of the adversarial games of Sections 3 and 4 appear in a separate Appendix.

2. The model

We consider an incomplete information game of criminal trial based on the adversarial trial model of Shin (1998), with four players: the judge, the jury, the prosecution, and the defendant. The true circumstance, called the 'state', can be one of three possibilities, $s \in \mathcal{S} = \{0, 1, 2\}$, where $s = 0$ means innocent, $s = 1$ moderate crime, and $s = 2$ serious crime. Four types of evidence are admissible: by default the preliminary evidence Z, and the signals $\sigma \in \Sigma = \{0, 1, 2\}$ that the adversaries may submit during the trial. Interpretation of these evidence and their relation to the states are given below.

The preliminary evidence Z, presented by the prosecution in pre-trial hearings, supports the charge and shapes prior beliefs about the relationship between the state (i.e. the seriousness of the crime, if any) and the potential signals that the adversaries may obtain and submit during the trial. The evidence Z consists of the prosecution's collection of facts, reports, or documents, etc., that directly or indirectly relate to the crime, possibly including the defendant's past criminal records. We do not analyze how the prosecution comes to gather Z nor enumerate the exact Bayesian updating procedure by which Z affects the priors at the outset of the trial. We assume that given evidence Z the judge admits the case to trial, and we take the beliefs based on Z as the initial, exogenous priors determining the strength of the prosecution's case. Thus, failing any counter evidence/alibi from the defendant or further corroboration by the prosecution during the trial stage, we say that the evidence Z, or the prosecution's case (i.e. the priors), is initially 'strong' if it generates the verdict of serious crime; 'solid' if it generates the verdict of moderate crime; 'mild' if it generates acquittal, under full set of verdicts. The analysis in this paper is concerned with the strong case.

Table 1 Joint density of state/signal

	$\sigma = 0$	$\sigma = 1$	$\sigma = 2$
$s = 0$	$p(0,0)$	$p(0,1)$	$p(0,2)$
$s = 1$	$p(1,0)$	$p(1,1)$	$p(1,2)$
$s = 2$	$p(2,0)$	$p(2,1)$	$p(2,2)$

Any of the cases (including a mild one) admitted to trial must have met some minimum plausibility requirements, and the process by which the plausibility test is carried out is not the subject of our analysis.[6] In particular, a mild case does not mean it should be rejected; a case, be it strong, solid or mild, can lead to any type of verdict depending on the adversaries' strategies and evidence submissions during the trial. We shall be more precise on these issues in Section 3.

The starting point of our analysis is after the case has been admitted to trial, given the charge supported by the prosecution's (default) evidence Z, and the jury made informed of the relevant background. At this point the parties share the common prior beliefs summarized in Table 1, where $p(s, \sigma)$ denotes the commonly known joint density of states and the signals σ that the adversaries may submit during the trial. These signals, $\sigma = 0$, $\sigma = 1$ and $\sigma = 2$, lend strong support to the states $s = 0$, $s = 1$ and $s = 2$, respectively. Though not noise-free, a signal $\sigma = j$ indicates that the true state $s = j$ is 'beyond reasonable doubt', hence, as we formally show in the Appendix, generates the corresponding verdict. Accordingly, the prosecution's and the defendant's signals are assumed to be perfectly correlated, which rules out the possibility that two different states are each established beyond reasonable doubt. Furthermore:

Assumption 1 The priors satisfy the monotone likelihood ratio property (Milgrom, 1981): $p(0,0) \geqslant p(1,0) + p(2,0)$, $p(1,1) \geqslant p(0,1) + p(2,1)$, and $p(2,2) \geqslant p(0,2) + p(1,2)$.

For example, when the true state is $s = 0$ (innocent), the adversaries are more likely to obtain, if any, the signal $\sigma = 0$ (evidence supporting innocence) than the other two signals. Therefore submission of $\{\sigma = 0\}$ during the trial should considerably increase the probability that $s = 0$. The two adversaries' access to the

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signal should be considered independent, so we let ϕ_i be the probability that adversary $i = d, p$ (d for defendant, and p for prosecution) obtains the signal σ.[7]

The submission strategies of the adversaries, denoted by R_i, are specified as follows. The defendant who obtains a signal σ can either submit σ or instead submit $\varnothing$; if she does not obtain any signal then her only possible submission is $\varnothing$. On the other hand, if the prosecution obtains a signal σ then he can submit either σ or Z; when he does not obtain any signal his default submission is Z. Thus, while the adversaries may be 'economical with the truth' to support their respective cases, fabricating a signal σ is not possible.[8]

Let $v \in \{0, 1, 2\}$ be the verdict returned by the jury, where $v = 0$ is the verdict of innocence, $v = 1$ the verdict of moderate crime, and $v = 2$ the verdict of serious crime.[9] The payoffs to the defendant from verdict v, represented by $X_d(v)$, reflect explicit penalties imposed by the judge plus any other (possibly subjective) losses due to stigma etc, and similarly the prosecution's payoffs represented by $X_p(v)$ may include prestige and improved career expectations or personal satisfaction from convictions obtained etc. $X_p(\cdot)$ is increasing and $X_d(\cdot)$ decreasing.[10]

Let C_{sv} be the commonly known social costs from verdict v when the true state is s. The social cost C_{sv} results from any miscarriage of justice, either by acquitting a guilty person or convicting an innocent person or even convicting a guilty person with an inaccurate verdict. This cost is distinct from the individual payoffs to the defendant and the prosecution as discussed above. We assume that the judge and the jury have identical preferences and that both seek to minimize the expected social costs from erroneous verdicts, a standard objective specification in the literature (for instance, Andreoni, 1991). In our model, the essential role of the

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[7] Independent access to the signal is a more plausible description given the noncooperative nature of search for evidence (or alibi) by the adversaries. Allowing a small amount of correlation between the likelihood of the two parties receiving signals should not affect the paper's main findings—one of the adversaries still may end up observing the signal while the other might fail and the equilibrium submission strategies should not be significantly altered. However, in the case of perfect correlation, strategic submissions by the adversaries would cease to have any meaningful impact on the outcome of a trial.

[8] While we recognize that fabrication of evidence (i.e. signal) is likely to be of some concern in specific situations, it is also very reasonable to think that generally fabrication (or perjury) carries a considerable risk of detection and future lawsuits with its implied deterrence effect. Our view is that allowing for fabrication would merely complicate the updating procedure without altering the main message of our analysis.

[9] The jury is to be treated as a single unit in this paper. When different jury members have different information relevant to a trial, strategic interdependence of jurors' voting decisions is another interesting question (see Feddersen and Pesendorfer, 1998); the assumption of jury as a single decision making unit with the commonly available information will help us to focus on our main question, without biasing our judgement, about the desirability of verdict restriction.

[10] We take penalties and compensations corresponding to different verdicts as specified exogenously by law for benchmark cases. Thus the ranking of verdicts, in order of preference, is $v = 2$, $v = 1$, $v = 0$ for the prosecution and the opposite for the defendant. We shall assume that the payoff functions $X_p(\cdot)$ and $X_d(\cdot)$ are cardinal though this is not necessary for the defendant's payoff function $X_d(\cdot)$. These payoff functions reflect the adversaries' evaluations of penalties and compensations.

