Law Enforcement Costs and Legal Presumptions*

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July 30, 2000

Abstract

We study and compare law enforcement costs under two alternative legal presumptions, one more pro-defendant than the other, with the objective of reducing crime to a target level. We identify relative strengths and weaknesses of these legal presumptions in terms of components of law enforcement costs such as "evidence production" costs, "collusion prevention" costs, trial costs, and (when the potential offender is an official) "agent compensation" costs. We show that relatively pro-defendant presumptions have several cost advantages, but some of these advantages disappear if law enforcers never collude with potential offenders or if resources to motivate law enforcers are limited.

Key Words: Law enforcement, crime, corruption, supervision, evidence, implementation, burden of proof, presumptions

JEL Classification: D73, D78, K41, K42

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*We thank Keith Hylton for comments and Eric Posner for a useful conversation on the subject and related literature. Earlier versions of this paper benefited from presentations at ASSET 1998 meetings, Bilkent University, Birkbeck College, Erasmus University, University College Dublin and University of Liverpool. Remaining errors are our own.

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1 Introduction

Most legal systems "presume innocence" of criminal defendants. The accuser bears the primary responsibility of producing evidence that supports his claim "beyond reasonable doubt," to imply a "high" relative likelihood of guilt to innocence. Though 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.[1] Examples abound in anti-corruption legislation. Thailand promulgated a decree in 1975 which 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 thirty members of The Organization of American States signed in 1996 a treaty including illicit enrichment provisions, to combat transnational bribery. The view that shifting the burden of proof to the accused will deter corruption is widely held among corruption experts.[2] What logic underlies this view, and under what circumstances would a change in legal presumptions produce the desirable effects, such as economizing on law enforcement costs or reducing the crime level with a given law enforcement budget?

The question as to what constitutes the best standard of proof in establishing guilt is studied by Rubinfeld and Sappington (1987), Andreoni (1991), Shin (1994), Sanchirico (1997) and Bernardo et al. (1999), among others. In the context of civil litigation, Sanchirico shows that the high evidential standards of pro-defendant presumptions economize on litigation costs by filtering out "less valuable" cases, while Bernardo et al. focuses on the feedback from legal presumptions to criminal incentives. Shin (1994) provides an analysis of crimes with victims, where an arbitrator determines the standard of proof and adjudicates on the basis of evidences submit-

[1] There are also examples of shifts in the opposite direction. To give one, in the U.S.A. recent proposals by the Congress plan to shift the burden of proof in many tax (court) cases from the defaulting tax-payers to the Internal Revenue Service ("Features of *IRS* overhaul bill," USA TODAY, 07/09/98).

[2] See, for example, Klitgaard (1988, p.95). Klitgaard also provides a thorough discussion of Singapore's and Hong Kong's successful use of such legal reforms in fighting corruption. Coldham (1995) is a recent survey and interpretation of anti-corruption laws in Africa. He mentions several provisions under the Kenyan, Zimbabwean, Zambian, and Tanzanian Prevention of Corruption Acts which implicitly or explicitly shift the burden of proof to the civil servant.

ted by a plaintiff and a defendant.[3] The papers by Rubinfeld and Sappington, and Andreoni, view the court/jury system as choosing an optimal standard of proof to minimize an objective function that includes the social costs of type I and type II errors in convicting/acquitting a defendant. The literature by and large ignores the fact that legal presumptions influence (i) the incentives to commit crimes, in particular, (ii) the possibility of collusion between law enforcers and criminals, and (iii) law enforcement costs.[4] The present paper incorporates these missing elements and offers several new insights on whether a state, through its legislators, should set high or low standards of proof in apprehending and convicting potential criminals.[5]

Our approach is fundamentally different from the literature in that we shift the focus from the *ex-post* trial stage to the *ex-ante* stage of a criminal decision and analyze the role of legal presumptions in *crime prevention.* We present a principal-supervisor-agent model where the principal represents the government/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 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. We note, however, that we do not consider the subjective social costs of verdict er-

[3]See Cooter and Ulen (1997, pp 370-373) for interpretations and analysis of burden of proof, and Shin (1998) where the arbitrator decides alternatively whether to rely on his own evidence. Most of this literature thus focus on the statistical inference of the "fact-finder", given a body of evidence.

[4]An exception is Bernardo et al. (1999); they provide a formal analysis of the relationship between legal presumptions and criminal incentives but ignore collusion possibilities and incentive problems in the law enforcement system, mainly because their model is rather applicable to civil litigation. See also Davis (1994).

[5]A clarification: We say that *a legal presumption is more pro-defendant* than another if it bears a heavier burden of proof (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. Garner (1995), in *A Dictionary of Modern Legal Usage*, defines 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 the legal presumption is modified to further favor the defendant, the accuser's task of producing evidence and persuading the fact-finder is relatively difficult, his burden of proof, heavy. In this case, we say that the burden of proof is shifted to the accuser.

rors and instead focus on the criterion of minimizing direct law enforcement costs, including compensation of law enforcers (evidence production and collusion prevention costs), trial costs and agent compensation costs (which applies when the potential offender is an employee of the state). Though the ultimate choice of the legal presumption may require a clear specification of both direct law enforcement costs and social costs of wrongful verdicts, any such specification is bound to be subjective. Our analysis therefore complements the existing literature and, we believe, provides useful guidelines for a comprehensive approach.

We highlight several important considerations in evaluating legal presumptions. Stringent evidential standards of strongly pro-defendant presumptions should make *evidence production* relatively costly. However, the evidential standards used in establishing guilt feed back to individual incentives to commit crimes.[6] For instance, 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. Therefore, though a departure from the presume innocence rule would decrease evidence production costs for a fixed crime level, on the other hand it could be indirectly enhancing incentives to commit crimes, which, in turn, would generate an increase in law enforcement costs. Another consideration is that the prospect of a conviction may prompt the potential felon to make a side-transfer to the law enforcer (i) at an early stage prior to the criminal act and evidence production, so that committing a crime is a safe option, and otherwise (ii) at the post-detection stage where evidence is produced, to avoid punishment. Legal presumptions indirectly affect *collusion possibilities* between law enforcers and potential criminals, depending also on the nature of law enforcers, i.e., on whether they are susceptible to collusion.[7] Another

[6] That greater accuracy in adjudication has a deterrent effect is well known (Kaplow (1998), Posner (1999)). The impact of legal presumptions on criminal deterrence is not so clear, however.

[7] Becker and Stigler (1974) is the first formal analysis of ex-post collusion in law enforcement. Collusion cannot be ignored, judging by the top-of-the-iceberg evidence from many regions of the world. To mention a few, in 1989, in one Chinese city 21 percent of bribery occurred within the law enforcement sector, according to the studies on China reported in Li and Hung (1998). See Klitgaard (1988, pp 98-100) for striking accounts of internal corruption in the Hong Kong Police Department during the sixties and seventies. Many recent instances of police corruption can also be found on the internet: in Nicaragua, "the national police...fired their top legal advisor for allegedly being the point man for a Honduran

important factor determining the choice of legal presumptions should be *availability of resources* to effectively motivate the law enforcers.

Our main result is that, absent a constraint on resources to compensate law enforcers who are susceptible to collusion, the relatively pro-defendant legal presumption allows implementation of *all* crime levels at lower expected costs, for three reasons: "Collusion prevention" costs, "agent compensation costs" and "expected trial costs" are all lower under the pro-defendant presumption. Expected trial costs are relatively low because fewer cases are tried for the same target level of crime, agent compensation costs are low because the risk of being punished when innocent is relatively small, which is reflected in the agent's wage (if the agent is an employee of the state and the crime in question is, for example, corruption). Collusion prevention costs are also low because the corresponding surplus is low: criminals are willing to pay less to avoid monitoring by law enforcers and potentially be convicted. We identify two environments in which the relatively pro-defendant legal presumption may lose its cost advantage.

First, in the presence of a reward constraint on law enforcement, a range of low crime levels cannot be implemented under the relatively pro-defendant presumption: when the probability of an offense is very low, very high rewards must be promised to motivate law enforcers to collect high quality evidence. In contrast, when the burden of proof is shifted to criminal defendants, a given law enforcement effort has a better chance of producing evidence that meets the courts' lower standards in establishing guilt, therefore relatively modest rewards can induce law enforcers to exert the necessary efforts. Thus, when resources to motivate law enforcers are bounded, evidence production component of law enforcement costs play an important role. This result is suggestive of why several middle- and low-income countries have shifted the burden of proof to the accused in their struggle to curb down bureaucratic corruption.

