

# Law Enforcement and Legal Presumptions<sup>1</sup>

Mehmet Bac

*Bilkent University, Bilkent 06533, Ankara, Turkey*

E-mail: [bac@bilkent.edu.tr](mailto:bac@bilkent.edu.tr)

and

Parimal Kanti Bag

*Department of Economics and Finance, Birkbeck College, University of London,*

*7-15 Gresse Street, London, W1T 1LL, United Kingdom*

E-mail: [pbag@econ.bbk.ac.uk](mailto:pbag@econ.bbk.ac.uk)

Received February 9, 2001; revised July 30, 2001

## **Bac, Mehmet, and Bag, Parimal Kanti**—Law Enforcement and Legal Presumptions

We compare two alternative legal presumptions, one more pro-defendant than the other, with the objective of reducing bureaucratic corruption to any target level at minimum social costs, broadly defined to include law enforcement costs, trial costs, and verdict error costs. In the absence of collusion possibilities between law enforcers and offenders, presumption of innocence involves lower social costs for low corruption targets while presumption of guilt has a cost advantage for high corruption targets. Allowing for collusion enlarges the corruption range over which the presumed innocence rule will dominate. However, there are two possible exceptions to this outcome, namely, if the government's law enforcement budget is limited and if the offenders can be penalized only up to a maximum permissible limit. In each of these cases, presumption of guilt may become the cost-effective rule. *J. Comp. Econ.*, December 2001, 29(4), pp. 722–748. Bilkent University, Bilkent 06533, Ankara, Turkey; and Department of Economics and Finance, Birkbeck College, University of London, 7-15 Gresse Street, London W1T 1LL, United Kingdom. © 2001 Elsevier Science

*Journal of Economic Literature* Classification Numbers: D73, D78, K41, K42.

---

<sup>1</sup> We gratefully acknowledge constructive criticisms and suggestions by two anonymous referees of this Journal and the Editor, John Bonin, that led to a substantially modified current version. We also thank Keith Hylton and Eric Posner for their feedback, and the participants in seminars at Bilkent University, Birkbeck College, Erasmus University, University College Dublin, University of Liverpool, and the 2000 Econometric Society World Congress in Seattle. Remaining errors are our own responsibility.

## 1. INTRODUCTION

Most legal systems presume innocence of criminal defendants. The accuser bears the primary responsibility for producing evidence that supports his claim beyond reasonable doubt, which implies a high relative likelihood of guilt to innocence. Although presumption of innocence seems the common practice in criminal law, several countries have promulgated laws that shift the burden of proof to the accused for specific types of crime. Examples abound in anti-corruption legislation.<sup>2</sup> Thailand promulgated a decree in 1975 that stipulated that any unusually wealthy state official would be presumed guilty of abusing his power and duties. Singapore, with the Prevention of Corruption Act of 1960, and Hong Kong, with its Independent Commission Against Corruption adopted by the Legislative Council in 1974, have similar legislation. More than 30 members of the Organization of American States signed a treaty including illicit enrichment provisions to combat transnational bribery in 1996. The view that shifting the burden of proof to the accused will deter corruption is widely held among corruption experts.<sup>3</sup> The logic that underlies this view will be the main subject of our analysis in this paper.

Various questions relating to the standard of proof in trials have been studied in the literature. In the context of civil litigation, Sanchirico (1997) shows that the high evidentiary standards of pro-defendant presumptions economize on litigation costs by filtering out less valuable cases. Shin (1994) provides an analysis of crimes with victims in which an arbitrator determines the standard of proof and adjudicates on the basis of evidences submitted by the adversaries. Rubinfeld and Sappington (1987) and Andreoni (1991) view the court and jury system as one that chooses an optimal standard of proof to minimize an objective function that includes the social costs of type *I* and type *II* errors in convicting or acquitting a defendant. However, the literature ignores for the most part the fact that legal presumptions influence the incentives to commit crimes, in particular, the possibility of collusion between law enforcers and criminals, and law enforcement costs. Recently, Bernardo et al. (2000) and Boyer et al. (2000) analyzed the relationship between standards used in establishing guilt and criminal incentives but they ignore collusion possibilities. Bernardo et al. do not consider the incentive problems in the law enforcement system.<sup>4</sup> The present paper incorporates these

<sup>2</sup> There are also examples of shifts in the opposite direction. In the United States, there have been proposals before the Congress to shift the burden of proof in many tax cases from the defaulting tax-payers to the Internal Revenue Service ("Features of *IRS* overhaul bill," USA TODAY, 07/09/98).

<sup>3</sup> See, for example, Klitgaard (1988, p. 95). Coldham (1995) is a survey and interpretation of anti-corruption laws in Africa. He mentions several provisions under the Kenyan, Zimbabwean, Zambian, and Tanzanian Prevention of Corruption Acts that implicitly or explicitly shift the burden of proof to the civil servant.

<sup>4</sup> Their model is applicable to civil litigation. Davis (1994) and Hay and Spier (1997) analyze burdens of proof in the case of civil litigation. For criminal cases, the extent of the prosecution's burden of proof is the subject of recurrent debates in law journals. Solan (1999) provides a recent view and assessment.

elements and offers several new insights into whether a state, through its legislators, should set high or low standards of proof in apprehending and convicting potential criminals.<sup>5</sup>

Similar to Bernardo et al. and Boyer et al., we focus on the *ex-ante* crime-decision stage as opposed to the *ex-post* trial stage to analyze the role of legal presumptions in crime prevention. We present a principal–supervisor–agent model in which the principal represents the government or legislator, the supervisor represents the law enforcement system, and the agent represents the potential offender. We consider two legal presumptions that attribute different burdens of evidence for production and persuasion to the law enforcement system. We ask whether specific, especially low, crime targets can be implemented under each presumption. Then we evaluate and compare the corresponding implementation costs. The social implementation cost objective function consists of the social cost of the crime net of the benefit of the offender, plus direct law enforcement costs for evidence production and collusion prevention, trial costs, and verdict error costs. To minimize this objective function under each presumption rule, the principal has to take into account the fact that the supervisor's effort, which is needed to detect criminal behavior, is not directly observable. Thus, an incentive-compatible law enforcement effort that implements the crime target must be induced. Moreover, collusion between the supervisor and the agent must be prevented. We also introduce upper bounds on rewards that can be paid to the supervisor and on penalties that can be imposed on the criminal agent and evaluate the impact of these constraints on social costs under each legal presumption.

Our analysis will highlight several important considerations in evaluating legal presumptions. How the social costs of wrongful guilty verdicts compare with those of unpunished offenses is a prime consideration. The larger the cost and probability of a wrongful guilty verdict, the larger the cost advantage of the relatively pro-defendant legal presumption, which generates greater accuracy in adjudication. However, as we show, this conclusion holds only for relatively low crime targets. On the other hand, stringent evidence standards of strongly pro-defendant presumptions should feed back to individual incentives to commit crimes<sup>6</sup> and

<sup>5</sup> For clarification, we say that a legal presumption is more pro-defendant than another if it bears a heavier burden of proof, both for the production and persuasion, on the accuser by setting a higher threshold relative likelihood of guilt to innocence for convictions. The concepts of legal presumption and burden of proof are neither identical nor unrelated. In *A Dictionary of Modern Legal Usage*, Garner (1995, p. 121) defines the burden of proof in two categories, the burden of production to mean "the duty of producing evidence . . . to have a given issue considered in the case," and the burden of persuasion to mean the burden of "convincing the fact-finder to view the facts in a way that favors" one's claim. Legal presumption, on the other hand, is "a judicially applied prediction or legal probability." Thus, if legal presumption is modified to favor further the defendant, the accuser's task of producing evidence and persuading the fact-finder is relatively difficult so that his burden of proof is heavy. In this case, we say that the burden of proof is shifted to the accuser.

<sup>6</sup> That greater accuracy in adjudication has a deterrent effect is well known (Kaplow (1994, 1998), Posner (1999)). However, the impact of legal presumptions on criminal deterrence is not so clear.

thus make evidence production relatively costly. However, when the presumption of innocence is relaxed, both the guilty and the innocent are punished more often. If the consequent increase in the probability of wrongful convictions relative to accurate convictions is large, accuracy of adjudication falls and so does the opportunity cost of becoming a criminal. Furthermore, if this incentive effect cannot be countered by modifying penalties accordingly, for example, if penalties are already set at the highest level permissible by law, constitutional or human rights considerations, it generates an increase in law enforcement costs. The third and equally important channel through which legal presumptions influence criminal incentives is the possibility of collusion.<sup>7</sup> The prospect of a conviction may prompt the potential felon to make a side payment to the law enforcer at an early stage prior to the criminal act so that committing a crime is a safe option and otherwise at the post-detection stage, in which evidence is produced, to avoid punishment. A fourth consideration is the government's ability or inability to credibly promise sufficiently high rewards to motivate effectively law enforcers.

The paper is organized as follows. The next section presents the model. In Section 3, we compare two legal presumptions by allowing for collusion and assuming unbounded rewards. These assumptions are relaxed in Section 4. Section 5 presents a summary and discussion of our results and concludes.

## 2. THE MODEL

We consider a three-layer hierarchy consisting of a principal, a supervisor, and an agent, all of whom risk-neutral, and in which the supervisor's and the agent's outside options are normalized to zero. The principal represents the government, the supervisor represents the law enforcement system, i.e., the chain from police to prosecution or an auditor who may be either a government official or entirely independent, and the agent is the potential offender.

We consider the crime to be corruption. The agent is a civil servant or bureaucrat and the potential crime is a violation of duty for private gain, such as fraud, spying for foreign secret services, or money laundering. The agent, to whom the principal delegates authority, can misuse authority for a private gain of  $z$

<sup>7</sup> Becker and Stigler (1974) is the first formal analysis of *ex-post* collusion in law enforcement. Collusion cannot be ignored, judging by the evidence from many regions of the world. In 1989, 21% of bribery occurred within the law enforcement sector in one Chinese city, according to Li and Hung (1998). Klitgaard (1988, pp. 98–100) provides striking accounts of internal corruption in the Hong Kong Police Department during the 1960's and 1970's. Many recent instances of police corruption can be found on the internet. For an authentic account of the police's involvement with a group of criminals, namely, drug-dealers in the United States, see May 1998 General Accounting Office, General Government Division (B-277817) report, "Law Enforcement: Information on Drug Related Police Corruption." In particular, see Appendix III: Examples of publicly disclosed investigations of drug-related police corruption in large cities between 1988 and 1998. These are available at <http://www.druglibrary.org/schaffer/govpubs/gao/gg98111.pdf>. For an extensive discussion and analysis of a judicial corruption case in the seventh circuit, Cook County, see DiBiagio (1998).

dollars, that is, choose to be corrupt ( $\hat{b} = 1$ ) or remain honest ( $\hat{b} = 0$ ), with  $z$  being common knowledge. We take the agent's, possibly mixed, strategy  $b \in [0, 1]$ , i.e., his likelihood of being corrupt, as a proxy for the level of corruption. The supervisor's task is to monitor the agent, collect evidence, and, if any, submit it to the principal. The principal can observe neither the supervisor's monitoring effort nor the outcome of monitoring, nor whether the supervisor and the agent collude.<sup>8</sup> While the disputable issue under the supervisor's investigation and the collected evidence, if any, are about occurrence of corruption, the implementation objective of the principal concerns the unobservable, hence nonverifiable, level of corruption.