Table 2 True state/verdict: loss

	$v = 0$	$v = 1$	$v = 2$
$s = 0$	0	C_{01}	C_{02}
$s = 1$	C_{10}	0	C_{12}
$s = 2$	C_{20}	C_{21}	0

judge is to control and referee the trial process, that is, to decide on the law as opposed to the jury's responsibility concerning the facts based on which a verdict must be reached (Sprack, 1992, p. 144).

The following characteristics of the costs from verdict errors will be assumed (see also Table 2):

Assumption 2 $C_{02} > C_{01} > 0$, $C_{20} > C_{21} > 0$, $C_{10} > 0$ and $C_{12} > 0$. The cost of a correct verdict is the same for all verdicts and normalized to be zero, i.e. $C_{00} = C_{11} = C_{22} = 0$.

Assumption 3 The cost of verdict errors are symmetric: $C_{sv} = C_{vs}$, $s \neq v$.

The essence of Assumption 2 is that, given the true state, further apart the verdict from the true state, the greater is the cost. Assumption 3 should not be taken as literally applicable. It is a useful, working assumption that simplifies the analysis and allows for intuitive interpretations of our results. It states that n-step errors in the verdict decision have the same social cost, where $n = 1$ *or* 2, no matter the direction of the error. Note, however, that Assumption 3 does not imply $C_{01} = C_{21}$ or $C_{12} = C_{10}$, though these are all one-step error costs.

3. Equilibrium when the lesser offense is included

In this section we study the case where the judge lacks the authority to restrict the jury's choice set—the law mandates, by statute or opinion, the duty to include the related, lesser offense. Thus, in terms of the model, the judge and the jury can be thought of as a single player and all three verdicts, innocent, moderate crime, and serious crime, will be considered by the jury. The sequence of events in this game, to be denoted as Γ_1, is as follows:

(i) Nature draws a state s and a signal σ. Adversary i obtains the signal σ with probability ϕ_i.

(ii) Based on a preliminary evidence Z and possibly privately observed signal σ, the prosecution decides on a charge either of moderate crime or serious crime. Then the defendant adopts a particular stance strictly less than the charge brought by the prosecution. The adversaries are allowed to trial and prior beliefs about the relationship between signals and states are formed.

(iii) The prosecution and the defendant simultaneously submit their respective evidence. The submissions can be either the true signal (if observed) or the default signal Z in the case of prosecution, and $\varnothing$ in the case of defendant.

(iv) Based on the submissions of the adversaries, the jury decides on a verdict less than or equal to the charge brought by the prosecution.

The main findings of our analysis in this section and Section 4 should remain valid even if the adversaries submit their evidence sequentially—the prosecution first, followed by the defendant.

3.1 Analysis of Γ_1

Our basic approach in analyzing the game Γ_1 (i.e. the submission strategies of the adversaries, the updating by the judge/jury, and the determination of the optimal verdict, etc.) is very similar to the analysis of the adversarial arbitration game in Shin (1998). Let the quadruple $\{\sigma = 0\}$, $\{\sigma = 1\}$, $\{\sigma = 2\}$, and $\{Z\}$ (respectively, $\varnothing$) denote the action sets (or evidence submissions) of the prosecution and the defendant, and also the information set of the jury ($\mathcal{I}$). In the Appendix, we derive sufficient conditions for the following strategies, to be denoted as $\mathcal{E}_1$, to form a unique Bayesian Nash equilibrium of Γ_1.

The prosecution brings the charge of serious crime and adopts the submission strategy R_p

$$\begin{cases} \{\sigma = 0\} \to \{Z\} \\ \{\sigma = 1\} \to \{Z\} \\ \{\sigma = 2\} \to \{\sigma = 2\} \\ \{\varnothing\} \to \{Z\}, \end{cases} \tag{1}$$

that is, if he obtains the signal of serious crime, he submits it, and in all other cases he submits the default evidence.

The defendant, in turn, always claims innocence and adopts the following submission strategy R_d

$$\begin{cases} \{\sigma = 0\} \to \{\sigma = 0\} \\ \{\sigma = 1\} \to \{\sigma = 1\} \\ \{\sigma = 2\} \to \{\varnothing\} \\ \{\varnothing\} \to \{\varnothing\}, \end{cases} \tag{2}$$

that is, submits the signals of innocence or moderate crime if available, and remains silent otherwise.

Finally, the jury's verdict choice strategy is

$$\begin{cases} \{\sigma = 0\} \to v = 0 \\ \{\sigma = 1\} \to v = 1 \\ \{\sigma = 2\} \to v = 2 \\ \{Z, \varnothing\} \to v = 2, \end{cases} \tag{3}$$

and the judge's strategy is simply to accept the jury's verdict.

The two most important properties of this strategy configuration are that the prosecution is submitting the default evidence Z in support of his charge unless he has evidence $\sigma = 2$ at hand, and that the jury/judge decides $v = 2$ when $(Z, \varnothing)$ is submitted. The verdict is $v = 2$ when $(Z, \varnothing)$ is submitted, primarily because the prosecution brought a strong case and consequently prior beliefs had been much biased in favor of the serious crime $s = 2$; these beliefs are further strengthened by the defendant's failure to bring in counter-evidence to the prosecution's charge supported by submission of Z.[11] We are interested in this outcome because our objective is to show that it can be prevented if the law allows for All-or-nothing verdict requests that may be socially desirable. The key observation of this section is that under our assumptions the strategy configuration $\mathcal{E}_1$ constitutes an equilibrium:

Proposition 1   Suppose assumptions 1–3 hold. For the trial with unrestricted verdicts, under plausible conditions the prosecution always brings a charge of serious crime and the defendant claims innocence. The two adversaries adopt trial strategies involving some news management as in (1) and (2), that is, they selectively submit the signal observed and otherwise 'remain silent'. Based on a strong case brought by the prosecution, the jury returns a verdict of serious crime unless the defendant produces an evidence of innocence or moderate crime; for the latter submissions the jury returns a corresponding verdict as in (3).

Note that bringing the charge of serious crime is a weakly dominant strategy for the prosecution, and so is claiming innocence for the defendant. Bringing a moderate charge is weakly dominated for the prosecution as it eliminates the possibility of a verdict of serious crime. The prosecution's equilibrium strategy will change in the all-or-nothing verdict scenario studied in the next section, where a charge of serious crime may trigger a continuation game in which $v = 1$ is ruled out. However, the defendant's strategy to always claim innocence will continue to be dominant.