Second, if the principal has an elite force of law enforcers who are honest and never collude, or if collusion is impossible or very costly to sustain, collusion prevention costs are zero. Agent compensation costs are also zero if the potential offender is not an employee of the principal. Now the choice between the two legal presump-

car smuggling ring" (03/07/97; http://zbeng.com/osac/day3244.html); in McAllen, Texas, ex-Sherrif Eugenio Falcon "admitted to operating a bail bond kickback scheme out of the Starr County Jail, accepting more than $11,000 in bribes between March and November 1997" (http://reporternews.com/texas/sher0327.html), etc.

tions rests on expected trial costs and evidence production costs. We show that the latter will be determined by a simple balance between the likelihood of type I and type II errors. If shifting the burden of proof to criminal defendants increases the probability of avoiding type II error by more than the probability of committing type I error, accuracy in adjudication increases, then a stronger deterrence, hence lower expected evidence production costs, will obtain for any target level of crime. This will be the case if the innocent is more likely than the guilty to "disprove" an accusation based on the relatively low quality evidence admissible when the burden of proof is shifted to criminal defendants. Presumably, this is also the logic underlying concerted international efforts by OECD and The Organization of American States to fight corruption by shifting the burden of proof to public officials holding assets much beyond their lawful earnings.

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 concludes. The proofs of Propositions 1 and 2 appear in the Appendix.

2 The Model

We consider a three-layer hierarchy consisting of a principal, a supervisor and an agent, all risk-neutral, where the supervisor's and the agent's outside options are normalized to zero. The principal represents the legislator or the government, the supervisor represents the law enforcement system (the chain from police to prosecution, effective in producing evidence to bringing potential offenders to court), and the agent is the potential offender.[8] We distinguish between two types of crime according to the position of the agent. In the first case the agent is also an employee of the principal, for example a civil servant or bureaucrat. The potential crime we consider then is a "violation of duty for private gain" such as fraud, spying for foreign secret services, transfer of millions of dollars raised for public projects to private accounts, etc. The model description below corresponds to this type of

[8]Modeling explicitly the behavior of the many tiers in the law enforcement hierarchy is a complex task, beyond the scope of this paper. This modeling strategy also does not seem necessary for our purpose.

crime, referred to as corruption.[9] In the second case, the agent is not an employee of the principal but a potential offender who may commit a crime for a private benefit. Both cases are violations of criminal law and their analysis are similar except for the treatment of the agent. In Section 3 the model is easily adapted to study the second case.

The agent, on whom the principal delegates an authority, can misuse authority for a private gain of z dollars, that is, choose to be corrupt ($\hat{b} = 1$), or remain honest ($\hat{b} = 0$), z being common knowledge. We take the agent's (possibly mixed) strategy $b \in [0, 1]$, 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 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.[10] 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 (as we state precisely in the sequel) concerns the unobservable, hence nonverifiable, *level of corruption.*[11]

2.1 Types and Production of Evidence

The following evidential 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 ($\hat{b} = 1$ is realized). The second type of evidence is considered as suggestive, "low quality" (type-l) evidence of corruption.[12] Type-h and type-l evidences are potentially admissible in courts, a choice we leave

[9] As the examples above indicate, we are not considering petty corruption like \$10 speed money, a violation of duty or crime that is rather handled within the disciplinary procedures of the state department or organization.

[10] Three-layer hierarchies in economic models that allow for the possibility of side contracts have been formally introduced by Tirole (1986; 1992) and Laffont (1990), and later on extensively studied by Kofman and Lawarrée (1993), Bac (1996 a,b), Bag (1997), and Bac and Bag (1999), among others.

[11] The fact that the level of corruption is nonverifiable does not, of course, undermine the principal's objective. It is implemented in the model described below as a Nash equilibrium strategy.

[12] 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.

to the principal. Evidences of quality lower than type-l are never admitted in court, hence cannot be used to penalize the agent; to any such evidence, we refer as a situation of no evidence. In the next subsection, we link type-h and type-l evidences to legal presumptions and 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, no matter the agent's action; he is on the wrong track;
- 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 ($\hat{b}=0$ or $\hat{b}=1$): if the agent is guilty ($\hat{b}=1$), 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 ($\hat{b}=0$) are p_i^e, $e=h,l$, with $p_i^h+p_i^l=1$.

It is natural to assume $p_g^h > p_i^h$, that high quality evidence is relatively more likely when the agent is guilty than innocent. We further make two sets of assumptions. First, to reduce notational burden in the analysis we assume $p_i^h = 0$ (so that $p_i^l = 1$) and $1 > p_g^h > 0$, which makes type-h evidence, if produced, proof of guilt/corruption. None of our results depends on the normalization $p_i^h = 0$; all that is needed is that type-h evidence be relatively more informative.[13] Second, $1 > p_g^l > 0$, so that with evidence of low quality the possibility that the agent is guilty cannot be ruled out.

Thus, 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 $b\mu(m)p_g^h$, 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 $c(m)$. We assume the following:

Assumption 1 *The effort cost function $c:[0,\, m^+)\to\Re_+$ is twice continuously differentiable, increasing and (weakly) convex in m, with $c(0)=0$ and $c'(m)\to 0$ as $m\to 0$. The success probability of monitoring, $\mu:[0,\ m^+)\to[0,\,1)$, is also twice*

[13] The following conditional probabilities are easily verified: *prob(agent is corrupt|evidence is type-h)=1, prob(agent is corrupt| evidence is type-l)* $= bp_g^l/(bp_g^l+(1-b)) < 1$; on the other hand, *prob(agent is innocent | evidence is type-h)=0, prob(agent is innocent | evidence is type-l)*$=(1-b)/(bp_g^l+(1-b)) > 0$. Type-$h$ evidence is therefore more informative than type-l.

continuously differentiable, increasing and strictly concave in m*, with* $\mu(0) = 0$*,* $\mu'(m) \to \infty$ *as* $m \to 0$*, and* $\mu'(m) \to 0$ *as* $m \to m^+$*.*

This assumption guarantees that the supervisor will exert a positive effort given a positive reward for successful conviction, and the equilibrium effort will be bounded away from m^+ given any finite reward.

The method of enforcement, that is, whether the supervisor's effort is interpreted as *examination* of an individual to learn whether the individual has committed a crime/corruption yet unobserved, or whether it is interpreted as an *investigation* effort to determine who committed a known crime/corruption is immaterial for the analysis. In both cases the supervisor/law enforcer faces qualitatively the same types of uncertainties: ex-ante he does not know whether the examined/investigated individual is a criminal, and the type of evidence he will be able to collect, if any.[14]

2.2 Burdens of Proof and Expected Trial Costs

In criminal cases, the burden is on the prosecution (supervisor) to produce the evidence that establishes his claim "beyond reasonable doubt". When the prosecution produces the evidence, the burden shifts on the accused to persuade the tribunal that the claim does not hold beyond reasonable doubt. Just how heavy the prosecution's burden of proof should be, or just what level of doubt is reasonable, is determined in our model by the principal. We consider two choices, in accordance with the evidence classification introduced in the previous subsection.

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, for courts reject accusations based on type-l evidence. We refer to this case as <u>*Allocation* $\mathcal{S}$</u>, or, loosely, the *presume innocence* rule. Under what we call <u>*Allocation* $\mathcal{A}$</u>, or the *presume guilt* rule, the agent's (potential defendant) burden of proof is relatively heavy: When the supervisor submits at least evidence of type-l, the agent is presumed guilty, and guilt is established unless the agent disproves the accusation. Recall that under *Allocation* $\mathcal{S}$ the type-h evidence used in supporting the accusation proves guilt by definition, hence cannot be disproved. Under *Allocation* $\mathcal{A}$, type-l evidence can be challenged and disproved by the agent, and we assume that

[14] Investigation and examination may differ in their costs, and as Kaplow and Shavell (1994) show, may have differential effects on behavior in a context where individuals are allowed to report their own criminal acts. We do not pursue this line of analysis here.

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 $1 > r_i > r_g > 0$.