The following evidentiary standards are assumed to be common knowledge. The first type of evidence is high quality (type- $h$ ), in that it provides very strong support for the hypothesis that the agent is corrupt, i.e., that  $\hat{b} = 1$  is realized. The second type of evidence is considered as suggestive, low quality (type- $l$ ) evidence of corruption.<sup>9</sup> Type- $h$  and type- $l$  evidence are potentially admissible in courts, a choice we leave to the principal. Evidence of quality lower than type- $l$  is never admitted in court, hence, it cannot be used to penalize the agent. We consider any such evidence to be equivalent to no evidence. Below, we link type- $h$  and type- $l$  evidence to legal presumptions and the burden of proof.

The supervisor uses the following technology to generate evidence. Given a monitoring effort  $m$ , with probability  $1 - \mu(m)$ , the supervisor is not able to obtain any evidence. Regardless of the agent's action, the supervisor receives no useful information. With probability  $\mu(m)$ , monitoring results in some evidence but the likelihood of its quality, type- $h$  or type- $l$ , will depend on the agent's action. If the agent is guilty, i.e.,  $\hat{b} = 1$ , the supervisor generates evidence of type  $e = h, l$  with probability  $p_g^e$ , where  $p_g^h + p_g^l = 1$ . The corresponding probabilities if the agent is innocent, i.e.,  $\hat{b} = 0$  are  $p_i^h$  and  $p_i^l$ , with  $p_i^h + p_i^l = 1$ .

We assume that  $p_g^h > p_i^h$  so that high quality evidence is more likely when the agent is guilty rather than innocent. We make two further sets of assumptions. First, to reduce notational burden, we assume that  $p_i^h = 0$  so that  $p_i^l = 1$  and  $0 < p_g^h < 1$ , which makes type- $h$  evidence, if produced, proof of guilt or corruption. None of our qualitative results depends on this normalization; all that is needed is for type- $h$  evidence to be relatively more informative.<sup>10</sup> Second,  $0 < p_g^l < 1$ , so that

<sup>8</sup> Three-layer hierarchies in economic models that allow for the possibility of side contracts were introduced formally by Tirole (1986; 1992).

<sup>9</sup> A type- $h$  evidence could be having the agent on video handing over a roll of cash. Type- $l$  evidence can be thought of as a consistent story of corruption, a noisy collection of facts that reasonably support the hypothesis that the agent is corrupt.

<sup>10</sup> The following conditional probabilities are easily verified.  $\text{Prob}(\text{agent is guilty} \mid \text{evidence is type-}h) = 1$  and  $\text{prob}(\text{agent is guilty} \mid \text{evidence is type-}l) = bp_g^l / (bp_g^l + (1 - b)) < 1$ . On the other hand,  $\text{prob}(\text{agent is innocent} \mid \text{evidence is type-}h) = 0$  and  $\text{prob}(\text{agent is innocent} \mid \text{evidence is type-}l) = (1 - b) / (bp_g^l + (1 - b)) > 0$ . Therefore, type- $h$  evidence is more informative than type- $l$  evidence. The only result that would be affected if we drop the normalization is Lemma 3.

with evidence of low quality the possibility that the agent is guilty cannot be ruled out.

Given the agent's corruption strategy  $b$  and the supervisor's effort  $m$ , if the supervisor and the agent do not collude, the supervisor will produce type- $h$  evidence with probability  $b\mu(m)p_g^h$  and type- $l$  evidence with probability  $b\mu(m)(1 - p_g^h) + (1 - b)\mu(m)$ . The supervisor's cost of exerting effort  $m$  is  $c(m)$ , which is twice continuously differentiable, increasing and weakly convex in  $m$ , with  $c(0) = 0$  and  $c'(m) \rightarrow 0$  as  $m \rightarrow 0$ . The success probability of monitoring,  $\mu: [0, m^+) \rightarrow [0, 1)$ , is also twice continuously differentiable, increasing and strictly concave in  $m$ , with  $\mu(0) = 0$ ,  $\mu'(m) \rightarrow \infty$  as  $m \rightarrow 0$ , and  $\mu'(m) \rightarrow 0$  as  $m \rightarrow m^+$ . These assumptions guarantee that the supervisor will exert a positive effort, given a positive reward for conviction, and that the equilibrium effort will be bounded away from  $m^+$  for any finite reward.<sup>11</sup>

In criminal cases, the burden is on the prosecution or supervisor to produce the evidence that establishes his claim beyond reasonable doubt. When the prosecution produces the evidence, the burden shifts to the accused to persuade the tribunal that the claim does not hold beyond reasonable doubt. The weight of the prosecution's burden of proof, or the level of doubt considered to be reasonable, is determined in our model by the principal. We consider two choices based on the classification of evidence.

A heavy burden of proof stipulates tight screening. The presumption is strongly pro-defendant so that the supervisor must have type- $h$  evidence at hand because courts will reject accusations based on type- $l$  evidence. We refer to this case as presumption  $\mathcal{I}$ , or, loosely, the presumed innocence rule. Under presumption  $\mathcal{G}$ , or the presumed guilt rule, the agent's or the defendant's burden of proof is relatively heavy. When the supervisor submits type- $l$  evidence, the agent is presumed guilty so that guilt is established unless the agent disproves the accusation. Recall that, under presumption  $\mathcal{I}$ , type- $h$  evidence proves guilt by assumption; hence, it cannot be contested. Under presumption  $\mathcal{G}$ , type- $l$  evidence can be challenged and disproved by the agent. We assume that an innocent agent has a better chance of creating enough doubt of guilt to induce acquittal, with probability  $r_i$ , than a guilty agent, with probability  $r_g$ ; so we let  $0 < r_g < r_i < 1$ .

A trial that meets the standard of admissible evidence of presumption  $j = \mathcal{I}, \mathcal{G}$ , costs  $L^j$ . The agent is tried, under presumption  $\mathcal{I}$ , with probability  $b\mu(m)p_g^h$  and,

<sup>11</sup> The supervisor's *ex-ante* efforts in controlling corruption is what is known in the literature as enforcement by monitoring (Mookherjee and Png, 1992). The method of enforcement, that is, whether the supervisor's effort is interpreted as an examination of an individual's possible involvement in some corrupt activity yet unobserved, or whether it is interpreted as an investigation to determine who might be involved in a known corruption scandal is immaterial for the analysis. *Ex-ante*, the supervisor does not know whether the particular individual is corrupt, or what type of evidence he will be able to collect, if any. As Kaplow and Shavell (1994) show, investigation and examination may differ in costs and may have differential effects on behavior if individuals are allowed to report their own criminal acts. We do not pursue this line of analysis.

under presumption  $\mathcal{G}$ , with probability  $\mu(m)$ .<sup>12</sup> Thus, expected trial costs are

$$EL^{\mathcal{I}} = b\mu(m)p_g^h L^{\mathcal{I}} \quad \text{and} \quad EL^{\mathcal{G}} = \mu(m)L^{\mathcal{G}}.$$

Notice that, given  $b$  and  $m$ ,  $EL^{\mathcal{I}} < EL^{\mathcal{G}}$  if  $L^{\mathcal{I}} = L^{\mathcal{G}}$  because the parties are more likely to end up in the courtroom under presumption  $\mathcal{G}$ . Expected trial costs under presumption  $\mathcal{G}$  would be even higher if  $L^{\mathcal{I}} < L^{\mathcal{G}}$ , i.e., a trial would cost less under presumption  $\mathcal{I}$  because the verdict would take less time and resources when screening is tight and the court admits only high quality evidence. In the analysis, we assume that  $L^{\mathcal{I}} \leq L^{\mathcal{G}}$ .

An incentive scheme under presumption  $j = \mathcal{I}, \mathcal{G}$  is denoted by  $\langle w_A^j, w_S^j, R^j, F^j \rangle$ . It consists of a pair of base wages,  $w_A^j$  and  $w_S^j$ , respectively, for the agent and the supervisor, a reward  $R^j$  for the supervisor upon conviction of the agent's guilt, and a penalty  $F^j$  imposed on the agent for being found guilty. The supervisor's reward,  $R^j$ , depends on the type of evidence used in establishing guilt, so  $R^j = R_h^j$  or  $R_l^j$  for evidence of type  $h$  or  $l$ .<sup>13</sup>

Let  $ER^j$  and  $EF^j$  denote the principal's expected reward payments and the expected penalty or fine costs of the agent, respectively. The penalty  $F^j$  may be monetary or non-monetary. We assume that the penalty is a fine and that it accrues to the principal. On the other hand, nonmonetary penalties do not appear directly in the principal's objective function. This difference is inconsequential for the comparative analysis in this paper because the relevant component of the principal's objective is the wage paid to the agent less the expected fine collection, which is zero for nonmonetary penalties. This component will always amount to the same value because of the agent's participation constraint.

The expected social cost of verdict errors is denoted  $CVE^j$ . We have  $CVE^{\mathcal{I}} = \pi_u^{\mathcal{I}} C_u$  and  $CVE^{\mathcal{G}} = \pi_u^{\mathcal{G}} C_u + \pi_w^{\mathcal{G}} C_w$ , where  $C_u$  and  $C_w$  denote the social cost of unpunished offenses and wrongful convictions, respectively, and  $\pi_u^j$  and  $\pi_w^j$  are the corresponding probabilities. Thus,

$$CVE^{\mathcal{G}} = \bar{b}[1 - \mu(m) + \mu(m)p_g^l r_g]C_u + (1 - \bar{b})\mu(m)p_i^l(1 - r_i)C_w,$$

and

$$CVE^{\mathcal{I}} = \bar{b}[1 - \mu(m) + \mu(m)p_g^l]C_u.$$

Given the same law enforcement effort, a wrongful conviction is less likely under

<sup>12</sup> That the probability of a trial under presumption  $\mathcal{G}$  does not depend on the agent's action is an artifact of our simplifying assumptions; it should not be interpreted literally. The basic idea is that, under presumption  $\mathcal{G}$ , the standard of admissible evidence is weak so that the agent, whether guilty or innocent, faces a relatively large probability of being tried.