3.2 Intuition

Let us explain the intuition behind the equilibrium $\mathcal{E}_1$, especially optimality of the verdict decisions given the trial strategies. The jury's decision to acquit, or convict of moderate or serious crime when a powerful corresponding evidence is submitted in court is intuitive and follows from Assumptions 1, 2, and 3 (unless the prior probabilities in Table 1 are strongly biased in favor of the defendant or the prosecution to induce a verdict $v \neq \sigma$). Assumptions 1 and 3 also favor the 'middle road' verdict $v = 1$ when the adversaries submit $\{Z, \varnothing\}$, that is, when the defendant fails

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[11] Under these circumstances, the jury could turn in another verdict only if the bias in beliefs is to some extent neutralized, that is, only if one of the adversaries provides concrete evidence in the form of a signal $\{\sigma = 0\}$ or $\{\sigma = 1\}$.

to counter the prosecution's powerful default evidence Z. However, in equilibrium $\mathcal{E}_1$, the jury returns the verdict of serious crime, $v = 2$. Optimality of the verdict $v = 2$ under the default evidence $\{Z, \varnothing\}$ stipulates some asymmetry in the primitives of the model, either in the prior probabilities $p(s, \sigma)$ presented in Table 1 or in the adversaries' relative access to the signal σ. For instance, given Assumptions 1 and 3, if the adversaries have equal access to the signal ($\phi_d = \phi_p$), the verdict $v = 2$ generates a smaller expected social cost than the verdict $v = 1$ only if $\sum_\sigma p(1, \sigma) < \sum_\sigma p(2, \sigma)$, that is, only if the prior probability that the defendant committed the serious crime $s = 2$ is larger than the moderate crime $s = 1$. Or if $\sum_\sigma p(1, \sigma) \geqslant \sum_\sigma p(2, \sigma)$, a necessary condition for the jury to return the verdict of serious crime is $\phi_d > \phi_p$: the defendant (who fears the outcome $v = 2$) should have a relatively easy access to evidence demonstrating the facts, her innocence if indeed she is innocent. So, when circumstances are such that the defendant could relatively easily provide an evidence (or signal) contrary to the charge of serious crime, failure to do so by submitting instead $\varnothing$-evidence will increase the probability that she is guilty of the charged crime. This biases the jury/judge's decision in favor of $v = 2$ when $\{Z, \varnothing\}$ submissions are received.

The jury must also prefer turning in the verdict $v = 2$, not $v = 0$, when $\{Z, \varnothing\}$ is submitted. Both verdict choices involve social costs, such as convicting of the serious crime when the person is innocent or guilty of moderate crime, or acquitting the defendant who is guilty of moderate or serious crime. To gain some intuition let us suppose that the social costs of the two one-step errors in the corresponding verdict decisions, C_{12} and C_{10}, are approximately the same. Since by Assumption 3 $C_{02} = C_{20}$, as we show in the Appendix, the verdict $v = 2$ involves smaller expected social error costs than the verdict $v = 0$ if $[p(0, 0) + p(0, 1)](1 - \phi_d) + p(0, 2)(1 - \phi_p) \leqslant [p(2, 0) + p(2, 1)](1 - \phi_d) + p(2, 2)(1 - \phi_p)$. If $\phi_d = \phi_p$, this condition holds only if $\sum_\sigma p(0, \sigma) \leqslant \sum_\sigma p(2, \sigma)$, i.e. given submissions of the default evidence $\{Z, \varnothing\}$ by the adversaries, if the prior probability that the defendant has committed the serious crime $s = 2$ is larger than the prior probability that she is innocent, $s = 0$. Alternatively, if $\sum_\sigma p(0, \sigma) > \sum_\sigma p(2, \sigma)$, the necessary condition for the verdict $v = 2$ to be chosen over $v = 0$ is $\phi_d > \phi_p$. The intuition is the same as explained above: when the prior probability of innocence is larger than that of serious crime, the verdict $v = 2$ can dominate $v = 0$ only if the party who has the greatest incentive to suppress the evidence of serious crime, the defendant, has a relatively large probability of obtaining such evidence.

To summarize the above discussion, the conditions required for Proposition 1 are likely to hold, so that $\mathcal{E}_1$ is an equilibrium of Γ_1, if $\phi_d \geqslant \phi_p$ and $\sum_\sigma p(2, \sigma) \geqslant \max_s \{\sum_\sigma p(s, \sigma)\}$, that is, if the defendant has a relatively easy access to evidence, and if prior beliefs of the jury/judge are biased in favor of the prosecution's charge, the state $s = 2$ where the defendant commits the serious crime (the prosecution's case is strong). What if these conditions do not hold, so that the judge/jury's optimal choice is $v = 1$ or $v = 0$ when the adversaries submit $\{Z, \varnothing\}$? Then, it can be shown that the prosecution will always bring a

genuine charge, serious or moderate crime, as warranted by his evidence of $\sigma = 2$ or $\sigma = 1$. In that case, eliminating the middle verdict $v = 1$ from the jury's choice set cannot have any screening effect; it can only generate verdict errors. Therefore the conditions making the verdict of serious crime an optimal decision under the prosecution's default evidence are essential for the result we wish to highlight in this paper.

3.3 Numerical example

The following numerical example illustrates Proposition 1.

Let $\phi_d = \phi_p = 1/2$ so that the prosecution and the defendant are equally likely to obtain a signal. We also choose a cost matrix satisfying Assumptions 2 and 3

$$C_{00} = 0 \qquad C_{01} = 5 \qquad C_{02} = 7$$
$$C_{10} = 5 \qquad C_{11} = 0 \qquad C_{12} = 6$$
$$C_{20} = 7 \qquad C_{21} = 6 \qquad C_{22} = 0.$$

Let the joint density of state/signal be as follows

$$p(0,0) = 2/9 \qquad p(0,1) = 2/27 \qquad p(0,2) = 0$$
$$p(1,0) = 1/27 \qquad p(1,1) = 2/9 \qquad p(1,2) = 1/27$$
$$p(2,0) = 4/27 \qquad p(2,1) = 1/27 \qquad p(2,2) = 2/9$$

satisfying Assumption 1. Note that the joint probabilities in the above matrix add up to unity, and that the matrix is not symmetric. The prior probability of $s = 2$ is quite large, meaning that the judge/jury is biased in favor of the prosecution's charge. This example satisfies all the conditions sufficient for the (unique) equilibrium $\mathcal{E}_1$ of Γ_1, derived in the Appendix.

The above example also illustrates the results presented in the next section for suitable choices of $X_p(v)$ values, for instance, $X_p(0) = 0, X_p(1) = 10, X_p(2) = 16$.

4. Equilibrium when the lesser offense may be excluded

4.1 All-or-nothing provision

We take the equilibrium $\mathcal{E}_1$ of Proposition 1 as the starting premise for the following analysis. We now consider a judicial provision that allows more freedom to the adversaries' trial strategies by vesting the judge with the authority to uphold or reject a request affecting the verdict choices for jury deliberation. Specifically, the judge makes the following rule publicly known even before the prosecution brings his charge:

> If in stage (ii) of the game Γ_1 the prosecution brings the charge of serious crime, the defendant can make a request for all-or-nothing verdict. If the judge agrees to the defendant's request, the verdict $v = 1$ will be ruled out from the jury's choice set;

otherwise the full set of verdicts will be considered by the jury. The rest of the game Γ_1 remains unchanged.