A trial, if the evidence submitted meets the standard corresponding to the burden of proof allocation $j = \mathcal{A}, \mathcal{S}$, costs L^j.[15] The agent is tried under Allocation $\mathcal{S}$ with probability $b\mu(m)p_g^h$, under Allocation $\mathcal{A}$ with probability $\mu(m)$.[16] Thus, expected trial costs are

$$EL^{\mathcal{S}} = b\mu(m)p_g^h L^{\mathcal{S}} \quad \text{and} \quad EL^{\mathcal{A}} = \mu(m)L^{\mathcal{A}},$$

under Allocation $\mathcal{S}$ and $\mathcal{A}$, respectively. Notice that, given b and m, we have $EL^{\mathcal{S}} < EL^{\mathcal{A}}$ if $L^{\mathcal{S}} = L^{\mathcal{A}}$, because the agent is more likely to end up in the courtroom under Allocation $\mathcal{A}$. Expected trial costs under Allocation $\mathcal{A}$ would be even higher if we consider the possibility $L^{\mathcal{S}} < L^{\mathcal{A}}$, that a trial would cost less under Allocation $\mathcal{S}$ 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 $L^{\mathcal{S}} \leq L^{\mathcal{A}}$.

2.3 Sequence of Events

An incentive scheme under the burden of proof allocation $j = \mathcal{A}, \mathcal{S}$ 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 on conviction of the agent's guilt, and a penalty F^j imposed on the agent for being found guilty.[17] The supervisor's reward, R^j, may or may not depend on the type of evidence: if the principal can identify the type of evidence used in establishing guilt, which he must if he himself determines that the agent is guilty, then we call it the *sophisticated* principal's case, and then $R^j = R_h^j$ or R_l^j depending on the evidence, of type h or l. However, if the principal cannot distinguish between the two types of evidence

[15]The costs L^j not only denote the prosecuting lawyers' fees, but may sometimes include the defense lawyers' fees if the agent is entitled to receiving support related to legal expenses from the principal by contract or the laws of the State.

[16]That the probability of a trial under Allocation $\mathcal{A}$ does not depend on the agent's action b is an artifact of our simplifying assumptions; it should not be interpreted as literally applicable. The basic idea is that since type-l evidence is of a lower quality, relatively easily produced, and admitted to court under Allocation $\mathcal{A}$, the agent, guilty or innocent, accordingly faces a *relatively large* risk of trial.

[17]Our results are not affected if alternatively we assume that the supervisor is rewarded for bringing in evidence, whether guilt is established or not.

(e.g., if an independent judge rules the agent guilty), we are in the <u>*unsophisticated*</u> principal's case where the successful supervisor receives a single reward.

Let ER^j and EF^j denote respectively the principal's expected reward payments and the expected penalty/fine costs of the agent. The penalty F^j may be monetary in kind and used by the principal to achieve his objective to control crime/corruption, or it can be non-monetary. In the analysis we shall assume that the penalty is a fine and that it accrues to the principal, though we discuss the case of non-monetary penalties in a remark following Proposition 1. The principal's problem of minimizing implementation costs is stated as follows.

$$min\{TC^j\} = min\{w_A^j + w_S^j + ER^j - EF^j + EL^j\} \tag{1}$$

for *any* given corruption target $\bar{b}$, subject to the moral hazard constraints in law enforcement (the supervisor should be induced to exert an evidence production effort that, in turn, induces the strategy $\bar{b}$ by the agent), participation constraints and collusion-proofness constraints. These are stated explicitly in the next section. We have two remarks on the principal's the objective function.

- The cost objective is readily decomposable into its components: w_A^j represents "agent compensation" costs, $w_S^j + ER^j$ represents "evidence production" and/or "collusion prevention" costs, EF^j denotes expected fine collections and EL^j denotes expected trial costs.
- Direct social costs of crime/corruption are irrelevant for the analysis of evaluating alternative legal presumptions, hence omitted in (1). The costs, say Γ, that the crime directly inflicts on the society (e.g. damages, lost opportunities, economic distortions, etc.) are not affected by legal presumptions.

The sequence of events is as follows. Given a corruption target $\bar{b}$, the principal determines the burden of proof and a corresponding incentive scheme. If the supervisor and the agent both accept the incentive scheme, the game proceeds to the (*ex-ante*) collusion stage where the agent may offer a side-transfer to the supervisor to avoid being monitored in return. If they don't collude ex-ante, they play a monitoring-corruption game in which the supervisor determines his effort m and the agent simultaneously determines his corruption strategy b. Once the equilibrium strategies are played and the outcome $(\hat{\mu}, \hat{b})$ is observed, another, *ex-post*, occasion for collusion arises when supervision generates evidence, of type-l or type-h. The agent may then make a side-transfer to the supervisor for destroying the evidence. In the final stage the supervisor submits evidence (if any) to the principal, the agent may or may not be tried, convicted or acquitted if tried, and the principal applies the incentive scheme to yield all the parties their respective payoffs.

3 Potential Benefits of Presuming Innocence

We proceed in this section with the comparison of total implementation costs under Allocation $\mathcal{A}$ and $\mathcal{S}$. We wish to highlight two important assumptions: first, the supervisor may collude with the agent; second, there is no upper limit to the supervisor's rewards. We also assume that there is no upper bound on penalty to keep the exposition as simple as possible; our results go through if we assume an upper bound. Moreover, as we show in the sequel, the requirement that the incentive scheme be collusion-proof already brings about an endogenous bound on penalty.[18] We begin with the crime of corruption where the agent is an employee of the principal.

3.1 Burden of Proof and Control of Corruption

3.1.1 Participation Constraints and Payoffs

Given an incentive scheme, let U_i^j be the (ex-ante) expected utility of $i = A, S$ under Allocation $j = \mathcal{A}, \mathcal{S}$. The agent's expected utility and participation constraint can be written as

$$U_A^j = w_A^j + bz - EF^j(b, m) \geq 0,^{19} \tag{2}$$

where the expected penalty $EF^j(b, m)$ depends on b and m. The supervisor's expected utility and participation constraint is

$$U_S^j = w_S^j + ER^j(b, m) - c(m) \geq 0. \tag{3}$$

[18] We introduce upper bounds on penalties in Section 4.2 and also drop the assumption that the supervisor may collude with the agent, and in Section 4.1 we introduce upper bounds on rewards.

[19] We do not include a separate trial costs for the agent; as discussed in footnote 15, these costs can be subsumed as part of the trial costs in the principal's objective function to account for many employment contracts and/or provision for legal support by the State. Including separate trial costs for the agent does not alter the qualitative conclusions of this paper, as we discuss in a remark following Proposition 1.

Define X^j as the probability of conviction under Allocation j, conditional on $\hat{\mu} = 1$ (the supervisor obtains some evidence, of type-l or h). Thus,

$$X^{\mathcal{S}} = bp_g^h \quad \text{and} \quad X^{\mathcal{A}} = b(p_g^h + (1 - p_g^h)(1 - r_g)) + (1 - b)(1 - r_i). \tag{4}$$

Note that $X^{\mathcal{A}}$ includes two possibilities of conviction, first, if type-h evidence is generated (which cannot be disproved because it is a proof of guilt by definition), second, if type-l evidence is produced which the agent fails to disprove. When the principal successfully implements a target level of crime/corruption $\bar{b}$, we use $\overline{X}^j$ to denote X^j. The agent's expected penalty under Allocation j can now be written as

$$EF^j(b, m) = X^j \mu(m) F^j. \tag{5}$$

The principal's expected reward payments to the supervisor is

$$ER^{\mathcal{S}}(b, m) = X^{\mathcal{S}} \mu(m) R^{\mathcal{S}} \tag{6}$$

under Allocation $\mathcal{S}$, while under Allocation $\mathcal{A}$

$$ER_S^{\mathcal{A}}(b, m) = b[p_g^h R_h^{\mathcal{A}} + (1 - p_g^h)(1 - r_g) R_l^{\mathcal{A}}]\mu(m) + (1 - b)(1 - r_i)\mu(m) R_l^{\mathcal{A}}, \tag{6S}$$

$$ER_U^{\mathcal{A}}(b, m) = X^{\mathcal{A}} \mu(m) R_{lh}^{\mathcal{A}} \tag{6U}$$

for the sophisticated and the unsophisticated principal case, respectively.[20] We first ignore the collusion possibilities and consider the monitoring-corruption game.