<sup>13</sup> Our results are not affected if we assume that the supervisor is rewarded for simply bringing in evidence, nor if we assume that the principal cannot distinguish between the two types of evidence and that the supervisor receives a single reward. The proof is available on request.

the presumption of innocence and an unpunished offense is less likely under the presumption of guilt.<sup>14</sup>

Let  $\Gamma$  denote the social costs of the corruption under consideration, which may consist of the loss of public confidence in bureaucracy, lost opportunities and economic distortions. Also, let

$$LEC^j = w_A^j + w_S^j + ER^j - EF^j \quad (1)$$

denote law enforcement costs that exclude trial costs. Then, the overall social costs of implementing any  $\bar{b}$  can be written as

$$TC^j = g(LEC^j + EL^j) + CVE^j + \bar{b}\Gamma, \quad (2)$$

where  $g(\cdot)$  represents the social costs of public funds, which measures potentially distortionary taxation and other social opportunity costs of financing law enforcement and litigation. Note that, if a presumption rule has a cost advantage in implementing a target corruption level for the linear specification  $g(x) = x$ , it continues to have a cost advantage under any weakly convex  $g(x)$ .<sup>15</sup> Therefore, we choose the linear form,  $g(LEC^j + EL^j) = LEC^j + EL^j$ .

The agent's expected benefit  $\bar{b}z$  from corruption will appear as a negative item in the  $LEC^j$  component of Eq. (2), once the agent's participation constraint is taken into account. Thus, it is not included separately to avoid double counting. For any given corruption target  $\bar{b}$ , the cost  $\bar{b}\Gamma$  is fixed and may be ignored, as we do below, in the cost minimization exercise.

For any given corruption target  $\bar{b}$ , under each presumption rule  $j$ , the principal would like to minimize

$$TC^j = LEC^j + EL^j + CVE^j, \quad (3)$$

subject to the moral hazard constraint in law enforcement, participation constraints and collusion-proofness constraints. These constraints are formulated below.

The sequence of events in the model is as follows. Given a corruption target  $\bar{b}$ , the principal determines the legal presumption,  $\mathcal{I}$  or  $\mathcal{G}$ , and a corresponding incentive scheme. If the supervisor and the agent both accept the incentives scheme, the game proceeds to the *ex-ante* collusion stage in which the agent may offer a side payment to the supervisor to avoid being monitored. If the supervisor is not collusive or they do not collude, the two parties play a monitoring-corruption game in which the supervisor determines his effort  $m$  and the agent determines simultaneously his corruption strategy  $b$ . Once the equilibrium strategies are played and the outcome  $(\hat{\mu}, \hat{b})$  is observed, another occasion for collusion arises *ex-post*,

<sup>14</sup> Under our assumptions,  $\pi_w^{\mathcal{I}} = 0$ ,  $\pi_w^{\mathcal{G}} > 0$ ; hence,  $\pi_w^{\mathcal{G}} > \pi_w^{\mathcal{I}}$  and  $\pi_u^{\mathcal{I}} > \pi_u^{\mathcal{G}} > 0$ .

<sup>15</sup> Weak convexity of  $g(\cdot)$  would account for nondecreasing marginal social opportunity cost of funds.



when the supervision generates evidence of type- $l$  or type- $h$ . If the supervisor is collusive, the agent may make a side payment to the supervisor in return for the destruction of the evidence. In the final stage, the supervisor submits his evidence to the principal, the agent may or may not be tried and, if tried, be convicted or acquitted. In this stage, the principal applies the incentive scheme to determine the payoffs for all parties.

Given an incentive scheme, let  $U_i^j$  be the *ex-ante* expected utility of  $i = A, S$  under presumption  $j = \mathcal{I}, \mathcal{G}$ .

The agent's expected utility and participation constraint can be written as<sup>16</sup>

$$U_A^j = w_A^j + bz - EF^j(b, m) \geq 0, \quad (4)$$

where,

$$EF^{\mathcal{I}}(b, m) = bp_g^h \mu(m) F^{\mathcal{I}}, \quad \text{and}$$

$$EF^{\mathcal{G}}(b, m) = [b(p_g^h + (1 - p_g^h)(1 - r_g)) + (1 - b)(1 - r_i)] \mu(m) F^{\mathcal{G}}.$$

The supervisor's expected utility and participation constraint is

$$U_S^j = w_S^j + ER^j(b, m) - c(m) \geq 0, \quad (5)$$

where,

$$ER^{\mathcal{I}}(b, m) = bp_g^h \mu(m) R^{\mathcal{I}}, \quad \text{and}$$

$$ER^{\mathcal{G}}(b, m) = b[p_g^h R_h^{\mathcal{G}} + (1 - p_g^h)(1 - r_g) R_l^{\mathcal{G}}] \mu(m) + (1 - b)(1 - r_i) \mu(m) R_l^{\mathcal{G}}.$$

Initially, ignore collusion possibilities or suppose that the supervisor is not collusive. In the monitoring-corruption game, the agent and the supervisor determine noncooperatively the strategies  $b \in [0, 1]$  and  $m \geq 0$ . Thus, to implement a corruption target  $\bar{b} \in (0, 1)$ , the incentive scheme must ensure not only that the Nash equilibrium strategy of the agent is  $\bar{b}$ , but also that the effort level  $m$  constitutes the supervisor's best reply to the agent's strategy  $\bar{b}$ .<sup>17</sup>

<sup>16</sup> We make the simplifying assumption that  $L^j$  is borne by the principal, which is mostly innocuous because any trial cost borne by the agent will ultimately be incurred by the principal due to the binding participation constraint of the agent. The same reasoning holds for the supervisor.

<sup>17</sup> Note that we have ignored two extremes,  $\bar{b} = 0$  and  $\bar{b} = 1$ . No principal should care about implementing  $\bar{b} = 1$ . On the other hand,  $\bar{b} = 0$  cannot be Nash implemented under presumption  $\mathcal{I}$ . The supervisor's best reply to  $b = 0$  is  $m = 0$  but  $b = 0$  is not a best reply to  $m = 0$  because type- $h$  evidence cannot be produced. Under presumption  $\mathcal{G}$ , implementing  $\bar{b} = 0$  is, in principle, possible. However, if the agent is induced to choose  $b = 0$  in equilibrium, it is common knowledge that the agent is honest. Therefore, any accusing report, which must contain only type- $l$  evidence, must be false and there is no reason to punish the agent.

The first equilibrium condition is that the penalty  $F^j$  establish the agent's indifference between  $b = 1$  and  $b = 0$ , given monitoring effort  $m$ . Using (4) and depending on the presumption  $j = \mathcal{I}$  or  $\mathcal{G}$ , the indifference condition is expressed as

$$F^{\mathcal{I}} = \frac{z}{p_g^h \mu(m)} \quad \text{or} \quad F^{\mathcal{G}} = \frac{z}{[p_g^h + (1 - p_g^h)(1 - r_g) - (1 - r_i)]\mu(m)}. \quad (6)$$

The second equilibrium condition is that the supervisor be induced to exert the effort  $m$ , to which the agent's strategy  $\bar{b}$  is a best reply. Using (5), we obtain the first-order condition

$$\bar{b} p_g^h R^{\mathcal{I}} = \frac{c'(m)}{\mu'(m)}, \quad (7\mathcal{I})$$

under presumption  $\mathcal{I}$ , and

$$\bar{b} [p_g^h R_h^{\mathcal{G}} + (1 - p_g^h)(1 - r_g)R_i^{\mathcal{G}}] + (1 - \bar{b})(1 - r_i)R_i^{\mathcal{G}} = \frac{c'(m)}{\mu'(m)}, \quad (7\mathcal{G})$$

under presumption  $\mathcal{G}$ . It is easy to check that, given  $\bar{b} \in (0, 1)$ , a higher monitoring effort can be induced by increasing the reward(s)  $R^j$  through (7 $\mathcal{I}$ ) or (7 $\mathcal{G}$ ) and decreasing the penalty  $F^j$  through (6) at the same time. Thus, if collusion is not an issue and rewards and penalties are not bounded from above, the principal can induce any effort level by using the two instruments,  $F^j$  and  $R^j$ .

When the supervisor is collusive, we assume that the supervisor and the agent collude whenever the corresponding expected surplus is strictly positive.<sup>18</sup> Denote by  $\tilde{U}_i^j$  the gross expected utility of  $i = A, S$  from *ex-ante* collusion. The surplus from *ex-ante* collusion is negative if

$$U_S^j - \tilde{U}_S^j \geq \tilde{U}_A^j - U_A^j.$$

Under *ex-ante* collusion, the supervisor exerts no effort so that the agent will optimize by setting  $\bar{b} = 1$  and obtain the payoff  $\tilde{U}_A^j = z + w_A^j$ . The supervisor's expected utility is given by (5), if the parties do not collude, and by  $\tilde{U}_S^j = w_S^j$ , if they collude. Therefore, the *ex-ante* collusion-proofness constraint is

$$ER^j(\bar{b}, m) - c(m) \geq w_A^j + z - U_A^j, \quad j = \mathcal{I}, \mathcal{G}. \quad (8)$$

<sup>18</sup> One way of introducing the costs of enforcing collusive agreements would be to assume, as in Tirole (1992), that each dollar of side payment from the agent is worth  $0 < t < 1$  dollars to the supervisor. All our qualitative results will hold under this or any alternative formulations that also include fixed costs of collusion. We prefer the simpler exposition.

Hence, the supervisor's net expected surplus from monitoring must be at least equal to  $z + w_A^j - U_A^j$ , which is the maximum side payment that the agent is willing to pay in order to avoid being monitored.