We refer to this legal provision as the 'All-or-nothing provision', and the resulting game as Γ_2. In the Appendix, we derive conditions under which the following strategy configuration, denoted $\mathcal{E}_2$, forms a Bayesian Nash equilibrium of Γ_2:

Prosecution   On obtaining the signal $\sigma = 1$, bring a charge of moderate crime and submit $\{\sigma = 1\}$; for all other observations, bring a charge of serious crime and submit according to $\mathcal{E}_1$.

Defendant   Claim innocence. If the prosecution brings a charge of moderate crime, play the submission strategy R_d in $\mathcal{E}_1$. If the charge is one of serious crime, request all-or-nothing verdict and submit according to R_d in $\mathcal{E}_1$ whether or not the judge upholds the request.

The Judge   If the defendant is charged with the serious crime and requests all-or-nothing verdict, uphold the request. Reject the request if the charge is of moderate crime.

The Jury   If the verdict set is $\{v = 0, v = 1, v = 2\}$, choose the verdict according to $\mathcal{E}_1$;

If the verdict set is $\{v = 0, v = 2\}$, determine the verdict as

$$\begin{cases} \{\sigma = 0\} \rightarrow v = 0 \\ \{\sigma = 1\} \rightarrow v = 0 \\ \{\sigma = 2\} \rightarrow v = 2 \\ \{Z, \varnothing\} \rightarrow v = 2 \end{cases}$$

If the verdict set is $\{v = 0, v = 1\}$, determine the verdict as

$$\begin{cases} \{\sigma = 0\} \rightarrow v = 0 \\ \{\sigma = 1\} \rightarrow v = 1 \\ \{\sigma = 2\} \rightarrow v = 0 \quad \text{or} \quad v = 1 \\ \{Z, \varnothing\} \rightarrow v = 0 \quad \text{or} \quad v = 1 \end{cases}$$

We assume that the jury's verdict decision is final, so that the judge accepts the verdict. In the concluding section we discuss the implications of the judge not accepting jury verdict. Also, note that in describing the jury's strategy under the verdict set $\{v = 0, v = 1\}$ we have intentionally not specified the optimal verdict except when it is already implied (as in the cases $\{\sigma = 0\} \rightarrow v = 0$ and $\{\sigma = 1\} \rightarrow v = 1$) by the equilibrium $\mathcal{E}_1$. These decisions will not be relevant for our analysis, under a condition which we introduce later. It is easy to check, however, the constrained optimal verdicts for the submissions $\{\sigma = 2\}$ and $\{Z, \varnothing\}$.

In the game Γ_1, where the lesser offense could not be excluded, the prosecution's strategy to bring a charge of serious crime was a weakly dominating strategy. In the game Γ_2, under the All-or-nothing provision, the prosecution needs to be careful about his charge because the charge of serious crime may induce a request for all-or-nothing verdict which, if upheld by the judge, modifies the verdict set by eliminating the moderate verdict. Then the resulting outcome of the trial may fall far below the prosecution's charge and expectations. To see this, suppose that the prosecution deviates from $\mathcal{E}_2$ and brings in an overstated charge of serious crime, on observing $\sigma = 1$. Then, according to the proposed equilibrium $\mathcal{E}_2$, the defendant requests all-or-nothing verdict, the judge upholds the request and under the verdict set $\{v = 0, v = 2\}$ the jury returns the verdict $v = 0$ if $\{\sigma = 1\}$ is submitted, $v = 2$ if $\{Z, \varnothing\}$ is submitted. As the prosecution deviates by bringing in a charge of serious crime, he optimally stays with the default evidence Z, because if the defendant is not able to provide an evidence to counter the charge and submits $\varnothing$, the jury will return a verdict of $v = 2$, the prosecution's preferred outcome. But the downside of this deviation is that, the prosecution does not know the defendant's hand.[12] The defendant too may have obtained the signal $\sigma = 1$. In that case the defendant will submit $\{\sigma = 1\}$ which according to $\mathcal{E}_2$ generates the verdict $v = 0$. Bringing an overstated charge of serious crime when his evidence rather suggests guilty of moderate crime may therefore be too risky for the prosecution and he may, as in the proposed equilibrium $\mathcal{E}_2$, prefer to bring a moderate charge as warranted by the signal $\sigma = 1$ in his possession. This effect can be summarized as follows:

Proposition 2 Suppose in the unrestricted verdict trial, upon submission of $\{\sigma = 1\}$ the jury would return a verdict of moderate crime, $v = 1$, as in equilibrium $\mathcal{E}_1$. Also suppose that if the prosecution brings a serious charge, under All-or-nothing provision the judge upholds the defendant's request to exclude the lesser offense from jury deliberation. Then under certain plausible conditions, the following constitute an equilibrium: The defendant who observes the evidence $\sigma = 1$ will make a request for all-or-nothing verdict and submit $\{\sigma = 1\}$; the jury on submission of $\{\sigma = 1\}$ will return the verdict $v = 0$; and the prosecution who observes the evidence $\sigma = 1$ will bring a genuine charge of moderate crime.

The relevant conditions under which Proposition 2 holds are derived in the Appendix (see (12) and (13)). Though All-or-nothing provision has the undesirable feature of possibly excluding the correct verdict, it also has the potentially beneficial effect of inducing the prosecution to bring the correct charge of moderate crime, thereby eliminating the possibility of a harsh, unwarranted punishment. The

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[12] This uncertainty will be mitigated, if not removed altogether, if the adversaries' likelihood of receiving signals were correlated—one of the referees raised this issue.

question as to whether All-or-nothing provision is socially beneficial hinges on the comparison between these two effects. We have the following proposition.

Proposition 3   Ex ante, All-or-nothing provision can generate an improvement in expected social costs of verdict decisions.

The exact relevant conditions for Proposition 3 are given by (14) and (15) in the Appendix, in addition to the other conditions that underlie the first two propositions.

4.2 Intuitions behind Propositions 2 and 3

We make several intuitive observations about the sufficient conditions for an effective All-or-nothing provision. The conditions (*a*) and (*b*) below imply that under All-or-nothing provision, when $v = 1$ is eliminated from jury deliberation on the defendant's request, on submission of the evidence $\{\sigma = 1\}$ the jury's optimal decision is the verdict $v = 0$.

(a) The second most probable state in the presence of an evidence of moderate crime is innocence, that is, $p(2, 1) < p(0, 1)$. The intuition is straightforward: when the optimal verdict (but eliminated according to All-or-nothing provision) is $v = 1$, a large $p(0, 1)$ relative to $p(2, 1)$ decreases the likelihood of an error in $v = 0$ relative to $v = 2$, therefore biases the verdict decision in favor of $v = 0$.[13]

(b) The social cost of declaring the defendant innocent when she committed the moderate crime is no larger than the cost of convicting her guilty of serious crime, that is, $C_{10} \leqslant C_{12}$. Obviously, this condition makes $v = 0$ more attractive than $v = 2$.