3.1.2 Equilibrium Conditions

In the monitoring-corruption game, the agent and the supervisor determine non-cooperatively the strategies $b \in [0, 1]$ and $m \geq 0$. Thus, to implement a corruption target $\bar{b}$, the incentive scheme must not only ensure that the Nash equilibrium strategy of the agent is $\bar{b}$, but also determine what effort level m to induce as the supervisor's best reply to the agent's strategy $\bar{b}$. The Nash equilibrium conditions corresponding to a $(\bar{b}, m)$ are formulated in (7) and (8$\mathcal{S}$)-(8$\mathcal{A}$U), for $\bar{b} \in (0, 1)$.[21]

[20] It is easy to check that setting $R_h^{\mathcal{A}} = R_l^{\mathcal{A}} = R_{lh}^{\mathcal{A}}$ in (6S) reduces to (6U).

[21] Note that we have excluded two extremes, $\bar{b} = 0$ and $\bar{b} = 1$. Implementing full corruption $\bar{b} = 1$ is straightforward and costs zero: fire the supervisor and let the agent safely be corrupt. The strategy $\bar{b} = 0$ cannot be Nash implemented under Allocation $\mathcal{S}$ because the probability of producing high quality type-h evidence, hence the probability that the supervisor will be rewarded,

Define p^j, the <u>effective</u> probability of conviction under Allocation j, as the difference between the probability of conviction when guilty and when innocent, conditional on $\hat{\mu} = 1$ (the supervisor obtains some evidence, of type-l or h). Thus,

$$p^{\mathcal{S}} = p_g^h \quad \text{and} \quad p^{\mathcal{A}} = p_g^h + (1 - p_g^h)(1 - r_g) - (1 - r_i).^{22}$$

As shown in the first equilibrium condition below, the relevant probability for the agent's criminal decision is of course the effective probability of conviction. The higher is p^j, the higher will be the expected opportunity cost of committing the crime. The term $p^j \mu(m) F^j$ can be called the <u>effective</u> expected penalty under allocation j.

The first equilibrium condition is that the penalty F^j establish the agent's indifference between $b = 1$ and $b = 0$, given a monitoring effort m. Another way of reading this condition is, in an induced equilibrium the agent's potential benefit z from corruption must be equal to the effective expected penalty from conviction. Using (2) and (5), depending on the Allocation $j = \mathcal{A}, \mathcal{S}$, this condition is expressed as

$$F^{\mathcal{S}} = \frac{z}{p_g^h \mu(m)} \quad \text{or} \quad F^{\mathcal{A}} = \frac{z}{p^{\mathcal{A}} \mu(m)}\ . \tag{7}$$

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 (6) in the supervisor's payoff expression (3), we obtain the first-order condition

$$\overline{X}^{\mathcal{S}} R^{\mathcal{S}} = \frac{c'(m)}{\mu'(m)} \tag{8$\mathcal{S}$}$$

under Allocation $\mathcal{S}$,

$$\bar{b}[p_g^h R_h^{\mathcal{A}} + (1 - p_g^h)(1 - r_g) R_l^{\mathcal{A}}] + (1 - \bar{b})(1 - r_i) R_l^{\mathcal{A}} = \frac{c'(m)}{\mu'(m)} \tag{8$\mathcal{A}$S}$$

under Allocation $\mathcal{A}$ with a sophisticated principal, and

$$\overline{X}^{\mathcal{A}} R_{lh}^{\mathcal{A}} = \frac{c'(m)}{\mu'(m)} \tag{8$\mathcal{A}$U}$$

is zero. The supervisor's best reply to $b = 0$ is $m = 0$, but $b = 0$ is not a best reply to $m = 0$. Under Allocation $\mathcal{A}$, implementing $\bar{b} = 0$ is, in principle, possible. However, when in equilibrium the agent is *induced* to choose $b = 0$, it is common knowledge that the agent is honest, therefore any accusing report (which must contain only low quality type-l evidence) is false. There would be no reason to punish the agent when it is common knowledge that he is *induced* to be innocent with probability one.

[22] Note that $p^A > p_g^h(1 - r_g) + (1 - p_g^h)(1 - r_g) - (1 - r_i) = r_i - r_g > 0$; $p^A < 1$ is obvious.

under Allocation $\mathcal{A}$ with an unsophisticated principal. It is easy to check that, given $\overline{b} \in (0, 1)$, a higher monitoring effort can be induced by increasing the reward(s) R^j through ($8\mathcal{S}$) (or ($8\mathcal{A}$S) or ($8\mathcal{A}$U)), and at the same time decreasing the penalty F^j through (7).

3.1.3 Collusion-Proofness Constraints

The supervisor and the agent, we assume, collude whenever the corresponding expected surplus is strictly positive. One way of introducing costs of enforcing collusive agreements in this model 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 go through under this or alternative modifications that also include fixed costs of collusion. We opt for the simpler exposition.

Denote by $\tilde{U}_i^j$ the expected utility of $i = A, S$ from ex-ante collusion. The surplus from ex-ante collusion is negative if

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

When the supervisor exerts no effort, the agent will optimally set $\tilde{b} = 1$ and obtain the payoff $\tilde{U}_A^j = z + w_A^j$. As for the supervisor's expected utility, it is given by (3) if the parties do not collude, by $\tilde{U}_S^j = w_S^j$ if they collude. The ex-ante collusion-proofness constraint is therefore

$$ER^j(\overline{b}, m) - c(m) \geq w_A^j + z - U_A^j, \qquad j = \mathcal{S}, \mathcal{A}. \tag{9}$$

That is, the supervisor's net expected surplus from monitoring must be at least equal to $z + w_A^j - U_A^j$, the maximum side-transfer that the agent is willing to make 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 penalty:[23]

$$R^{\mathcal{S}} \geq F^{\mathcal{S}}, \qquad R_n^{\mathcal{A}} \geq F^{\mathcal{A}}, \quad n = l, h, lh. \tag{10}$$

[23] 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 due to a commitment problem, if the low quality type-l evidence can be reproduced even after it is destroyed.

3.1.4 The Result and its Discussion

The least-cost incentive scheme is presented in Proposition 1 and derived in the Appendix. Implementation in this paper means *unique* implementation.

Proposition 1 *If the rewards paid for successful evidence production are not bounded above and the supervisor may collude with the agent, any corruption target* $\bar{b} \in (0, 1)$ *can be implemented full collusion-proof under either allocation, but the expected cost will be lower under Allocation* $\mathcal{S}$*, with a relatively heavy burden of proof on the supervisor. Implementation costs are*

$$TC^j = c(m_z^j) - \bar{b}z + EL^j,$$

where m_z^j *is the minimal level of induced enforcement effort necessary (and sufficient) to satisfy the ex-ante collusion-proofness constraint under allocation* j $(= \mathcal{A}, \mathcal{S})$, $EL^{\mathcal{S}} = \bar{b}\mu(m_z^{\mathcal{S}})p_g^h L^{\mathcal{S}}$ *and* $EL^{\mathcal{A}} = \mu(m_z^{\mathcal{A}})L^{\mathcal{A}}$*.*

The corresponding least-cost incentive schemes are as follows:

Allocation $\mathcal{S}$: $w_A^{\mathcal{S}} = 0, w_S^{\mathcal{S}} = c(m_z^{\mathcal{S}}) - \mu(m_z^{\mathcal{S}})[c'(m_z^{\mathcal{S}})/\mu'(m_z^{\mathcal{S}})] < 0$, $F^{\mathcal{S}} = z/[p_g^h \mu(m_z^{\mathcal{S}})]$ *and* $R^{\mathcal{S}} = [1/(\bar{b}p_g^h)][c'(m_z^{\mathcal{S}})/\mu'(m_z^{\mathcal{S}})]$.