The *ex-post* collusion-proofness constraint is relatively straightforward. To ensure that the supervisor reports the evidence produced, type-*h* or type-*l*, the corresponding reward should not fall below the agent's expected penalty:<sup>19</sup>

$$R^{\mathcal{I}} \geq F^{\mathcal{I}}, \quad R_h^{\mathcal{G}} \geq F^{\mathcal{G}}, \quad R_l^{\mathcal{G}} \geq (1 - r_g) \cdot F^{\mathcal{G}}. \quad (9)$$

### 3. COMPARING SOCIAL COSTS OF PRESUMPTION RULES

Consider the principal's problem of determining the presumption rule that lowers corruption to any target level  $\bar{b} \in (0, 1)$  at minimum social cost. Solving this problem involves first determining an optimal monitoring effort  $m$  under each presumption rule through an incentive mechanism and then comparing overall social costs in Eq. (3) to obtain the minimum.

As a first step, we consider the sub-problem of minimizing only law enforcement costs,  $LEC^j$ , under the same set of constraints. This exercise will highlight the impact of collusion possibilities and provide a useful benchmark for later analysis.

**LEMMA 1.** *Suppose that the rewards paid for successful evidence production and the penalties imposed on the convicted are not bounded above and that the supervisor may collude with the agent. If the objective is to minimize law enforcement costs only, any corruption target  $\bar{b} \in (0, 1)$  can be implemented under either legal presumption, but minimized law enforcement costs will be lower under presumption  $\mathcal{I}$ .*

*Law enforcement costs for each presumption will be minimized by inducing a unique minimal enforcement effort,  $m_z^j$ , that is necessary and sufficient to satisfy the ex-ante collusion-proofness constraint, with  $m_z^{\mathcal{I}} < m_z^{\mathcal{G}}$  and hence  $c(m_z^{\mathcal{I}}) < c(m_z^{\mathcal{G}})$ .*

*The minimized law enforcement costs are:  $LEC^j = c(m_z^j) - \bar{b}z$ , for  $j = \mathcal{I}, \mathcal{G}$ .*

The proof is in the Appendix. The incentive scheme that solves the sub-problem of minimizing law enforcement costs makes the participation constraints (4) and (5) of the agent and the supervisor binding, so that  $w_A^j - EF^j(\bar{b}, m) = -\bar{b}z$ , and  $w_S^j + ER^j(\bar{b}, m) = c(m)$ . These expressions lead to the minimized cost expression

<sup>19</sup> We obtained the same qualitative results under the assumption that *ex-post* collusion is impossible to sustain when the supervisor has only type-*l* evidence, possibly because the low quality evidence can be reproduced even after it is destroyed.

<sup>20</sup> The guilty agent's expected penalty is  $F^{\mathcal{G}}$  if the supervisor has type-*h* evidence and  $(1 - r_g) \cdot F^{\mathcal{G}}$  if he has type-*l* evidence. The innocent agent's expected penalty when the supervisor has type-*l* evidence is lower because he can disprove more easily type-*l* evidence, with probability  $r_l > r_g$ .

in Lemma 1, which consists of the supervisor's monitoring cost,  $c(m_z^j)$ , minus the expected social benefit of the crime,  $\bar{b}z$ .

Lemma 1 shows that collusion prevention costs are higher under presumption  $\mathcal{G}$ . The surplus from *ex-ante* collusion is larger because the agent is willing to make a larger side payment in order to avoid being monitored, and convicted with a higher probability, under presumption  $\mathcal{G}$ . To have the supervisor reject such a side payment, the principal increases the expected reward payments to induce a higher monitoring effort  $m_z^{\mathcal{G}} > m_z^{\mathcal{I}}$  and higher costs  $c(m_z^{\mathcal{G}}) > c(m_z^{\mathcal{I}})$ . Thus, the need to prevent collusion indirectly increases the resources that the principal should devote to evidence production relatively more under presumption  $\mathcal{G}$ .<sup>21</sup>

Lemma 1 has an interesting implication. If rewards and penalties are not bounded above and if we ignore the social costs of verdict errors and assume potentially collusive law enforcers, we should adopt pro-defendant legal presumptions regardless of the target level of corruption.<sup>22</sup>

The addition of verdict error costs and trial costs affects the choice between the two presumption rules in a subtle and interesting manner. Expected trial costs should be higher under presumption  $\mathcal{G}$  for any induced monitoring effort because the probability of a trial is relatively high and  $L^{\mathcal{I}} \leq L^{\mathcal{G}}$ . The effect of verdict error costs, on the other hand, is less clear-cut. Presumption of guilt involves relatively more type *I* errors, i.e., punishing the innocent, and fewer type *II* errors, i.e., acquitting the guilty. If  $C_w$  is much larger than  $C_u$ , i.e., if society emphasizes minimizing type *I* errors at the expense of increased type *II* errors, presumption of innocence dominates presumption of guilt.

Recall that expected verdict error costs are

$$CVE^{\mathcal{G}} = \bar{b}[1 - \mu(m) + \mu(m)p_g^l r_g]C_u + (1 - \bar{b})\mu(m)p_i^l(1 - r_i)C_w, \quad \text{and}$$

$$CVE^{\mathcal{I}} = \bar{b}[1 - \mu(m) + \mu(m)p_g^l]C_u.$$

Using these and the expressions for expected trial costs, we have

$$CVE^{\mathcal{G}}(m) + EL^{\mathcal{G}}(m) < CVE^{\mathcal{I}}(m) + EL^{\mathcal{I}}(m),$$

<sup>21</sup> Increases in the costs of producing evidence due indirectly to the sole purpose of eliminating collusion possibilities are called collusion prevention costs. In the absence of upper bounds on penalties and if collusion can be ruled out, evidence production costs could be made arbitrarily small by imposing arbitrarily large penalties. If collusion cannot be ruled out, collusion-proofness constraints alone determine monitoring effort and costs, hence we name the term  $c(m_z^j)$  collusion prevention costs.

<sup>22</sup> It can be shown that adding trial costs would not change this conclusion because trial costs are increasing in induced monitoring effort and the principal motivated by minimizing law enforcement costs plus expected trial costs would still induce the minimal effort implied by collusion-proofness and yield lower overall costs under the presumption of innocence. However, adding verdict error costs to the objective function may change this conclusion as we show below.

if and only if

$$\bar{b} > \frac{p_i^l(1 - r_i)C_w + L^G}{p_g^l(1 - r_g)C_u + p_i^l(1 - r_i)C_w + p_g^h L^I} \equiv \bar{b}_1. \tag{10}$$

Assume that  $L^G$  is not too high so that  $\bar{b}_1$  is well-defined and less than one.

Using the agent’s and the supervisor’s participation constraints satisfied with equality, we can write  $LEC^j(m) = c(m) - \bar{b}z$ .<sup>23</sup> Thus, the social cost expression (3) becomes

$$TC^j(m) = c(m) - \bar{b}z + CVE^j(m) + EL^j(m). \tag{11}$$

The following lemma follows directly from (11).

LEMMA 2. *Ignore the collusion possibilities. If any identical monitoring effort  $m$  is induced under the two presumption rules, presumption of guilt will involve strictly lower social costs if and only if  $\bar{b} > \bar{b}_1$ .*

Now let  $m^{j\mathcal{X}}$  minimize the social cost expression (11) under presumption rule  $j$ . That is,

$$\frac{c'(m^{I\mathcal{X}})}{\mu'(m^{I\mathcal{X}})} \geq \bar{b}p_g^h[C_u - L^I], \quad \text{and}$$

$$\frac{c'(m^{G\mathcal{X}})}{\mu'(m^{G\mathcal{X}})} \geq \bar{b}(1 - p_g^l r_g)C_u - (1 - \bar{b})(1 - r_i)p_i^l C_w - L^G,$$

holding with equality if  $m^{j\mathcal{X}} > 0$ .<sup>24</sup> One can check that  $m^{I\mathcal{X}} > m^{G\mathcal{X}}$  if and only if  $\bar{b} < \bar{b}_1$ .

We assume  $C_u > L^I$ , i.e., that the cost of a trial is less than the social cost of letting an offense go unpunished, which implies that  $m^{I\mathcal{X}} > 0$ . However, the right-hand side of the second condition may be negative, which would imply that  $m^{G\mathcal{X}} = 0$ . This leads to the following Lemma on implementation possibilities under the presumption of guilt.

<sup>23</sup> To implement  $\bar{b}$  at minimum social costs, these participation constraints must hold with equality. See the discussion following Lemma 1 or its proof.

<sup>24</sup> By adopting the simple linear form for the function  $g(\cdot)$  in Eq. (2) instead of its general implicit form, we do not alter any of the results qualitatively. Analysis in terms of the implicit form,  $g(\cdot)$ , will lead to similar conditions determining the solutions  $m^{j\mathcal{X}}$ . Equation (11) would be revised to read  $TC^j(m) = g(c(m) - \bar{b}z) + CVE^j(m) + EL^j(m)$ . Since  $g''(\cdot) \geq 0$  and  $-\bar{b}z$  is constant, the first- and second-order properties of  $c(m) - \bar{b}z$  and  $g(m)$  are qualitatively the same.

LEMMA 3. *There exists a critical corruption target*

$$\beta^G \equiv \frac{(1 - r_i)p_i^l C_w + L^G}{(1 - p_g^l r_g)C_u + (1 - r_i)p_i^l C_w} \quad (12)$$

*such that any corruption target  $\bar{b}$  can be implemented under the presumed guilt rule if and only if  $\bar{b} > \beta^G$ .*

We provide a sketch of the proof. It is easy to verify that  $0 < \beta^G < \bar{b}_1$ . The critical  $\beta^G$  sets the right-hand side of the inequality defining  $m^{G,X}$  equal to zero, which implies a positive  $m^{G,X}$  if  $\bar{b} > \beta^G$  and  $m^{G,X} = 0$  if  $\bar{b} \leq \beta^G$ . For low corruption targets, i.e.,  $\bar{b} \leq \beta^G$ , the marginal social cost of effort exceeds the marginal social benefit at any positive effort level. Hence, the likelihood of an offense is low and a conviction based on the low-quality evidence is rather likely to be wrong, which is socially costly. Adding the cost of a trial, the principal would not find it beneficial to induce any monitoring effort. If no monitoring effort is induced, the agent's best response would be to switch to  $b = 1$  and the target corruption level  $\bar{b} \leq \beta^G$  would not be implemented. To implement such low levels of corruption, the principal has no choice but to switch to presumption of innocence.<sup>25</sup> Lemma 3 concerns implementation possibilities only without a consideration of the collusion constraints.