On the other hand, the prosecution is likely to bring the charge of moderate crime when he has evidence $\sigma = 1$ of moderate crime, the charge of serious crime when he has the default evidence Z alone, under conditions (*c*) and (*d*) below. We note that the prosecution's payoff function $X_p(\cdot)$ is involved in this condition.

(c) $X_p(2)$ is sufficiently larger than $X_p(1)$ and $X_p(1)$ is sufficiently larger than $X_p(0)$. These two requirements are likely to hold if the prosecution's payoff function $X_p(\cdot)$ is neither 'too convex' nor 'too concave', that is, if the prosecution's incremental payoffs when the verdict passes from $v = 0$ to $v = 1$ and then to $v = 2$ are not too

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[13] There is some tension between this condition and the two conditions implying that the verdict $v = 2$ dominate the verdicts $v = 1$ and $v = 0$ when the adversaries submit $\{Z, \varnothing\}$. Thus, eliminating a verdict will generate efficiency gains *ex ante* if, while $v = 2$ dominates both $v = 1$ and $v = 0$ when $\{Z, \varnothing\}$ is submitted, $v = 0$ dominates $v = 2$ when $\{\sigma = 1\}$ is submitted. The social cost matrix (we assumed symmetric costs for simpler exposition) and asymmetries in the prior belief configurations of the judge/jury should be such that the above result is generated in the equilibria of the games Γ_1 and Γ_2, with and without the verdict choice $v = 1$. A relatively large prior probability of $s = 2$ makes $v = 2$ optimal when $\{Z, \varnothing\}$ is submitted, and a large $p(0, 1)$ relative to $p(2, 1)$ makes $v = 0$ dominate $v = 2$ when $v = 1$ is eliminated and $\{\sigma = 1\}$ is submitted.

disproportionate. If the prosecution's utility from obtaining the verdict of moderate crime is not that much higher than the one from acquittal of the defendant, then he would take the risk of acquittal, bring the charge of serious crime and suppress the evidence of moderate crime when he gets it. Then, All-or-nothing provision would not have the desired effect. If, on the other hand, the prosecution does not see a great utility difference between the two types of convictions, he would not bring a charge of serious crime in the first place, when the evidence at his hand stipulates a charge of moderate crime. Then, again, since the prosecution's charge would always be as warranted, All-or-nothing provision would not have the function of screening out unwarranted charges of serious crime.

(d) ϕ_d, the probability that the defendant obtains evidence supporting the true state, is sufficiently large. This is necessary, besides condition (c) above, for the prosecution to bring the charge of moderate crime when he has evidence of moderate crime. Only then will the prosecution not risk bringing a charge of serious crime and take the gamble of all-or-nothing verdict; he will rather settle for the verdict $v = 1$ by revealing $\{\sigma = 1\}$.

Our numerical example satisfies conditions (a) and (b). Indeed, if (a) and (b) hold and $X_p(\cdot)$ and ϕ_d satisfy (c) to generate the equilibrium behavior of the prosecution given in Proposition 2, we can state that the All-or-nothing provision generates an *ex ante* welfare gain if ϕ_p is not too small relative to ϕ_d. If the prosecution has little means to obtain an evidence σ to support any of the three states, then it is not worth using All-or-nothing provision to screen his information. Recall that condition (d) requires ϕ_d be sufficiently large. Thus, All-or-nothing provision improves *ex ante* social welfare if, besides conditions (a), (b), and (c), ϕ_d is large and ϕ_p is not too small relative to ϕ_d.

5. Conclusion

In this paper, we have pointed out the strategic role of the rule of law allowing the judge the freedom to exclude a lesser offense from jury deliberation on a request from the defendant, depending upon the case on trial and the charges by the prosecution about the seriousness of the crime in question. We have shown that under a set of conditions, the judge can improve on the overall efficiency of the trial procedure and minimize the *ex ante* expected losses from inaccurate verdicts by restricting the possible jury verdicts.

The assumption that the judge accepts the jury verdict is important and deserves some discussion. This assumption seems to be at odds with what has happened in a few cases, as in the Woodward trial where the judge eventually altered the jury verdict. In some jurisdictions, the law appears to be flexible in that it does not prescribe fully to which circumstances its all-or-nothing provision should apply, leaving the main responsibility to the judge's discretion. In our model, the judge has an incentive to renege on his all-or-nothing verdict decision and reinstate the *ex post* optimal verdict $v = 1$ when $\{\sigma = 1\}$ is submitted by the defendant. If the

prosecution expects the judge to reinstate the verdict $v = 1$ with probability one when $\{\sigma = 1\}$ is submitted, he will rather deviate back to the original strategy of bringing the overstated charge of serious crime, thus undermining the fact-finding and the potential loss-minimizing objective of the All-or-nothing provision. Though reneging on the all-or-nothing verdict decision by the judge is a real possibility, the courts most often abide by their ruling on verdict elimination (source: Massachusetts v. Woodward, Appeal Petition in http://www.courttv.com/trials/woodward/appeal.html): 'See Commonwealth v. Bowman, 373 Mass. 760, 767–768 (1977) (where trial judge and defendant made deliberate choice not to instruct the jury on manslaughter, Court refused to reduce second degree murder conviction); cf Commonwealth v. Clark, 378 Mass. 392, 407 (1979) (Court characterized as ''novel'' the assertion that a jury verdict may be reduced to a crime that was not charged by the indictment and not submitted to the jury).' Thus, the assumption that the judge accepts the jury verdict seems reasonably well supported by the rulings in the history of trials. We should also add two observations: First, reinstating a verdict that is ruled out invokes severe critiques from legal experts and damages the judge's individual reputation.[14] These reputation costs may be effective enough to induce the judge's acceptance of the jury's verdict decision. Second, and more importantly, our main result continues to hold if the probability that the judge alters the jury's verdict is small. The prosecution would still be deterred from bringing an overstated charge of serious crime if he believes it sufficiently likely that the judge will uphold the jury's decision from the restricted verdict set.

Acknowledgements

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[14] To quote from the appeal petition by four district attorneys for the Woodward trial case, 'the court ... [by reinstating the manslaughter verdict, abused] the broad discretion reserved to it by Mass. R. Crim. P.25(b)(2). Although the rule allows a trial judge to reduce a jury verdict to any lesser included offense, this is generally done when the jury verdict is against the weight of evidence or when significant trial errors create a substantial risk of a miscarriage of justice. See Commonwealth v. Keough, 385 Mass. 314. 320 (1982). Even then, the judge is only authorized to adjust the jury verdict to reflect a conclusion of a lesser charge of culpability based on the factual findings of the jury ... Here [in the Mass. v. Woodward trial] the judge's adjustment of the jury verdict reflected a difference in kind, not degree.' They criticize Judge Hiller Zobel severely: 'If this judge could arrive at this result upon these facts, then every trial judge would have the power to nullify the law, silence the people's elected voice, and dispense with the jury altogether.'