Allocation $\mathcal{A}$ – sophisticated case: $w_A^{\mathcal{A}} = (1 - r_i)z/p^{\mathcal{A}}$, *where* $p^{\mathcal{A}} = p_g^h + (1 - p_g^h)(1 - r_g) - (1 - r_i)$, $w_S^{\mathcal{A}} = c(m_z^{\mathcal{A}}) - \mu(m_z^{\mathcal{A}})[c'(m_z^{\mathcal{A}})/\mu'(m_z^{\mathcal{A}})] < 0$, $F^{\mathcal{A}} = z/[p^{\mathcal{A}}\mu(m_z^{\mathcal{A}})]$,

$$R_h^{\mathcal{A}} = \frac{1}{\bar{b}p_g^h}\{\frac{c'(m_z^{\mathcal{A}})}{\mu'(m_z^{\mathcal{A}})} - F^{\mathcal{A}}[\bar{b}(1-p_g^h)(1-r_g) + (1-\bar{b})(1-r_i)]\} \quad \text{and} \quad R_l^{\mathcal{A}} = F^{\mathcal{A}}.$$

Allocation $\mathcal{A}$ – unsophisticated case: $w_A^{\mathcal{A}}$, $w_S^{\mathcal{A}}$, *and* $F^{\mathcal{A}}$ *are as given in the sophisticated case, and*

$$R_{lh}^{\mathcal{A}} = \frac{1}{\overline{X}^{\mathcal{A}}}\frac{c'(m_z^{\mathcal{A}})}{\mu'(m_z^{\mathcal{A}})} \quad \text{where} \quad \overline{X}^{\mathcal{A}} = \bar{b}p_g^h + \bar{b}(1 - p_g^h)(1 - r_g) + (1 - \bar{b})(1 - r_i).$$

Finally, $m_z^{\mathcal{S}} < m_z^{\mathcal{A}}$*.*

Under the least-cost incentive scheme, the principal binds the participation constraints (2) and (3) of the agent and the supervisor, so $w_A^j - EF^j(\bar{b}, m) = -\bar{b}z$, and $w_S^j + ER^j(\bar{b}, m) = c(m)$. This yields the total cost expression given in Proposition 1, consisting of the supervisor's monitoring cost $c(m_z^j)$, minus $\bar{b}z$ which represents expected penalty collections net of the agent's wage, plus expected trial costs EL^j.

Proposition 1 shows that three components of total implementation costs should be higher under Allocation $\mathcal{A}$, when the burden is shifted from the supervisor to the agent.

- *Collusion prevention* costs are higher under Allocation $\mathcal{A}$. The surplus from ex-ante collusion is larger because the agent is willing to make a larger side-transfer in order to avoid being monitored (and convicted with a higher probability) under Allocation $\mathcal{A}$. To have the supervisor reject such a side transfer, the principal increases expected reward payments and induces a higher effort $m_z^{\mathcal{A}} > m_z^{\mathcal{S}}$, which increases implementation costs.

- Expected *trial costs* are higher under Allocation $\mathcal{A}$. The relatively pro-defendant presumption of Allocation $\mathcal{S}$ implies tight screening (type-l evidence is not admitted), therefore the probability of a trial is relatively low for any given corruption strategy of the agent; also, $L^{\mathcal{S}} \leq L^{\mathcal{A}}$, as trials should take less time and resources when the prosecution is endowed (as required) with evidence of higher quality, possibly leading to a summary judgement.

- *Agent compensation* costs are higher under Allocation $\mathcal{A}$. The relatively high probability of a wrongful conviction decreases the agent's utility $U_A^{\mathcal{A}}$ below his outside option. The principal has to compensate the agent for this loss by paying a wage premium $w_A^{\mathcal{A}} > w_A^{\mathcal{S}} = 0$. Agent compensation costs are not visible in the cost expression given in Proposition 1 because they are exactly offset by expected fine collections, a feature we owe to the fact that the principal optimally binds the participation constraint of the agent, risk neutrality, and to the assumption that penalties are fines that accrue to the principal. If penalties are non-monetary in kind, such as imprisonment, then we set $EF^j = 0$ in the principal's objective. In this case total costs will be $TC^{\mathcal{S}} = c(m_z^{\mathcal{S}}) + EL^{\mathcal{S}}$ and $TC^{\mathcal{A}} = c(m_z^{\mathcal{A}}) + w_A^{\mathcal{A}} + EL^{\mathcal{A}}$, which shows that the result $TC^{\mathcal{S}} < TC^{\mathcal{A}}$ continues to hold, where $w_A^{\mathcal{A}}$ represents the positive agent compensation costs under Allocation $\mathcal{A}$.

Four remarks are in order.

1. The result in Proposition 1 holds even stronger if it is costly to penalize the agent, i.e., if we include into the principal's objective expected costs of

non-monetary sanctions such as imprisonment. The probability of conviction being lower under Allocation $\mathcal{S}$, the expected cost of such non-monetary sanctions should be lower under Allocation $\mathcal{S}$, given the crime.

2. The analysis above ignores the cost, say, t_A, the agent incurs if tried. Proposition 1 holds even stronger if we include the expected value of these costs into the agent's objective. This would increase collusion prevention costs relatively more under Allocation $\mathcal{A}$ because, ex-ante, the agent would be willing to pay more to avoid being monitored for the additional reason of avoiding a costly potential trial, which is more likely under Allocation $\mathcal{A}$.

3. The principal's sophistication in rewarding the supervisor based on the quality of evidence does not yield him any special cost savings, and a sophisticated mechanism can equivalently (from all parties' point of view) be replaced by a simpler, unsophisticated mechanism for Allocation $\mathcal{A}$. We carried out the analysis by distinguishing between the two cases with the intention of showing this fact. Because all parties are risk-neutral, what is important for the supervisor's effort decision is the overall (ex-ante) expected rewards, while the exact distribution of (ex-post) rewards between high and low quality evidence is immaterial.

4. As we show in the following subsection, the result in Proposition 1 continues to hold with a minor qualification in the standard case of crime deterrence where the agent is not an employee of the principal.

3.2 Burden of Proof and Crime Deterrence

Suppose that the agent is a potential offender who can reap the benefit z by committing a given crime. The problem is now slightly modified: The participation constraint (2) is irrelevant and the wage w_A^j is accordingly omitted from the incentive scheme. The agent's expected utility is

$$U_A^j = \bar{b}z - EF^j(\bar{b}, m),$$

where $EF^j(\bar{b}, m) = \overline{X}^j \mu(m) F^j$ and $\overline{X}^j$ is given in (4). The expression of total costs is given by (1) with $w_A^j = 0$, and the equilibrium conditions (7) and (8$\mathcal{S}$) (or (8$\mathcal{A}$S) or (8$\mathcal{A}$U)) carry over here. The least-cost incentive scheme is exactly as given in Proposition 1. Now, $U_A^{\mathcal{S}} = 0$ and $U_A^{\mathcal{A}} = -(1 - r_i)z/p^{\mathcal{A}}$.

If the parties collude ex-ante,[24] the supervisor obtains the expected utility $\tilde{U}_S^j = 0$ and the agent obtains the expected utility $\tilde{U}_A^j = z$. Therefore the ex-ante collusion-proofness constraint $U_S^j - \tilde{U}_S^j \geq \tilde{U}_A^j - U_A^j$ is given by $ER^j(\bar{b}, m) - c(m) \geq z - U_A^j$. The arguments in the proof of Proposition 1 can be applied to show that the principal must induce the minimal effort m_z^j that satisfies this ex-ante collusion-proofness constraint. Since $U_A^{\mathcal{S}} > U_A^{\mathcal{A}}$ and the left hand side $ER^{\mathcal{A}}(\bar{b}, m) - c(m)$ is increasing in equilibrium induced effort m, we must have $m_z^{\mathcal{A}} > m_z^{\mathcal{S}}$: a higher evidence production effort should be induced under Allocation $\mathcal{A}$.

Given this fact, total costs $TC^j = w_S^j + ER^j - EF^j + EL^j$ can be expressed as

$$TC^{\mathcal{S}} = c(m_z^{\mathcal{S}}) - z\bar{b} + EL^{\mathcal{S}}$$

under Allocation $\mathcal{S}$, where $c(m_z^{\mathcal{S}}) = ER^{\mathcal{S}} + w_S^{\mathcal{S}}$ because the supervisor's participation constraint is binding, and $z\bar{b} = EF^{\mathcal{S}}$ by the first equilibriun condition in (7). Under Allocation $\mathcal{A}$ we have

$$TC^{\mathcal{A}} = c(m_z^{\mathcal{A}}) - \frac{z\overline{X}^{\mathcal{A}}}{p^{\mathcal{A}}} + EL^{\mathcal{A}}$$

where $c(m_z^{\mathcal{A}}) = ER^{\mathcal{A}} + w_S^{\mathcal{A}}$, $z\overline{X}^{\mathcal{A}}/p^{\mathcal{A}} = EF^{\mathcal{A}}$ and $\overline{X}^{\mathcal{A}}$ is defined in (4) as the probability of conviction under Allocation $\mathcal{A}$. Using (4), it is easy to check that

$$TC^{\mathcal{A}} - TC^{\mathcal{S}} = [c(m_z^{\mathcal{A}}) - c(m_z^{\mathcal{S}})] - [\frac{(1 - r_i)z}{p^{\mathcal{A}}}] + [EL^{\mathcal{A}} - EL^{\mathcal{S}}]. \qquad (11)$$

The first and the third term in brackets reflect respectively the excesses of collusion prevention and expected trial costs under Allocation $\mathcal{A}$; both are positive. The second term stands for $EF^{\mathcal{A}} - EF^{\mathcal{S}}$, the excess of fine collections under Allocation $\mathcal{A}$, which disappears if penalties are non-monetary hence excluded from the principal's objective.