The cost-minimizing effort levels  $m^{IX}$  and  $m^{GX}$  are both unique and positive for  $\bar{b} > \beta^G$  because the objective function (3) is strictly convex in  $m$ . We are now ready to present the first set of results. For these results, we do not impose any upper-bound constraints on rewards or penalties.

PROPOSITION 1. *If the supervisor is not collusive, so that the collusion-proofness constraints do not apply or bind, all corruption targets  $\bar{b} < \bar{b}_1$  can be implemented at smaller overall social costs under the presumed innocence rule. The opposite ranking obtains for  $\bar{b} > \bar{b}_1$ . For  $\bar{b} = \bar{b}_1$ , the two presumption rules will involve the same social costs.*

*Proof.* Consider  $\bar{b} > \bar{b}_1$ . By Lemma 2,  $TC^G(m^{IX}) < TC^I(m^{IX})$ . On the other hand,  $\bar{b} > \bar{b}_1$  implies  $m^{IX} < m^{GX}$ , both of which are strictly positive-valued because  $m^{IX} > 0$ . Since  $m^{GX}$  is the optimal effort under the presume guilt rule,  $TC^G(m^{GX}) \leq TC^G(m^{IX})$ . Thus,  $TC^G(m^{GX}) < TC^I(m^{IX})$ .

Similar arguments apply in the remaining cases,  $\bar{b} < \bar{b}_1$  and  $\bar{b} = \bar{b}_1$ . Q.E.D.

<sup>25</sup> A similar lower bound  $\beta^I$  on implementable corruption targets would arise under presumption of innocence if we drop the normalization assumption that high quality evidence used in establishing guilt is noiseless. However, since high-quality evidence is less noisy than low quality evidence, the probability of punishing the innocent would be smaller under presumption of innocence, which would imply  $\beta^I < \beta^G$ . The range of implementable targets would still be larger under the presumed innocence rule, or, there would be a range of low corruption targets that can be implemented only by presuming innocence.

The result that the overall social costs of implementing high corruption targets are smaller under guilt presumption is quite intuitive. As the probability of an offense goes to one, the probability of a wrongful conviction vanishes under presumption of guilt; however, under presumption of innocence, the probability of an unpunished offense tends to increase. Then, overall social costs of verdict errors tilts the balance in favor of the presumed guilt rule. Note that, by Lemma 3, presumption of innocence is the only alternative for  $\bar{b} \leq \beta^G$ . For  $\bar{b} \in (\beta^G, \bar{b}_1)$ , both rules can be used but presumption of innocence has the cost advantage.

Proposition 1 ignores the possibility of collusion. In the next proposition we show that introducing collusion possibilities generates a bias in favor of presumption of innocence.

**PROPOSITION 2.** *If the supervisor is collusive, all corruption targets  $\bar{b} \leq \bar{b}_1$  can be implemented at smaller overall social costs under the presumed innocence rule. For  $\bar{b} > \bar{b}_1$ , presumption of guilt generates lower social costs if  $m^{G,X} \geq m_z^G$ , that is, if the collusion constraints are not binding. However, if  $m^{G,X} < m_z^G$ , no clear-cut ranking of the two presumption rules can be offered.*

*Proof.* By Lemma 1, we know that a minimal effort  $m_j^I$  must be induced to prevent *ex-ante* collusion under presumption rule  $j$ . Moreover,  $m_z^I < m_z^G$ . By Lemma 3,  $\bar{b} \in (0, \beta^G]$  cannot be implemented by the presumed guilt rule even without imposing the *ex-ante* collusion-proofness constraint. To see whether the presumed innocence rule can implement these targets, we must consider the *ex-ante* collusion-proofness constraint.

Consider  $\bar{b} \in (0, \bar{b}_1]$ . If  $m^{I,X} \geq m_z^I$ , the *ex-ante* collusion-proofness constraint is not binding under presumption of innocence and Proposition 1 would apply, so that the presumed innocence rule would be optimal. On the other hand, if  $m^{I,X} < m_z^I$ , the *ex-ante* collusion-proofness constraint is binding under presumption of innocence so that the principal would induce  $m_z^I$ , which is feasible.<sup>26</sup> In this case, we must also have  $m^{G,X} < m_z^G$  because  $m^{G,X} \leq m^{I,X}$  and  $m_z^I < m_z^G$ . Thus, the *ex-ante* collusion-proofness constraint is binding also under presumption of guilt so that the principal must induce effort  $m_z^G$  for  $\bar{b} \in (\beta^G, \bar{b}_1]$ . We already know that  $\bar{b} \in (0, \beta^G]$  is not implementable. For  $\bar{b} \in (\beta^G, \bar{b}_1]$ ,  $TC^I(m_z^I) < TC^I(m_z^G) < TC^G(m_z^G)$ . The first inequality follows from the fact that  $TC^I(m)$  is increasing in  $m$  the further away we get from unconstrained optimal effort,  $m^{I,X}$ , while the last inequality follows from the assumption that  $\bar{b} \leq \bar{b}_1$ .

Consider  $\bar{b} > \bar{b}_1$ . For any induced effort, implementing any such  $\bar{b}$  by presuming guilt generates lower social costs if the *ex-ante* collusion-proofness constraint is not binding, which is the case presented in Proposition 1. This case will obtain if  $m^{G,X} \geq m_z^G$ . Suppose  $m^{G,X} < m_z^G$  so that the principal must induce the constrained effort solution,  $m_z^G$ , to prevent *ex-ante* collusion. Note that, because  $m_z^I < m_z^G$ , it is possible to have  $m_z^I < m^{I,X}$  while  $m^{G,X} < m_z^G$ . The principal may still be able to

<sup>26</sup> We emphasize feasibility because, under the presumed guilt rule, no positive effort level is feasible.

induce the unconstrained effort solution,  $m^{\mathcal{I}\mathcal{X}}$ , under presumption of innocence, which may yield a lower total social cost than does the constrained effort solution under presumption of guilt. Thus, no clear-cut ranking obtains and the comparison between the two presumption rules depends on whether the optimal effort levels can be induced, or, if not, how far the induced feasible effort lies from the optimal, unconstrained level under each presumption rule, on the specification of the effort cost function  $c(\cdot)$ , on the monitoring technology  $\mu(\cdot)$ , and on other parameters.<sup>27</sup>

Q.E.D.

Introducing the possibility of collusion can only make the case for presumption of innocence stronger and possibly induce the principal to implement even relatively high corruption targets, i.e.,  $\bar{b} > \bar{b}_1$ , through presumption of innocence. This is likely to be the case if the collusion constraint is binding, so that collusion prevention costs are positive under presumption of guilt but not under presumption of innocence. We highlight below the factors affecting  $\bar{b}_1$  that play a crucial role in determining the choice of the presumption rule. Proposition 3 follows directly from the definition of  $\bar{b}_1$  given in (10).

**PROPOSITION 3.** *The critical value for  $\bar{b}_1$  is larger and presumption of innocence becomes the better choice for a wider range of corruption targets, the larger is the social cost and the probability of a wrongful conviction, the smaller is the social cost and the probability of an unpunished offense, and the larger is the cost of a trial under presumption of guilt relative to presumption of innocence.*

The factors mentioned above also affect the lower implementable bound  $\beta^{\mathcal{G}}$  under presumption of guilt, defined, in Lemma 3, in the same way that they affect  $\bar{b}_1$ . Thus, an increase in the accuracy in adjudication implies that relatively high corruption targets are implemented at lower social cost by presuming innocence and, at the same time, the low range  $(0, \beta^{\mathcal{G}})$  of corruption targets that cannot be implemented by presuming guilt is enlarged.

#### 4. LEGAL PRESUMPTIONS UNDER BOUNDED REWARDS AND PENALTIES

In this section, we first introduce a constraint on available resources to motivate law enforcers, maintaining the assumption that they may collude with the bureaucrats, and then we consider the impact of upper bounds on penalties. We show that, in each of these cases, presumption of guilt may become the preferred alternative.

The rewards to motivate law enforcers in gathering type- $h$  evidence can become arbitrarily large, especially as the target level of corruption approaches zero (see the expression of  $R^{\mathcal{I}}$  in the proof of Lemma 1). If the government's law enforcement budget is limited, it will not be credible to promise such large rewards. Let  $\bar{R}$  be the

<sup>27</sup>Note that we do not solve fully for the optimal incentive mechanisms. We only determine the incentives, i.e., the wages, rewards, and penalties, necessary for the comparative analysis in Proposition 2.



maximum reward that the principal can afford. With this upper bound on rewards, the principal may not be able to induce the minimal collusion-proof effort,  $m_z^j$ . Thus, full corruption will occur. We show that the relevance of this undesirable effect depends on the presumption rule.

**PROPOSITION 4.** *Suppose that the supervisor may collude with the agent. There exist lower bounds  $\bar{R}^{\mathcal{G}}$  and  $\bar{R}^{\mathcal{I}}(\bar{b})$  on the maximal reward  $\bar{R}$  such that any corruption target  $\bar{b} \in (\beta^{\mathcal{G}}, 1)$  can be implemented through presumption  $\mathcal{G}$  if and only if  $\bar{R} \geq \bar{R}^{\mathcal{G}}$ , and any corruption target  $\bar{b} \in (0, 1)$  can be implemented through presumption  $\mathcal{I}$  if and only if  $\bar{R} \geq \bar{R}^{\mathcal{I}}(\bar{b})$ .  $\bar{R}^{\mathcal{I}}(\bar{b})$  is decreasing in  $\bar{b}$  and becomes arbitrarily large as  $\bar{b}$  goes to 0. Thus, given any finite  $\bar{R} \geq \bar{R}^{\mathcal{G}}$ , there exists a critical  $\bar{b}_{\mathcal{I}}(\bar{R}) > 0$  such that, if  $\beta^{\mathcal{G}} < \bar{b}_{\mathcal{I}}(\bar{R})$ , the range  $\bar{b} \in (\beta^{\mathcal{G}}, \bar{b}_{\mathcal{I}}(\bar{R}))$  can be implemented only through presumption  $\mathcal{G}$ , while the range  $(0, \beta^{\mathcal{G}}]$ , is not implementable under either presumption rule.*

The proof of Proposition 4 is in the Appendix.