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Appendix

Analysis of Γ_1

Below we derive the conditions, based on comparisons of expected social costs due to errors from alternative verdicts, under which the strategy configuration $\mathcal{E}_1$ constitutes an equilibrium.

The submission strategies during the trial leads the fact-finders to revise their prior beliefs. So it is appropriate to state a tie-breaking assumption for the submission strategies: If an adversary obtains the same expected payoff from submitting a signal and submitting the default evidence, then (s)he submits the signal. The joint density over the triplet $(s, \sigma, \mathcal{I})$ generated by the submission strategies R_p and R_d is summarized in Tables 3–6: Table 3 gives the probability weights when $\{\sigma = 2\}$ is submitted by the prosecution; similarly, Table 4 displays the weights when $\{\sigma = 1\}$ is submitted by the defendant, Table 5 when $\{\sigma = 0\}$ is submitted by the defendant, and Table 6 when the adversaries submit $\{Z, \varnothing\}$. The conditional probability of state s given submission σ, denoted by $p(s|\sigma)$, can be derived from the joint density of $(s, \sigma, \mathcal{I})$ and be simplified as follows[15]

$$p(s|\sigma) = \frac{p(s, \sigma)}{\sum_{r \in \mathcal{S}} p(r, \sigma)}$$

....

[15] These conditional probabilities are well-defined because each submission is made with positive probability, according to $\mathcal{E}_1$. There are no out-of-equilibrium submissions here, hence, no need to postulate out-of-equilibrium beliefs.

Table 3 Joint density of $(s, \sigma, \mathcal{I})$: $\{\sigma = 2\}$

	$\sigma = 0$	$\sigma = 1$	$\sigma = 2$
$s = 0$	0	0	$p(0,2)\phi_p$
$s = 1$	0	0	$p(1,2)\phi_p$
$s = 2$	0	0	$p(2,2)\phi_p$

Table 4 Joint density of $(s, \sigma, \mathcal{I})$: $\{\sigma = 1\}$

	$\sigma = 0$	$\sigma = 1$	$\sigma = 2$
$s = 0$	0	$p(0,1)\phi_d$	0
$s = 1$	0	$p(1,1)\phi_d$	0
$s = 2$	0	$p(2,1)\phi_d$	0

Table 5 Joint density of $(s, \sigma, \mathcal{I})$: $\{\sigma = 0\}$

	$\sigma = 0$	$\sigma = 1$	$\sigma = 2$
$s = 0$	$p(0,0)\phi_d$	0	0
$s = 1$	$p(1,0)\phi_d$	0	0
$s = 2$	$p(2,0)\phi_d$	0	0

Table 6 Joint density of $(s, \sigma, \mathcal{I})$: $\{Z, \varnothing\}$ submissions

	$\sigma = 0$	$\sigma = 1$	$\sigma = 2$
$s = 0$	$p(0,0)(1 - \phi_d)$	$p(0,1)(1 - \phi_d)$	$p(0,2)(1 - \phi_p)$
$s = 1$	$p(1,0)(1 - \phi_d)$	$p(1,1)(1 - \phi_d)$	$p(1,2)(1 - \phi_p)$
$s = 2$	$p(2,0)(1 - \phi_d)$	$p(2,1)(1 - \phi_d)$	$p(2,2)(1 - \phi_p)$

Now, note that optimality of the strategies R_p and R_d follow easily from the payoffs of the adversaries given the jury/judge's strategy. The equilibrium conditions to be derived below therefore rest on the best reply of the jury/judge to the trial strategies R_d and R_p.

Now suppose that the evidence $\{\sigma = 0\}$ is submitted (by the defendant, according to $\mathcal{E}_1$). The verdict $v = 0$ is optimal for the jury/judge if and only if the following hold:

$$p(1|0)C_{10} + p(2|0)C_{20} \leqslant p(0|0)C_{01} + p(2|0)C_{21}$$

$$p(1|0)C_{10} + p(2|0)C_{20} \leqslant p(0|0)C_{02} + p(1|0)C_{12}$$

Using Assumption 3, these conditions simplify to

$$\frac{p(0,0) - p(1,0)}{p(2,0)} \geqslant \frac{C_{20} - C_{21}}{C_{01}} \tag{4}$$

$$\frac{p(0,0) - p(2,0)}{p(1,0)} \geqslant \frac{C_{10} - C_{12}}{C_{02}} \tag{5}$$

Suppose that the evidence $\{\sigma = 1\}$ is submitted (by the defendant, according to $\mathcal{E}_1$). The verdict $v = 1$ is optimal if and only if the following hold

$$p(0|1)C_{01} + p(2|1)C_{21} \leqslant p(1|1)C_{10} + p(2|1)C_{20}$$

$$p(0|1)C_{01} + p(2|1)C_{21} \leqslant p(0|1)C_{02} + p(1|1)C_{12}$$

i.e. using Assumption 3 and simplifying

$$\frac{p(1,1) - p(0,1)}{p(2,1)} \geqslant \frac{C_{21} - C_{20}}{C_{10}} \tag{6}$$

$$\frac{p(1,1) - p(2,1)}{p(0,1)} \geqslant \frac{C_{01} - C_{02}}{C_{12}} \tag{7}$$

The L.H.S. of both (6) and (7) exceed 1 by Assumption 1; condition (6) holds because $C_{21} - C_{20} < 0$ by Assumption 2, and (7) holds because $C_{01} - C_{02} < 0$ by Assumption 2. Thus, $v = 1$ is unambiguously the optimal verdict if $\{\sigma = 1\}$ is submitted by either adversary.

Suppose that the evidence $\{\sigma = 2\}$ is submitted (by the prosecution, according to $\mathcal{E}_1$). The verdict $v = 2$ is optimal if and only if the following hold

$$p(0|2)C_{02} + p(1|2)C_{12} \leqslant p(0|2)C_{01} + p(2|2)C_{21}$$

$$p(0|2)C_{02} + p(1|2)C_{12} \leqslant p(1|2)C_{10} + p(2|2)C_{20}$$

i.e. using Assumption 3 and simplifying

$$\frac{p(2,2) - p(1,2)}{p(0,2)} \geqslant \frac{C_{02} - C_{01}}{C_{21}} \tag{8}$$

$$\frac{p(2,2) - p(0,2)}{p(1,2)} \geqslant \frac{C_{12} - C_{10}}{C_{20}} \tag{9}$$

Our assumptions so far do not necessarily imply (8) and (9).

Finally, suppose the prosecution submitted Z and the defendant submitted $\varnothing$, according to $\mathcal{E}_1$. The expected social costs for verdicts $v = 0$, $v = 1$ and $v = 2$ compare as follows.