Thus, unless there is an important difference in expected fine collections, or if penalties are non-monetary, total costs are higher under Allocation $\mathcal{A}$, re-establishing the same conclusion as in Proposition 1: *When rewards are unbounded above and collusion in the law enforcement system is possible, any crime level* $\bar{b} \in (0, 1)$ *can*

[24]It may be argued that collusion between a potential offender and law enforcer is relatively more difficult to establish and sustain than the collusion involving a civil servant in the case of corruption. Though this argument has its merits, our conclusions will remain intact as long as collusion between the law enforcer and the potential offender remains possible. Numerous cases of collusion between the mafia, the police and even prosecutors as reported in the news media suggest that this possibility should not be ignored.

be implemented at lower costs by presuming innocence, i.e., by shifting the burden of proof away from potential offenders. This is true for any private benefit z that accrues to the offender, and given any monitoring technology of the law enforcer as represented by the functions $\mu(\cdot)$ and $c(\cdot)$ satisfying assumption 1.

When the agent is not an employee of the principal, the only difference in total costs occurs under Allocation $\mathcal{A}$. The principal no longer needs to compensate the agent for the decrease in his expected utility, and the "unpaid compensation" $-U_A^{\mathcal{A}} = (1-r_i)z/p^{\mathcal{A}}$ that goes to the principal as excess of expected fines, measures the potential offender's loss of welfare when his burden of proof is increased to be presumed guilty when accused with type-l evidence.[25] *Thus, in the standard case of crime, lower collusion prevention and expected trial costs should make the presume innocence rule a better alternative.*

4 Potential Benefits of Presuming Guilt

In this section we introduce a constraint on available resources (ex-post) to motivate law enforcers, maintaining the assumption that they may collude with potential offenders, and next we consider the case of reliable law enforcers who never collude. We show that in each of these cases shifting the burden of proof to the accused may become the preferred alternative.

4.1 Bounded Rewards

The rewards to motivate law enforcers in gathering type-h evidence, as we have shown in Section 3, can become arbitrarily large as the target level of crime/corruption approaches zero (see the incentive scheme in Proposition 1, Allocation $\mathcal{S}$.) If the principal's resources are limited, it will not be credible to promise such large rewards. Let $\overline{R}$ be the maximum reward that the principal can afford. An upper bound $\overline{R}$ on reward(s) affects the principal's objective indirectly by limiting the utility that the supervisor expects from monitoring and producing evidence. The

[25]An objection to this argument would be that the principal should "internalize" the agent's loss of welfare and include it into his cost objective, in other words, that "agent compensation costs" should be taken into consideration even if the agent is not an employee of the principal. Our conclusion in this subsection would then hold even stronger, removing the minor qualification mentioned in Remark 4 following Proposition 1.

principal then may not be able to induce the minimal collusion-proof effort m_z^j, especially for low $\overline{b}$ levels. We show that the relevance of this undesirable effect depends on the supervisor's proof burden.

Proposition 2 *Any crime/corruption target* $\overline{b} \in (0,\, 1)$ *can be implemented through Allocation* $\mathcal{A}$ *if and only if*

$$\overline{R} \geq \overline{R}^{\mathcal{A}} \equiv \frac{1}{(1-r_i)} \frac{c'(m_z^{\mathcal{A}})}{\mu'(m_z^{\mathcal{A}})}, \tag{12}$$

and through Allocation $\mathcal{S}$ *if and only if*

$$\overline{R} \geq \overline{R}^{\mathcal{S}}(\overline{b}) \equiv \frac{1}{\overline{b} p_g^h} \frac{c'(m_z^{\mathcal{S}})}{\mu'(m_z^{\mathcal{S}})}.$$

Thus, given any finite $\overline{R} \geq \overline{R}^{\mathcal{A}}$*, there exists a critical crime/corruption target*

$$\overline{b}_S(\overline{R}) = \frac{1}{\overline{R} p_g^h} \frac{c'(m_z^{\mathcal{S}})}{\mu'(m_z^{\mathcal{S}})},$$

such that $\overline{b} \in (0,\ \overline{b}_{\mathcal{S}}(\overline{R}))$ *can be implemented only through Allocation* $\mathcal{A}$*.*

The (ex-post) resource constraint raises a completely different and new concern from the previously discussed comparisons of costs due to evidence production, trials, collusion prevention, and agent compensation. The issue here is not which kind of legal presumption achieves crime/corruption implementation at lower cost, but rather which presumption can *at all* achieve this objective for especially low crime/corruption targets.

Proposition 2 states that modifying legal presumptions to shift the burden of proof to the agent is the only solution to reducing crime/corruption below a critical target level $\overline{b}_S(\overline{R})$ if the maximal reward $\overline{R}$ is bounded above, provided that this bound exceeds $\overline{R}^{\mathcal{A}}$ defined in (12). The intuition is as follows. The critical upper bounds $\overline{R}^{\mathcal{S}}(\overline{b})$ and $\overline{R}^{\mathcal{A}}$ are derived from the equilibrium conditions (8$\mathcal{S}$) and (8$\mathcal{A}$S) or (8$\mathcal{A}$U), determining the supervisor's optimal effort. The rewards at these bounds are just enough to induce the minimal effort m_z^j that prevents ex-ante collusion. Now, the supervisor's expected rewards ER^j depend, proportionately, on both the likelihood of crime/corruption $\overline{b}$ *and* reward(s) R^j. When $\overline{b}$ is low, relatively high rewards should be promised under Allocation $\mathcal{S}$ to induce the minimal collusion-proof monitoring effort; this is so because under Allocation $\mathcal{S}$ the probability of producing the corresponding high quality evidence and being rewarded is relatively low. On the other hand, relatively modest rewards induce the appropriate effort given the higher probability of generating at least type-l evidence, of lower quality but admissible in court under Allocation $\mathcal{A}$. Therefore the reward constraint will have a stronger bite with a heavy burden of proof on the supervisor. This result provides a possible explanation of why several countries that lack the proper resources or where the law enforcement agencies are inept in generating high quality evidence have resorted to changing legal presumptions and shifting the burden of proof to the accused, especially in their fight against corruption.

4.2 Law Enforcement without Collusion

We modify one more assumption and consider the case of law enforcement without collusion with potential offenders, such as special investigative agencies with their elite corps of investigators.

4.2.1 Crime Prevention

Consider the standard case of crime prevention (the agent is not an employee of the principal) studied in Section 3, but now assume that the law enforcer (or the supervisor) never colludes. Thus, collusion-proofness constraints (9) and (10) are dropped. In the absence of these constraints (which, as we have shown earlier, generate an endogenous upper bound on penalty) the principal can implement arbitrarily low levels of crime by imposing arbitrarily high penalties. We shall accordingly assume that the agent can be imposed only up to a maximum penalty $\overline{F}$.[26] The results derived below do not depend on the level of $\overline{F}$.

Below we review the principal's problem of crime implementation at minimum cost. The agent's expected utility is

$$U_A^j = \bar{b}z - \overline{X}^j \mu(m) F^j \tag{13}$$

where $\overline{X}^j$, the probability of conviction conditional on production of evidence (type-l or h), is defined in (4). Recall the equilibrium conditions: First, to implement a crime target $\bar{b} \in (0, 1)$ the agent's effective expected penalty must be equal to the

[26] Upper bounds on penalties are required by constitution in many countries. For instance the Eighth Amendment to the U.S. Constitution states that "Excessive bail shall not be required, nor excessive fines imposed, nor cruel and unusual punishment inflicted."

benefit from committing the crime. From (13) and using (4), this condition can be expressed as in (5):

$$F^{\mathcal{S}} = \frac{z}{p_g^h \mu(m_I^{\mathcal{S}})} \qquad \text{or} \qquad F^{\mathcal{A}} = \frac{z}{p^{\mathcal{A}} \mu(m_I^{\mathcal{A}})}. \tag{14}$$

The second equilibrium condition requires that the principal induce the supervisor to exert the effort m_I^j ($j = \mathcal{S}, \mathcal{A}$) through (8$\mathcal{S}$) or (8$\mathcal{A}$S) or (8$\mathcal{A}$U) that also satisfies (14). Following the same procedure as in the proof of Proposition 1, it can be shown that the principal's cost objective stipulates inducing the minimal possible enforcement effort. Now, in the absence of collusion possibilities, the upper bound on penalties will generate a lower bound on induced effort. This lower bound on m, as we show, depends on the allocation, $j = \mathcal{A}, \mathcal{S}$. The difference between total costs under the two allocations can be expressed as in (11), which we reproduce below:

$$TC^{\mathcal{A}} - TC^{\mathcal{S}} = [c(m_I^{\mathcal{A}}) - c(m_I^{\mathcal{S}})] - [\frac{(1-r_i)z}{p^{\mathcal{A}}}] + [EL^{\mathcal{A}} - EL^{\mathcal{S}}].$$

As discussed in subsection 3.2, the second and the third terms in the brackets reflect respectively excess of expected fine collections and expected trial costs under Allocation $\mathcal{A}$. Now, the first term measures the excess of evidence production costs under Allocation $\mathcal{A}$, which we show below is determined by the relative magnitude of type I and type II errors associated with the two allocation rules.