Adopting a pro-prosecution presumption ( $\mathcal{G}$ ) is the only way to implement corruption targets  $\bar{b} \in (\beta^{\mathcal{G}}, \bar{b}_{\mathcal{I}}(\bar{R}))$ , if  $\bar{b}_{\mathcal{I}}(\bar{R})$  exceeds  $\beta^{\mathcal{G}}$ , provided that the maximal reward is bounded above but exceeds  $\bar{R}^{\mathcal{G}}$ . The critical bounds  $\bar{R}^{\mathcal{I}}(\bar{b})$  and  $\bar{R}^{\mathcal{G}}$  are derived from the equilibrium conditions (7I) and (7G). The intuition is as follows. At these bounds, the rewards are just enough to induce the minimal effort  $m_z^j$  that prevents *ex-ante* collusion. The supervisor's expected rewards,  $ER^j$ , depend proportionately on both the corruption target,  $\bar{b}$ , to be implemented and the reward(s),  $R^j$ . When  $\bar{b}$  is low, relatively high rewards should be promised under presumption  $\mathcal{I}$  to induce the minimal collusion-proof monitoring effort. This result follows because the probability of producing high quality evidence and being rewarded is relatively low under presumption  $\mathcal{I}$ . On the other hand, relatively modest rewards induce the appropriate effort given the higher probability of generating at least type- $l$  evidence, which is admissible in court under presumption  $\mathcal{G}$ . Therefore, the reward constraint will provide a stronger incentive with a heavy burden of proof on the supervisor under presumption  $\mathcal{I}$ . This result provides a possible explanation for the choice of several countries that lack the proper resources or have law enforcement agencies that are inept in generating high quality evidence to change legal presumptions and shift the burden of proof to the accused in their fight against corruption. In several developing countries in which human rights are weak, the cost of a wrongful conviction may not be deemed as high as in developed countries. This would imply a low value for  $\beta^{\mathcal{G}}$  in our model and generate a stronger case for the assumption in Proposition 4 that  $\beta^{\mathcal{G}} < \bar{b}_{\mathcal{I}}(\bar{R})$ . In that case, presumption of guilt would be preferred in reducing corruption to levels in the range  $(\beta^{\mathcal{G}}, \bar{b}_{\mathcal{I}}(\bar{R}))$  if rewards are bounded.

To focus on how the choice of the legal presumption is affected when there is a maximum penalty  $\bar{F}$  that can be imposed on the agent, we assume no possibility of collusion. The impact of introducing collusion, as shown in Lemma 1, is to impose a constraint on the minimal effort that must be induced, as  $m \geq m_z^j$ . Since

the introduction of an upper bound on penalties will also impose a lower bound on effort levels, neglecting the possibility of collusion will keep the exposition simple.

Effort levels  $m^{\mathcal{I}\mathcal{X}}$  and  $m^{\mathcal{G}\mathcal{X}}$  are defined as the optimal effort levels to be induced when collusion is impossible or not binding, assuming that there are no limits on the penalties that can be imposed on the convicted agent. If the penalty constraint binds, the principal has no choice but to impose the maximal penalty  $\bar{F}$ , which induces minimal effort levels,  $m^{\mathcal{I}}$  and  $m^{\mathcal{G}}$ , that are determined uniquely through the agent's equilibrium indifference conditions. Hence, we have

$$\frac{z}{\bar{F}} = p_g^h \mu(m^{\mathcal{I}}), \quad \text{and} \quad (13)$$

$$\frac{z}{\bar{F}} = [p_g^h + (1 - p_g^h)(1 - r_g) - (1 - r_i)] \mu(m^{\mathcal{G}}). \quad (14)$$

Clearly,  $m^{\mathcal{G}} < m^{\mathcal{I}}$  if and only if:

$$(1 - p_g^h)(1 - r_g) > 1 - r_i. \quad (15)$$

Intuitively, if switching from the presumed innocence to the presumed guilt rule leads to an increase in the probability of avoiding an unpunished offense, i.e., avoiding a type *II* error, that exceeds the increase in the probability of a wrongful conviction, i.e., committing a type *I* error, the incentives to remain innocent are strengthened. As a result, the same corruption target  $\bar{b}$  can be implemented under presumption  $\mathcal{G}$  through less intensive monitoring. Thus, the impact of introducing a penalty constraint is similar to the effect of introducing the possibility of collusion. Induced effort levels cannot fall below a level  $m^j$ , which is specific to the legal presumption rule  $j$ . If (15) holds (fails), introducing a penalty constraint favors presumption of guilt (innocence). Obviously, if the penalty constraint is not binding, the principal induces the unconstrained optimal effort  $m^{j\mathcal{X}}$  under presumption  $j$ .

**PROPOSITION 5.** *Suppose that the supervisor is noncollusive and that the supervisor's reward is not bounded above. Assume that (15) holds. Then, all  $\bar{b} > \bar{b}_1$  can be implemented at lower social costs under the presumed guilt rule. For  $\bar{b} \in (\beta^{\mathcal{G}}, \bar{b}_1)$ , the targets are implemented at lower social cost by presuming innocence, if the penalty constraint is not binding, i.e., if  $m^{\mathcal{I}\mathcal{X}} \geq m^{\mathcal{I}}$ . No clear-cut ranking of the presumption rules can be offered if  $m^{\mathcal{I}\mathcal{X}} < m^{\mathcal{I}}$ .*

The proof is omitted as it follows the same arguments already made in the proof of Proposition 2.<sup>28</sup> For  $\bar{b} > \bar{b}_1$ , if the penalty constraint is not binding under presumption of guilt, Proposition 1 applies and the principal adopts the presumed

<sup>28</sup> The difference is superficial. Instead of having a minimal effort constraint imposed by collusion-proofness, we have a minimal effort constraint imposed by maximal penalties.

guilt rule by inducing effort  $m^{\mathcal{G}\mathcal{X}}$ . Condition (15), combined with  $\bar{b} > \bar{b}_1$  implying that  $m^{\mathcal{G}\mathcal{X}} > m^{\mathcal{I}\mathcal{X}}$ , guarantees that, if the penalty constraint is binding under presumption of guilt, it must also be binding under presumption of innocence. For  $\bar{b} < \bar{b}_1$ , we cannot provide a clear ranking of the presumption rules unless we know that the penalty constraint is not binding under presumption of innocence. Thus, especially for corruption targets slightly lower than  $\bar{b}_1$ , if the penalty constraint is binding under presumption of innocence, presumption of guilt may generate lower social costs under (15). An intuitive condition in terms of the probabilities of type *I* and type *II* errors was given above.

The importance of the impact of introducing a penalty constraint can be seen from (14). The smaller is the maximal penalty  $\bar{F}$  that can be imposed relative to the private benefit  $z$  accruing to the offender, the more likely is the case that the principal's effort choice will be constrained. Furthermore, the larger is the difference between the left and the right-hand sides of (15), the smaller is  $m^{\mathcal{G}}$  relative to  $m^{\mathcal{I}}$ ; hence, the stronger is the case for presumption of guilt.

## 5. CONCLUSION

The standard approach to determining legal presumptions or the optimal standard of proof in trials uses a framework in which a fact-finder, who is adjudicating a possible crime committed already, minimizes verdict error costs. This paper addresses the problem from a different perspective. We focus on the *ex-ante* stage of corruption prevention and investigate which legal presumption implements a target level of corruption at lower overall social costs. The social costs are broadly defined to include law enforcement costs, trial costs, verdict error costs, and any other net direct losses inflicted on the society. The popular justification for presumption of innocence is that societies attribute a large cost to wrongful convictions relative to unpunished offenses. We show that favoring presumption of innocence can have much larger benefits than just the minimization of verdict error costs, although we also identify limitations of this rule.

Cast in terms of corruption, our analysis applies to any other type of crime with minor qualifications. The main conclusion is that the socially optimal legal presumption rule depends on the targeted crime level. Specifically, for any given crime, a general rule emerges that it is socially less costly to implement high crime levels by presuming guilt and to implement low crime levels by presuming innocence. In our single agent model, a high crime level means the agent commits a specific crime with a probability exceeding some threshold level. Equivalently, our model can be considered to have a continuum of agents in which a high crime level implies that a large fraction of the agent population commits the crime. The exact value of the threshold probability or the population fraction committing the crime that separates high and low levels of crime depends on several variables, namely, the probability and the cost of wrongful convictions and unpunished offenses, whether collusion between law enforcers and potential criminals is possible, the relative

costs of trials, whether rewards for successful law enforcers and penalties on the convicted are bounded from above, and the precision of the evidence admitted in trials to establish guilt under the two legal presumptions.

For corruption, generating high-quality, indisputable evidence of guilt may be very difficult. Relying on such evidence to establish guilt under presumption of innocence would imply a very high probability of unpunished offense. At the same time, it would imply that the probability of a wrongful conviction based on lower quality evidence admissible to court under presumption of guilt is reasonably small. Under these conditions, presumption of guilt becomes the better alternative to implement even intermediate levels of corruption targets. This is the main explanation that our analysis offers for why the less developed countries in which corruption is relatively high have resorted to presumption of guilt more than have the western developed countries in which corruption is relatively low. If the social cost of a wrongful conviction is deemed much smaller in these countries than in western countries, presumption of guilt gains further support. The analysis also provides a plausible explanation for the concerted efforts of several countries to revise and harmonize their legal systems to adopt pro-prosecution legal presumptions in fighting international bribery which is widespread, according to many observers, but was not even recognized as a criminal act until recently (Rose-Ackerman, 1999). Finally, in jurisdictions in which resources to motivate law enforcers are bounded, we show that presumption of guilt may become the only alternative for implementing some intermediate range of corruption targets. A range of very low corruption levels can not be implemented under the presumed guilty rule because the net social marginal benefit of inducing enforcement effort becomes negative due to unacceptably high probability of wrongful convictions. Then, presumption of innocence becomes the only alternative.

We show that the impact of an upper bound on admissible penalties is to introduce a minimal enforcement effort that should be induced. This effort level depends on a simple balance between the likelihood of type *I* and type *II* errors in adjudication. If shifting the burden of proof to criminal defendants increases the probability of avoiding a type *II* error by more than it increases the probability of committing a type *I* error, accuracy in adjudication increases. Hence, a stronger deterrence obtains so that the same crime level can be implemented through a smaller minimal enforcement effort under presumption of guilt. This will be the case if the innocent are more likely than the guilty to disprove an accusation based on the relatively low quality evidence that is admissible under the presumption of guilt. This condition is likely to hold for the crime of corruption. If, in addition, there is an upper bound on penalties, the optimal enforcement effort is more likely to be constrained under presumption of innocence. Then, presumption of innocence may lose its cost advantage over presumption of guilt. This could provide a rationale for the international efforts of the OECD and the Organization of American States to fight corruption by shifting the burden of proof to public officials holding assets in significant excess of their lawful earnings. If innocent officials can disprove such

accusations easily while guilty officials cannot, shifting the burden of proof to the officials can generate cost savings for implementing any given level of corruption.