The jury/judge's expected cost from $v = 0$ is

$$\frac{\Delta_1}{\Delta_0 + \Delta_1 + \Delta_2} C_{10} + \frac{\Delta_2}{\Delta_0 + \Delta_1 + \Delta_2} C_{20}$$

where

$$\Delta_0 = p(0,0)(1 - \phi_d) + p(0,1)(1 - \phi_d) + p(0,2)(1 - \phi_p)$$

$$\Delta_1 = p(1,0)(1 - \phi_d) + p(1,1)(1 - \phi_d) + p(1,2)(1 - \phi_p)$$

$$\Delta_2 = p(2,0)(1 - \phi_d) + p(2,1)(1 - \phi_d) + p(2,2)(1 - \phi_p)$$

and $\Delta_1/(\Delta_0 + \Delta_1 + \Delta_2)$ and $\Delta_2/(\Delta_0 + \Delta_1 + \Delta_2)$ are respectively the conditional probability that the state is $s = 1$ and $s = 2$ given the submissions $\{Z, \varnothing\}$.

The jury/judge's expected cost from $v = 1$ is

$$\frac{\Delta_0}{\Delta_0 + \Delta_1 + \Delta_2} C_{01} + \frac{\Delta_2}{\Delta_0 + \Delta_1 + \Delta_2} C_{21}$$

where $\Delta_0/(\Delta_0 + \Delta_1 + \Delta_2)$ is the conditional probability that the state is $s = 0$ given the $\{Z, \varnothing\}$ submission.

Finally, if $v = 2$, the expected cost is

$$\frac{\Delta_0}{\Delta_0 + \Delta_1 + \Delta_2} C_{02} + \frac{\Delta_1}{\Delta_0 + \Delta_1 + \Delta_2} C_{12}$$

Thus, the optimal verdict is $v^{\star}(\{Z, \varnothing\}) = 2$ if and only if

$$\{[(p(0,0) + p(0,1))(1 - \phi_d) + p(0,2)(1 - \phi_p)]C_{02}$$
$$+ [(p(1,0) + p(1,1))(1 - \phi_d) + p(1,2)(1 - \phi_p)]C_{12}\}$$
$$- \{[(p(1,0) + p(1,1))(1 - \phi_d) + p(1,2)(1 - \phi_p)]C_{10}$$
$$+ [(p(2,0) + p(2,1))(1 - \phi_d) + p(2,2)(1 - \phi_p)]C_{20}\}$$
$$\leqslant 0 \tag{10}$$

and

$$\{[(p(0,0) + p(0,1))(1 - \phi_d) + p(0,2)(1 - \phi_p)]C_{02}$$
$$+ [(p(1,0) + p(1,1))(1 - \phi_d) + p(1,2)(1 - \phi_p)]C_{12}\}$$
$$- \{[(p(0,0) + p(0,1))(1 - \phi_d) + p(0,2)(1 - \phi_p)]C_{01}$$
$$+ [(p(2,0) + p(2,1))(1 - \phi_d) + p(2,2)(1 - \phi_p)]C_{21}\}$$
$$\leqslant 0 \tag{11}$$

Under Assumptions 1, 2, 3, and conditions (4), (5), (8), (9), (10), and (11), $\mathcal{E}_1$ is an equilibrium of Γ_1. Uniqueness of equilibrium $\mathcal{E}_1$ is guaranteed by our tie-breaking rule for submission strategies. The above analysis leads to Proposition 1 in Section 3.

Analysis of Γ_2

The Jury's strategies We begin with some observations concerning the jury's verdict strategies. We know that in the game Γ_1 the verdict set is $\{v = 0, v = 1, v = 2\}$ and the equilibrium is $\mathcal{E}_1$. The players' strategies and the verdict decisions in $\mathcal{E}_2$ when the verdict set $\{v = 0, v = 1, v = 2\}$ is generated coincide with those in $\mathcal{E}_1$, and therefore constitute mutual best replies. When the judge upholds the defendant's request for all-or-nothing verdict following a charge of serious crime, the verdict set becomes $\{v = 0, v = 2\}$. Clearly, given the submission strategies of the adversaries, the verdict decisions $\{\sigma = 2\} \rightarrow v = 2$, $\{\sigma = 0\} \rightarrow v = 0$ and $\{Z, \varnothing\} \rightarrow v = 2$ are optimal, by conditions (5), (9), and (10). What remains to be shown is that when the verdict $v = 1$ is excluded, it is optimal for the jury to turn in the verdict of innocence ($v = 0$) rather than guilty of serious crime ($v = 2$) if the defendant submits evidence of moderate crime $\{\sigma = 1\}$ to counter the charge of serious crime. This will be the case if

$$p(1|1)C_{10} + p(2|1)C_{20} \leqslant p(0|1)C_{02} + p(1|1)C_{12}$$

or if

$$\frac{p(2,1) - p(0,1)}{p(1,1)} \leqslant \frac{C_{12} - C_{10}}{C_{20}} \tag{12}$$

Thus, condition (12), which we assume in the following analysis, is necessary for $\mathcal{E}_2$ to be an equilibrium of Γ_2.

The Defendant's strategies Given a charge of serious crime, the defendant's request to exclude the moderate verdict (which the judge upholds), and given the submission strategies of the adversaries according to $\mathcal{E}_2$, it is clear that the defendant has nothing to lose by requesting all-or-nothing verdict: If she has $\sigma = 1$, she will generate $v = 0$ by submitting $\{\sigma = 1\}$; if she has $\sigma = 0$, she can always generate

the verdict $v = 0$ by submitting $\{\sigma = 0\}$; if she has $\sigma = 2$, the verdict will be $v = 2$ in any case (because the signals are perfectly correlated, the prosecution either observes $\sigma = 2$ or has only the default evidence Z, and the submissions $\{\sigma = 2\}$ and $\{Z, \varnothing\}$ both generate $v = 2$ whether or not $v = 1$ is included in the verdict set); if the defendant has no powerful evidence contrary to the charge so that she can submit only $\varnothing$, the verdict will be $v = 2$ according to the submission strategies in $\mathcal{E}_2$ (the prosecution will stay with his default submission Z unless he has the signal $\sigma = 2$). Thus, requesting all-or-nothing verdict in the face of a charge of serious crime is optimal.[16]

The Prosecution's strategies   There are four possibilities:

(i) The prosecution has $\sigma = 2$. In this trivial case the prosecution can always induce the verdict $v = 2$ by bringing the warranted charge of serious crime and submitting $\{\sigma = 2\}$, whether or not the defendant requests all-or-nothing verdict.

(ii) The prosecution has $\sigma = 1$. Recall, the prosecution attaches probability $0 < \phi_d < 1$ that the defendant too has the signal $\sigma = 1$. Given the submission strategies of the defendant and the jury's verdict decisions in $\mathcal{E}_2$, and given that the judge will uphold the all-or-nothing verdict request, the prosecution's expected payoff from charging the serious crime based on the default evidence Z is $\phi_d \cdot X_p(0) + (1 - \phi_d) \cdot X_p(2)$, whereas a charge of moderate crime and submitting $\{\sigma = 1\}$ generates the verdict $v = 1$ and the payoff $X_p(1)$. Hence, under All-or-nothing provision, the prosecution will bring a charge of moderate crime and submit truthfully the signal $\sigma = 1$ if and only if

$$X_p(1) > \phi_d \cdot X_p(0) + (1 - \phi_d) \cdot X_p(2)$$

i.e. if and only if
$$\phi_d > \frac{X_p(2) - X_p(1)}{X_p(2) - X_p(0)} \equiv \phi^\star \tag{13}$$

(Note that $\phi^\star < 1$ because $X_p(0) < X_p(1), X_p(2)$.) These observations are formally noted in Proposition 2.