To induce the minimal effort that implements the crime target $\bar{b}$ at minimum cost, the principal should set the penalties maximal under both allocation rules. The optimal rewards are then determined using (8$\mathcal{S}$), (8$\mathcal{A}$S) and (8$\mathcal{A}$U) where $F^j = \overline{F}$.[27] Using $F^j = \overline{F}$, the equilibrium condition (14) can be expressed as

$$z = p_g^h \mu(m_I^{\mathcal{S}})\overline{F} \qquad \text{or} \qquad z = p^{\mathcal{A}} \mu(m_I^{\mathcal{A}})\overline{F}, \tag{15}$$

where $p^{\mathcal{A}} = p_g^h + (1-p_g^h)(1-r_g) - (1-r_i)$ and $p_g^h = p^{\mathcal{S}}$ are the effective probabilities of conviction *conditional* on production of evidence, as defined in Section 3. Thus $p^{\mathcal{A}}\mu(m_I^{\mathcal{A}})$ and $p_g^h\mu(m_I^{\mathcal{S}})$ are the (unconditional) effective probabilities of conviction

[27] It should not be surprising that the penalties are set maximal within the bounds permissible by law: compared to the alternative, costly instrument of inducing intensive monitoring effort through higher rewards, raising penalties is costless and can even generate revenue for the principal when penalties take the form of fines. If imposing penalties is very costly, however, then a trade-off may be involved in the choice of penalties.

under allocations $\mathcal{A}$ and $\mathcal{S}$, respectively. From (15) we conclude that $m_I^{\mathcal{A}} < m_I^{\mathcal{S}}$, and therefore $c(m_I^{\mathcal{S}}) > c(m_I^{\mathcal{A}})$ if and only if $p^{\mathcal{A}} > p_g^h$. We summarize our observations in Proposition 3, followed by the underlying intuition:

Proposition 3 *With a collusion-free law enforcement and rewards paid for successful monitoring not bounded above, for any crime target, evidence production costs $c(m_I^j)$ are lower under Allocation $\mathcal{A}$, with a relatively heavy burden of proof on potential offenders, if and only if* $(1 - r_i) < (1 - p_g^h)(1 - r_g)$.

When collusion can be ruled out, the evidence production cost advantage of a particular legal presumption should depend on its effect on individual criminal incentives. This, in turn, depends on the induced proportion of accurate decisions rather than only convictions or acquittals, in other words, on the *(conditional)* effective probabilities of convictions, $p^{\mathcal{A}}$ and $p^{\mathcal{S}}$. An increase in the probability of accurate acquittals and convictions induces agents to remain innocent, which the principal should encourage, while an increase in the probability of inaccurate convictions and acquittals induces agents to become criminals, which the principal should discourage. If $p^{\mathcal{A}} - p^{\mathcal{S}} > 0$ then by switching from the presume innocence to the presume guilt rule the increase in the probability of avoiding an inadequate acquittal (i.e., avoiding type II error) will exceed the increase in the probability of a wrongful conviction (i.e., committing a type I error), and the incentives to remain innocent are strengthened. As a result, changing legal presumptions to reduce law enforcers' burden of proof generates a fall in the required intensity of monitoring and cost of evidence production.

To obtain the general picture, the other two costs items in $TC^{\mathcal{A}} - TC^{\mathcal{S}}$ given in (11) (and reproduced above) should be included. As mentioned, though expected fine collections are larger under Allocation $\mathcal{A}$, so are expected trial costs. It should be noted that implementing a crime target through less intensive enforcement effort is a factor that also reduces trial costs: the probability of producing evidence of any given quality will decrease ($\mu(m)$ will fall), therefore fewer cases will make it to the courtroom. In light of this, if $(1 - r_i) < (1 - p_g^h)(1 - r_g)$ so that evidence production costs are lower under Allocation $\mathcal{A}$, we have $m_I^{\mathcal{A}} < m_I^{\mathcal{S}}$, hence $\mu(m_I^{\mathcal{A}}) < \mu(m_I^{\mathcal{S}})$. Despite the lower probability of generating any evidence under Allocation $\mathcal{A}$, the probability of generating evidence of quality admissible in court, hence expected trial costs, could still be higher under Allocation $\mathcal{A}$. Despite this fact, lower evidence production costs and higher expected fine collections (if included) could make Allocation $\mathcal{A}$ overall cheaper for the principal.

4.2.2 Corruption Control

How would our conclusion change if the agent is an employee of the principal and the crime that the principal wants to control is, say, corruption? The analysis is the same as above, except that now we have to take into consideration the agent's participation constraint. Agent compensation costs, as shown in Section 3, are positive and given by $(1 - r_i)\mu(m_I^{\mathcal{A}})\overline{F}$ under Allocation $\mathcal{A}$ because the agent risks a punishment even when he remains innocent. Then the term $(1 - r_i)z/p^{\mathcal{A}}$ in (11) vanishes, and we reach the following conclusion: lower evidence production costs will imply lower total costs under Allocation $\mathcal{S}$.

Proposition 4 *When law enforcers do not collude and the potential offender is an employee of the state, the expected costs of implementing any target level of corruption is lower under Allocation $\mathcal{S}$ if $(1 - r_i) \geq (1 - p_g^h)(1 - r_g)$.*

Note that Proposition 4 is only a "sufficiency" result. If $(1 - r_i) < (1 - p_g^h)(1 - r_g)$ then $c(m_I^{\mathcal{A}}) < c(m_I^{\mathcal{S}})$, so that "evidence production" costs are lower under Allocation $\mathcal{A}$. But expected trial costs may still be higher under Allocation $\mathcal{A}$ to the extent that Allocation $\mathcal{S}$ turns out to be cheaper in overall implementation costs. Allocation $\mathcal{A}$ will have a large advantage in evidence production costs if r_i is sufficiently large and r_g is sufficiently small; i.e., if the innocent agent is likely, while the guilty agent is unlikely, to disprove an accusation supported by type-l evidence, and/or p_g^h, the probability of obtaining a high-quality evidence (when the agent is guilty), is small.

5 Conclusion

The standard approach in determining legal presumptions or the optimal standard of proof in trials uses a set-up in which a fact-finder, adjudicating on a (possible) crime already committed, maximizes the probability that the verdict is correct, based on the evidences presented by the accuser and the accused. This paper addresses the problem from a different perspective. We focus on the ex-ante stage of crime prevention and investigate the cost-efficient legal presumption in implementing a target level of crime. We show that the objective of minimizing expected law enforcement costs alone provides a sufficient rationale for presuming innocence, except possibly in the following cases: (i) the law enforcement system is collusion-free, (ii) an (ex-post) resource constraint limits rewards to successful law enforcers.

Minimizing law enforcement costs should be an important criterion in evaluating legal presumptions. We believe that our results and analysis nicely complement those that are based on the (equally important) criterion of minimizing social costs of verdict errors associated with different legal presumptions.

6 Appendix

Proof of Proposition 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 (2), (3), (7), (8), (9) and (10).

As a first step, we show that the optimal incentive scheme binds the agent's participation constraint (2). Fix any $\bar{b} \in (0, 1)$. Use the equilibrium condition (7) to rewrite (2) as

$$U_A^{\mathcal{S}} = w_A^{\mathcal{S}}; \qquad U_A^{\mathcal{A}} = w_A^{\mathcal{A}} - (1 - r_i)\mu(m)F^{\mathcal{A}}.$$

If, contrary to our claim, $U_A^j > 0$, then $w_A^j > 0$. But then w_A^j can be lowered, while still satisfying the participation constraint (2), to reduce implementation costs. Thus, $w_A^{\mathcal{S}} = 0$, and by (7), $w_A^{\mathcal{A}} = (1 - r_i)z/p^{\mathcal{A}} > 0$.