### APPENDIX

*Proof of Lemma 1.* The principal's problem is to choose  $\langle w_A^j, w_S^j, R^j, F^j \rangle$  to minimize (1) subject to (4), (5), (6), (7I) or (7G) respectively, (8) and (9).

First we check to see if the incentive scheme that minimizes law enforcement costs binds the agent's participation constraint (4). Fix any  $\bar{b} \in (0, 1)$ . Use the equilibrium condition (6) to rewrite (4) as

$$U_A^I = w_A^I; \quad U_A^G = w_A^G - (1 - r_i)\mu(m)F^G.$$

If  $U_A^j > 0$  contrary to our claim,  $w_A^j > 0$ . Then  $w_A^j$  can be lowered to reduce law enforcement costs but still satisfy (4). Thus,  $w_A^I = 0$  and, by (6),  $w_A^G = (1 - r_i)z/[p_g^h + (1 - p_g^h)(1 - r_g) - (1 - r_i)] > 0$ .

Similarly, the supervisor's participation constraint is also binding. Since the supervisor can always choose zero effort, net expected rewards from monitoring, i.e.,  $ER^j(\bar{b}, m) - c(m)$ , are always nonnegative and, as we show below, will be strictly positive. By setting  $w_S^j = c(m) - ER^j(\bar{b}, m) < 0$ ,<sup>29</sup> the principal extracts fully the supervisor's rent. Thus,  $w_S^j$  is determined once the effort level to be induced by the principal is solved in the latter part of this proof.

Given  $\bar{b} \in (0, 1)$ , the supervisor chooses an effort,  $m^*$ , to maximize  $\phi_S(m, \bar{b}) \equiv ER^j(\bar{b}, m) - c(m)$ . Condition (7I), or (6G) respectively, implies that  $m^* > 0$  for  $R^I > 0$  or  $(R_h^G, R_l^G) > 0$ , respectively. The maximized net rewards equal

$$\frac{c'(m^*)}{\mu'(m^*)}\mu(m^*) - c(m^*) > 0.<sup>30</sup>$$

For now, ignore the collusion-proofness constraints (8) and (9). Since the incentive scheme must bind the agent's participation constraint,  $w_A^j - EF^j(\bar{b}, m) = -\bar{b}z$ . Along with  $w_S^j$  derived above, substituting this equation into (1) yields

$$LEC^j(\bar{b}, m) = c(m) - \bar{b}z. \tag{A1}$$

This expression is increasing in  $m$ ; therefore, the principal should induce the lowest effort possible.

<sup>29</sup>The inequality  $w_S^j < 0$  should not be interpreted literally as a negative wage, because the supervisor's outside option is normalized to zero. If the outside option is worth  $\bar{w}$ ,  $w_S^j = \bar{w} + c(m) - ER^j(\bar{b}, m)$ , which can be positive.

<sup>30</sup>That  $\phi_S(m^*, \bar{b})$  will be positive, is easy to show:  $\phi_S(0, \bar{b}) = 0$ , because  $c'(0) = 0$ ,  $\mu'(0) = \infty$  and  $c(0) = 0$ , and then apply the fact that  $\phi_S(m, \bar{b})$  is increasing in  $m$ .

Now introduce the possibility of *ex-ante* collusion. By making appropriate substitutions using the expression of expected rewards in Section 3.1 and (7 $\mathcal{I}$ ) or (7 $\mathcal{G}$ ) in (8), the *ex-ante* collusion-proofness condition (8) can be written in terms of the equilibrium induced effort  $m$  as follows:

$$\frac{c'(m)}{\mu'(m)}\mu(m) - c(m) \geq z + w_A^j. \quad (\text{A2})$$

The penalties are already given by (6) but they depend on an endogenous variable, i.e., the induced effort  $m$  that is to be determined next. To obtain the expression for rewards, which also depend on the induced effort  $m$ , we consider each legal presumption separately.

*Presumption  $\mathcal{I}$ .* Under presumption  $\mathcal{I}$  the principal promises the supervisor a single reward  $R^{\mathcal{I}}$  if type- $h$  evidence, which establishes guilt, is produced. To obtain the equilibrium induced effort and the expression for  $R^{\mathcal{I}}$ , recall that law enforcement costs given by (A1) are increasing in  $m$ . On the other hand, the left-hand side of (A2) is also increasing in  $m$ , becomes arbitrarily large as  $m$  goes to  $m^+$ , and goes to zero as  $m$  goes to 0. The assertion that the left-hand side of (A2) is unbounded above is proved in Claim 1, following the proof of Lemma 1. Therefore, there exists a minimal effort  $m_z^{\mathcal{I}}$  that satisfies (A2) with equality, where  $w_A^{\mathcal{I}} = 0$ .

We now argue that, this  $m_z^{\mathcal{I}}$  will minimize law enforcement costs. First, we need to show that the *ex-post* collusion-proofness constraint (9), which we have ignored until now, is implied by the *ex-ante* collusion-proofness condition (8). Rewrite (8) as

$$\bar{b}p_g^h R^{\mathcal{I}}\mu(m) \geq z + c(m)$$

i.e.,

$$R^{\mathcal{I}} \geq \frac{c(m)}{\bar{b}p_g^h\mu(m)} + \frac{z}{\bar{b}p_g^h\mu(m)},$$

and using (6),

$$= \frac{c(m)}{\bar{b}p_g^h\mu(m)} + \frac{F^{\mathcal{I}}}{\bar{b}} > F^{\mathcal{I}}.$$

Now by (7 $\mathcal{I}$ ),  $R^{\mathcal{I}} = [c'(m_z^{\mathcal{I}})/\mu'(m_z^{\mathcal{I}})][1/(\bar{b}p_g^h)]$ , and by (6),  $F^{\mathcal{I}} = z/[p_g^h\mu(m_z^{\mathcal{I}})]$ . So,  $LEC^{\mathcal{I}} = c(m_z^{\mathcal{I}}) - \bar{b}z$ .

*Presumption G.* We already established that

$$w_A^G = \frac{(1 - r_i)z}{[p_g^h + (1 - p_g^h)(1 - r_g) - (1 - r_i)]},$$

which, substituted into the *ex-ante* collusion-proofness condition (A2), yields

$$\frac{c'(m)}{\mu'(m)}\mu(m) - c(m) \geq z \left\{ 1 + \frac{(1 - r_i)}{[p_g^h + (1 - p_g^h)(1 - r_g) - (1 - r_i)]} \right\}. \quad (\text{A3})$$

As under presumption  $\mathcal{I}$ , the principal must induce at least a minimal effort  $m_z^G$  satisfying (A3) with equality.

Since  $(c'(m)/\mu'(m))\mu(m) - c(m)$  is increasing in  $m$ ,  $m_z^G > m_z^{\mathcal{I}}$ .

To check that  $m_z^G$  minimizes law enforcement costs, we need to show that *ex-post* collusion-proofness constraints in (9) are satisfied. *Ex-ante* collusion-proofness is already satisfied through (A3), provided rewards  $(R_h^G, R_l^G)$  are chosen to induce  $m_z^G$  by satisfying Eq. (7G).<sup>31</sup> Thus, we need to determine suitable penalty and rewards. First determine the penalty, using (6), as

$$F^G = \frac{z}{[p_g^h + (1 - p_g^h)(1 - r_g) - (1 - r_i)]\mu(m_z^G)}.$$

Now choose  $R_l^G = F^G$  to satisfy the third constraint in (9). Next determine  $R_h^G$  using (7G):

$$R_h^G = \frac{1}{\bar{b}p_g^h} \left\{ \frac{c'(m_z^G)}{\mu'(m_z^G)} - F^G [\bar{b}(1 - p_g^h)(1 - r_g) + (1 - \bar{b})(1 - r_i)] \right\}.$$

By construction,  $(R_h^G, R_l^G)$  induces  $m_z^G$  and satisfies (A3), and equivalently (8). Therefore, rewrite (8) as

$$\begin{aligned} & [\bar{b}p_g^h R_h^G + \bar{b}(1 - p_g^h)(1 - r_g)F^G + (1 - \bar{b})(1 - r_i)F^G] \mu(m_z^G) - c(m_z^G) \\ & \geq z - \bar{b}z + \mu(m_z^G) F^G [\bar{b}p_g^h + \bar{b}(1 - p_g^h)(1 - r_g) + (1 - \bar{b})(1 - r_i)], \end{aligned}$$

which can be simplified to

$$\bar{b}p_g^h \mu(m_z^G) [R_h^G - F^G] \geq c(m_z^G) + z(1 - \bar{b}) > 0,$$

<sup>31</sup> Crucial to the determination of law enforcement costs is the induced effort  $m_z^G$ . There can be more than one combination of  $(R_h^G, R_l^G)$  that is consistent with  $m_z^G$ , but we consider only one such combination.

implying  $R_h^{\mathcal{G}} > F^{\mathcal{G}}$ . Thus, the second constraint in (9) is satisfied. Therefore, the minimized law enforcement costs under presumption  $\mathcal{G}$  are given by

$$LEC^{\mathcal{G}} = c(m_z^{\mathcal{G}}) - \bar{b}z.$$

Finally, since  $m_z^{\mathcal{I}} < m_z^{\mathcal{G}}$ , law enforcement costs will be lower under presumption  $\mathcal{I}$ . Q.E.D.

*Claim 1.*  $[c'(m)/\mu'(m)]\mu(m) - c(m)$  can be made arbitrarily large by inducing an appropriate  $m$  through adjustments in  $R^j$ .

*Proof of Claim 1.* Suppose not. Then there is a finite  $\eta$  such that  $[c'(m)/\mu'(m)]\mu(m) - c(m) \leq \eta$  for all  $m$  that can be induced. Choose any particular  $\tilde{m}$  induced by an appropriate reward,  $\tilde{R}^{\mathcal{I}}$ , such that

$$\frac{c'(\tilde{m})}{\mu'(\tilde{m})}\mu(\tilde{m}) - c(\tilde{m}) \leq \eta.$$

Now choose a sufficiently large  $R^{\mathcal{I}}$ , say  $\tilde{R}^{\mathcal{I}} > \tilde{R}^{\mathcal{I}}$ , such that  $\bar{b}p_g^h \tilde{R}^{\mathcal{I}} \mu(\tilde{m}) - c(\tilde{m}) > \eta$ . Clearly  $\tilde{m}$  cannot be the equilibrium effort for the reward choice  $\tilde{R}^{\mathcal{I}}$ ; so let  $\tilde{\tilde{m}}$  be the equilibrium effort. Thus, we have

$$\frac{c'(\tilde{\tilde{m}})}{\mu'(\tilde{\tilde{m}})}\mu(\tilde{\tilde{m}}) - c(\tilde{\tilde{m}}) > \bar{b}p_g^h \tilde{R}^{\mathcal{I}} \mu(\tilde{m}) - c(\tilde{m}) > \eta,$$

which is a contradiction.