(iii) The prosecution has $\sigma = 0$. The prosecution's optimal submission strategy is now to stay with the default submission Z. If the defendant also has $\sigma = 0$, she will submit $\{\sigma = 0\}$ and induce $v = 0$ independent of the charge and the jury's verdict set. If the defendant fails to obtain this signal, she can only submit $\varnothing$. The $\{Z, \varnothing\}$ submissions under a charge of serious crime still generate $v = 2$, whereas a charge of moderate crime can induce only $v = 0$ or $v = 1$. Therefore bringing the charge of serious crime on observing $\sigma = 0$ is a weakly dominating strategy for the prosecution.

(iv) The prosecution has only the default evidence Z. Now the prosecution does not know what evidence, if any, the defendant has. If the prosecution brings the charge of serious crime according to $\mathcal{E}_2$, the defendant will request all-or-nothing verdict and the judge will accept. The verdict will then be $v = 2$ if the defendant has $\sigma = 2$ or has only $\varnothing$ (the probability of this event is $\phi_d \cdot \sum_s p(s, 2) + 1 - \phi_d$), and the verdict will be $v = 0$ if the defendant has $\sigma = 1$ or $\sigma = 0$ (the probability of this event is $\phi_d \cdot (1 - \sum_s p(s, 2))$).

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[16] For this reason, on receiving the all-or-nothing verdict request the judge's posterior beliefs about the defendant's signal observation remain unchanged.

If the prosecution brings the charge of moderate crime, the verdict will be $v = 0$ if the defendant has $\sigma = 0$ (which happens with probability $\phi_d \cdot \sum_s p(s, 0)$) and, let us assume so, $v = 1$ otherwise (which happens with probability $\phi_d \cdot (1 - \sum_s p(s, 0)) + 1 - \phi_d$).[17] Therefore the prosecution will bring the charge of serious crime under the following (sufficient) condition

$$\left[\phi_d \cdot \sum_s p(s, 2) + (1 - \phi_d) \right] X_p(2) + \phi_d \cdot \left(1 - \sum_s p(s, 2) \right) X_p(0)$$

$$> \left[\phi_d \cdot \left(1 - \sum_s p(s, 0) \right) + (1 - \phi_d) \right] X_p(1) + \phi_d \cdot \left(\sum_s p(s, 0) \right) X_p(0)$$

which, by adding and subtracting $X_p(0)$ from the L.H.S. and rearranging, can be expressed as

$$\frac{X_p(2) - X_p(0)}{X_p(1) - X_p(0)} > \frac{1 - \phi_d \cdot \sum_s p(s, 0)}{1 - \phi_d \cdot (1 - \sum_s p(s, 2))} \tag{14}$$

Thus the prosecution's charge strategy in $\mathcal{E}_2$ is optimal if (12), (13), and (14) hold.

The Judge's strategies   The judge's strategy in $\mathcal{E}_2$ is to uphold the all-or-nothing verdict request of the defendant charged with serious crime. We have shown above that this strategy has the beneficial effect of deterring the prosecution from bringing an unwarranted charge of serious crime when he observes $\sigma = 1$. However, it also generates a cost. If the prosecution uses the type-Z evidence and brings the charge of serious crime, and if the defendant obtains the signal $\sigma = 1$, requests all-or-nothing verdict and submits $\{\sigma = 1\}$, upholding the request generates the verdict $v = 0$. This verdict is inefficient and is induced because the efficient verdict $v = 1$ is eliminated by the defendant's request. Clearly, only the following two scenarios are relevant in determining the judge's choice:

(i) The defendant fails to observe $\sigma = 1$ but the prosecution observes it;
(ii) The defendant observes $\sigma = 1$ but the prosecution does not.

Define $\alpha(1) = p(0, 1) + p(1, 1) + p(2, 1)$ as the (prior) probability of the signal $\sigma = 1$. According to $\mathcal{E}_2$, thus assuming that (12), (13), and (14) hold, in scenario (i) which happens with probability $(1 - \phi_d)\phi_p \cdot \alpha(1)$, the strategy to uphold the all-or-nothing verdict request induces the verdict $v = 1$ whereas if the judge rejects the request the verdict $v = 2$ is induced. On the other hand, in scenario (ii) which happens with probability $\phi_d(1 - \phi_p) \cdot \alpha(1)$, upholding the request induces the verdict $v = 0$, instead of the ex-post optimal verdict $v = 1$ which is induced if the judge rejects the all-or-nothing verdict request. Thus, the judge's strategy in $\mathcal{E}_2$ generates a benefit in scenario (i), a loss in scenario (ii). For $\mathcal{E}_2$ to be an equilibrium, the judge must find that the expected gains in (i), denoted $\mathcal{G}$, dominate the expected losses in (ii), denoted $\mathcal{L}$. We have

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[17] Assuming the verdict $v = 1$ to be the jury's choice when the defendant charged of moderate crime has $L = 2$ or no evidence to counter the charge, is harmless for our purpose. Taking the most optimistic outcome (from the prosecution's point of view) $v = 1$ for the moderate charge, we derive a sufficient condition (14) such that the serious charge turns out to be a better alternative when the prosecution has only the default evidence Z. If this condition holds but $v = 0$ is the jury's choice, bringing the charge of serious crime will still dominate bringing the moderate charge. While the precise optimal verdict can easily be derived by following a procedure similar to the one outlined in the early part of this paper, the extra conditions to be added thereby will be unnecessary for the analysis.

$$\mathcal{G} = (1 - \phi_d)\phi_p \cdot \alpha(1) \cdot [(p(0|1)C_{02} + p(1|1)C_{12}) - (p(0|1)C_{01} + p(2|1)C_{21})]$$
$$\mathcal{L} = \phi_d(1 - \phi_p) \cdot \alpha(1) \cdot [(p(1|1)C_{10} + p(2|1)C_{20}) - (p(0|1)C_{01} + p(2|1)C_{21})]$$

Note that $\mathcal{G} \geqslant 0$ by (7) and $\mathcal{L} \geqslant 0$ by (6). The net expected gain from upholding the all-or-nothing verdict request is $\mathcal{G} - \mathcal{L}$, which will be positive, assuming $\alpha(1) > 0$, if and only if

$$\mathcal{W} \equiv (1 - \phi_d)\phi_p[p(0, 1)(C_{02} - C_{01}) + C_{12}(p(1, 1) - p(2, 1)]$$
$$- \phi_d(1 - \phi_p)[p(2, 1)(C_{20} - C_{21}) + C_{10}(p(1, 1) - p(0, 1)] > 0 \qquad (15)$$

The above analysis leads to Proposition 3.