Q.E.D.

*Proof of Proposition 4.* First consider the presumption rule  $\mathcal{G}$ . By Lemma 3,  $\bar{b} \in (0, \beta^{\mathcal{G}}]$  cannot be implemented under presumption  $\mathcal{G}$ . Now suppose that any corruption target  $\bar{b} \in (\beta^{\mathcal{G}}, 1)$  can be implemented. Using (7 $\mathcal{G}$ ) with  $R_h^{\mathcal{G}} = R_l^{\mathcal{G}} = \bar{R}$ , we must have

$$\bar{R} \geq \frac{1}{\bar{b} [p_g^h + (1 - p_g^h)(1 - r_g)] + (1 - \bar{b})(1 - r_i)} \times \frac{c'(m_z^{\mathcal{G}})}{\mu'(m_z^{\mathcal{G}})},$$

and, by letting  $\bar{b}$  approach  $\beta^{\mathcal{G}}$  from above, we conclude that

$$\bar{R} \geq \underbrace{\frac{1}{\beta^{\mathcal{G}} [p_g^h + (1 - p_g^h)(1 - r_g)] + (1 - \beta^{\mathcal{G}})(1 - r_i)}}_{\rho} \times \frac{c'(m_z^{\mathcal{G}})}{\mu'(m_z^{\mathcal{G}})}$$



i.e.,

$$\bar{R} \geq \frac{1}{\rho} \times \frac{c'(m_z^G)}{\mu'(m_z^G)} \equiv \bar{R}^G. \quad (A4)$$

This completes the necessary part of the if and only if claim.

To show that (A4) is also sufficient for full collusion-proof implementation of any  $\bar{b} \in (\beta^G, 1)$ , write the *ex-ante* collusion-proofness constraint (A2) as

$$\begin{aligned} \mu(m_z^G)[c'(m_z^G)/\mu'(m_z^G)] &\geq c(m_z^G) + z + w_A^G \\ &= c(m_z^G) + z + \frac{(1-r_i)z}{[p_g^h + (1-p_g^h)(1-r_g) - (1-r_i)]}. \end{aligned}$$

By (A4), there exist rewards  $R_h^G$  and  $R_l^G$  that induce effort  $m_z^G$ , which satisfies this last condition. Furthermore, using (A4) in this last condition, we obtain

$$\begin{aligned} \bar{R} &\geq \frac{1}{\rho\mu(m_z^G)} \left\{ c(m_z^G) + z + \frac{(1-r_i)z}{[p_g^h + (1-p_g^h)(1-r_g) - (1-r_i)]} \right\} \\ &> \frac{(1-r_i)}{\rho} \cdot \frac{z}{[p_g^h + (1-p_g^h)(1-r_g) - (1-r_i)]\mu(m_z^G)} \\ &= \frac{(1-r_i)}{\rho} \cdot F^G. \end{aligned}$$

Since  $1-r_i > \rho$ ,  $\bar{R} > F^G$ . Hence, it is possible to find rewards  $R_h^G$  and  $R_l^G$ , not exceeding  $\bar{R}$ , such that the *ex-post* collusion-proofness constraints hold and all other equilibrium conditions are satisfied.

Now consider the presumption rule  $\mathcal{I}$ . Suppose that any corruption target  $\bar{b} \in (0, 1)$  can be implemented through presumption  $\mathcal{I}$ . Using (7 $\mathcal{I}$ ), we conclude that

$$\bar{R} \geq \frac{1}{\bar{b}p_g^h} \frac{c'(m_z^{\mathcal{I}})}{\mu'(m_z^{\mathcal{I}})}. \quad (A5)$$

The right-hand side of the expression is  $\bar{R}^{\mathcal{I}}(\bar{b})$  in the statement of the proposition. Hence, we have shown the necessary part of the if and only if claim. That the above condition is also sufficient for implementation of a specific  $\bar{b} \in (0, 1)$ , follows directly from Lemma 1.

However, note that because

$$\lim_{\bar{b} \rightarrow 0} \frac{1}{\bar{b}p_g^h} \frac{c'(m_z^{\mathcal{I}})}{\mu'(m_z^{\mathcal{I}})} = \infty,$$

constraint (A5) cannot be satisfied for low  $\bar{b}$ -values given an upper bound reward  $\bar{R}$ . In particular, given a fixed, finite  $\bar{R}$  such that  $\bar{R} \geq \bar{R}^G$ , even though all  $\bar{b} \in (\beta^G, 1)$  can be implemented through presumption  $\mathcal{G}$ , no

$$\bar{b} \in (0, \bar{b}_{\mathcal{I}}(\bar{R})),$$

can be implemented through presumption  $\mathcal{I}$ , where

$$b_{\mathcal{I}}(\bar{R}) = \frac{1}{\bar{R} p_g^h} \frac{c'(m_z^{\mathcal{I}})}{\mu'(m_z^{\mathcal{I}})}.$$

Here we are assuming that  $\beta^G < \bar{b}_{\mathcal{I}}(\bar{R})$ .

Thus, the implementation targets strictly between zero and one can be divided into three regions. The region  $(0, \beta^G)$  is not implementable by either presumption rule. The region  $(\beta^G, \bar{b}_{\mathcal{I}}(\bar{R}))$  can be implemented but only through presumption rule  $\mathcal{G}$ . The region  $[\bar{b}_{\mathcal{I}}(\bar{R}), 1)$  can be implemented under both presumption rules. Q.E.D.

## REFERENCES

- Andreoni, James, "Reasonable Doubt and the Optimal Magnitude of Fines: Should the Penalty Fit the Crime?" *Rand J. Econ.* **22**, 3:385–395, Autumn 1991.
- Becker, Gary, and Stigler, George J., "Law Enforcement, Malfeasance and the Compensation of Enforcers." *J. Legal Studies* **3**, 1:1–19, January 1974.
- Bernardo, Antonio, Talley, Eric, and Welch, Ivo, "A Theory of Legal Presumptions." *J. Law Econ. Organization* **16**, 1:1–49, April 2000.
- Boyer, Marcel, Lewis, Tracy R., and Liu, Wei Lin, "Setting Standards for Credible Compliance and Law Enforcement." *Can. J. Econ.* **33**, 2:319–340, May 2000.
- Coldham, Sam L., "Legal Responses to State Corruption in Commonwealth Africa." *J. African Law* **39**, 2:115–126, April 1995.
- Davis, Michael L., "The Value of Truth and the Optimal Standard of Proof in Legal Disputes." *J. Law Econ. Organization* **10**, 2:343–359, October 1994.
- DiBiagio, Thomas M., "Judicial Corruption, the Right to a Fair Trial, and the Application of Plain Error Review." *Amer. J. Criminal Law* **25**, 2:595–629, Summer 1998.
- GAO-United States, Washington DC, General Government Division (May 1998: B-277817) Report, "Law Enforcement: Information on Drug Related Police Corruption." (available at <http://www.druglibrary.org/schaffer/govpubs/gao/gg98111.pdf>).
- Garner, Bryan A., *A Dictionary of Modern Legal Usage*. New York: Oxford University Press, 1995.
- Hay, Bruce L., and Spier, Kathryn E., "Burdens of Proof in Civil Litigation: An Economic Perspective." *J. Legal Studies* **26**, 2:413–431, June 1997.
- Kaplow, Louis, "The Value of Accuracy in Adjudication: An Economic Analysis." *J. Legal Studies* **23**, 2:307–401, June 1994.
- Kaplow, Louis, "Accuracy in Adjudication." In Peter Newman Ed., *The New Palgrave Dictionary of Economics and the Law*, Vol. 1, pp. 1–7, New York: Stockton Press, 1998.
- Kaplow, Louis, and Shavell, Steven, "Optimal Law Enforcement with Self-reporting of Behavior." *J. Polit. Econ.* **102**, 3:583–606, June 1994.
- Klitgaard, Robert, *Controlling Corruption*. Berkeley, CA: University of California Press, 1988.

- Li, Shuhe and Hung, Victor, "Corruption and Contract Enforcement." Unpublished manuscript. Kowloon Hong Kong, City University of Hong Kong, Department of Economics and Finance, November 1998.
- Mookherjee, Dilip, and Png, Ivan P.L., "Monitoring vis-à-vis Investigation in the Enforcement of Law." *Amer. Econ. Rev.* **82**, 3:556–565, June 1992.
- Posner, Richard A., "An Economic Approach to the Law of Evidence." Chicago IL: University of Chicago Law School, John M. Olin Law and Economics Working Paper No. 66, February 1999.
- Rose-Ackerman, Susan, "Grand Corruption and the Ethics of Global Business." New Haven, CT: Yale Law School Working Paper No. 221, October 1999.
- Rubinfeld, Daniel L., and Sappington, David E.M., "Efficient Awards and Standards of Proof in Judicial Proceedings." *Rand J. Econ.* **18**, 2:308–315, Summer 1987.
- Sanchirico, Chris W., "The Burden of Proof in Civil Litigation: A Simple Model of Mechanism Design." *Int. Rev. Law Econ.* **17**, 3:431–447, Sept. 1997.
- Shin, Hyun Song, "The Burden of Proof in a Game of Persuasion." *J. Econ. Theory* **64**, 2:253–264, Oct. 1994.
- Solan, Lawrence M., "Refocusing the Burden of Proof in Criminal Cases: Some Doubt about Reasonable Doubt." *Texas Law Rev.* **78**, 2:105–139, Nov. 1999.
- Tirole, Jean, "Hierarchies and Bureaucracies: On the Role of Collusion in Organizations." *J. Law Econ. Organization* **2**, 2:181–214, Fall 1986.
- Tirole, Jean, "Collusion and the Theory of Organizations." In J.-J. Laffont, Ed., *Advances in Economic Theory*, Vol. 2, pp. 151–206. Cambridge, UK: Cambridge Univ. Press, 1992.