Similarly, the supervisor's participation constraint is also binding. Since the supervisor can always choose zero effort, net (expected) rewards from monitoring, $ER^j(\bar{b}, m) - c(m)$, is always nonnegative and, as we show below, will be strictly positive; by setting $w_S^j = c(m) - ER^j(\bar{b}, m) < 0$,[28] the principal fully extracts the supervisor's rent. Thus, w_S^j is determined, once the optimal 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 (8$\mathcal{S}$) (resp. (8$\mathcal{A}$S) or (8$\mathcal{A}$U)) implies that $m^* > 0$ for

[28] $w_S^j < 0$ should not be interpreted literally as negative wage, given that the supervisor's outside option is normalized to zero. If the outside option is worth $\overline{w}$ then $w_S^j = \overline{w} + c(m) - ER^j(\bar{b}, m)$, which can be positive. In any case, setting a nonnegative wage restriction does not affect any of the results, including this proposition, qualitatively; the principal may have to leave some rent to the supervisor.

$R^{\mathcal{S}} > 0$ (resp. $(R_h^{\mathcal{A}}, R_l^{\mathcal{A}}) > 0$ or $R_{lh}^{\mathcal{A}} > 0$), and the maximized net rewards equal

$$\frac{c'(m^*)}{\mu'(m^*)}\mu(m^*) - c(m^*) > 0.^{29}$$

For the time being ignore the collusion-proofness constraints (9) and (10). Since the optimal incentive scheme must bind the agent's participation constraint, $w_A^j - EF^j(\bar{b}, m) = -\bar{b}z$, which, along with w_S^j derived above, used in (1) yields

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

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

Now introduce the possibility of ex-ante collusion. The ex-ante collusion-proofness condition (9) can be written, by making appropriate substitutions using conditions (6) (resp. (6S) or (6U)) and (8$\mathcal{S}$) (resp. (8$\mathcal{A}$S) or (8$\mathcal{A}$U)) in (9), in terms of the equilibrium induced effort m as follows:

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

The optimal penalties are already given by (7), but they depend on an endogenous variable, viz. the induced effort m, to be determined next. To obtain the expression of optimal rewards (which also depend on the induced effort m) we consider each allocation rule separately.

Allocation Rule $\mathcal{S}$. Under Allocation $\mathcal{S}$ the principal promises the supervisor a single reward $R^{\mathcal{S}}$ if type-h evidence is produced, which establishes guilt. To obtain the equilibrium induced effort $m^{\mathcal{S}}$ and the expression of $R^{\mathcal{S}}$, recall that total 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 $m \to m^+$, and approaches zero as $m \to 0$. (The claim that the left hand side of $(A2)$ is unbounded above is proved in Claim 1, following the proof of Proposition 1.) Therefore a minimal effort $m_z^{\mathcal{S}}$ that satisfies $(A2)$ with equality, where $w_A^{\mathcal{S}} = 0$, exists.

The effort $m_z^{\mathcal{S}}$ is indeed the optimal induced effort. To show this, we need to show that the ex-post collusion-proofness constraint (10), which we ignored until

[29] That $\phi_S(m^*, \bar{b})$ will be positive, is easy to show: $\phi_S(0, \bar{b}) = 0$, because by Assumption 1 $c'(0) = 0$, $\mu'(0) = \infty$ and $c(0) = 0$, and then apply the fact that $\phi_S(m, \bar{b})$ is increasing in m.

now, is implied by the ex-ante collusion-proofness condition (9). To this end, rewrite (9) as follows:

$$\begin{aligned} \bar{b}p_g^h R^{\mathcal{S}} \mu(m) &\geq z + c(m) \\ \text{i.e.,} \qquad R^{\mathcal{S}} &\geq \frac{c(m)}{\bar{b}p_g^h \mu(m)} + \frac{z}{\bar{b}p_g^h \mu(m)}, \text{ and using (7),} \\ &= \frac{c(m)}{\bar{b}p_g^h \mu(m)} + \frac{F^{\mathcal{S}}}{\bar{b}} > F^{\mathcal{S}}. \end{aligned}$$

Therefore, the optimal induced effort is $m_z^{\mathcal{S}}$; by ($8\mathcal{S}$), $R^{\mathcal{S}} = [c'(m_z^{\mathcal{S}})/\mu'(m_z^{\mathcal{S}})][1/(\bar{b}p_g^h)]$, and by (7), $F^{\mathcal{S}} = z/[p_g^h \mu(m_z^{\mathcal{S}})]$. Finally, implementation costs under Allocation $\mathcal{S}$, given by ($A1$) with $m = m_z^{\mathcal{S}}$, can be further simplified using ($A2$) holding with equality as $TC^{\mathcal{S}} = c(m_z^{\mathcal{S}}) - \bar{b}z + EL^{\mathcal{S}}$.

Allocation Rule $\mathcal{A}$ – sophisticated case. Consider now the Allocation Rule $\mathcal{A}$ under the sophisticated principal assumption. We already established that $w_A^{\mathcal{A}} = (1 - r_i)z/p^{\mathcal{A}}$, which, substituted into the ex-ante collusion-proofness condition ($A2$), yields:

$$\frac{c'(m)}{\mu'(m)}\mu(m) - c(m) \geq z[1 + \frac{(1-r_i)}{p^{\mathcal{A}}}]. \tag{A3}$$

As under Allocation $\mathcal{S}$, the principal must induce at least a (minimal) effort $m_z^{\mathcal{A}}$ satisfying ($A3$) with equality. Since $(c'(m)/\mu'(m))\mu(m) - c(m)$ is increasing in m, $m_z^{\mathcal{A}} > m_z^{\mathcal{S}}$. To check that $m_z^{\mathcal{A}}$ is the optimal induced effort, we need to show that ex-post collusion-proofness constraints in (10) are satisfied. (Ex-ante collusion-proofness is already satisfied through ($A3$), provided rewards $(R_h^{\mathcal{A}}, R_l^{\mathcal{A}})$ are chosen to induce $m_z^{\mathcal{A}}$ by satisfying eq. ($8\mathcal{A}$S).) Thus, we need to determine suitable penalty and rewards. First determine the penalty, using (7), as $F^{\mathcal{A}} = z/[p^{\mathcal{A}}\mu(m_z^{\mathcal{A}})]$. Now choose $R_l^{\mathcal{A}} = F^{\mathcal{A}}$ to satisfy the first constraint in (10) for $n = l$. Next determine $R_h^{\mathcal{A}}$ using ($8\mathcal{A}$S) to yield the expression given in the proposition. By construction, $(R_h^{\mathcal{A}}, R_l^{\mathcal{A}})$ induce $m_z^{\mathcal{A}}$ and satisfy ($A3$), and equivalently (9). Therefore rewrite (9) as

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

which can be simplified to

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

implying $R_h^{\mathcal{A}} > F^{\mathcal{A}}$, thus satisfying the second constraint in (10) for $n = h$.

Implementation costs under Allocation $\mathcal{A}$ (with a sophisticated principal) are thus given by

$$TC^{\mathcal{A}} = c(m_z^{\mathcal{A}}) - \bar{b}z + EL^{\mathcal{A}}.$$

Since $m_z^{\mathcal{S}} < m_z^{\mathcal{A}}$ and $EL^{\mathcal{S}} < EL^{\mathcal{A}}$, implementation costs are lower under Allocation $\mathcal{S}$.[30]

The treatment of the unsophisticated principal case is very similar to the sophisticated principal's case and hence is omitted. **Q.E.D.**

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

Proof of Claim 1: Suppose not. Then there is a finite K such that $(c'(m)/\mu'(m))\mu(m) - c(m) \leq K$ for all m that can be induced. Choose any particular $\tilde{m}$ induced by an appropriate reward, $\tilde{R}^{\mathcal{S}}$, such that[31]

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

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

$$\frac{c'(\tilde{\tilde{m}})}{\mu'(\tilde{\tilde{m}})}\mu(\tilde{\tilde{m}}) - c(\tilde{\tilde{m}}) > \bar{b}p_g^h\tilde{\tilde{R}}^{\mathcal{S}}\mu(\tilde{m}) - c(\tilde{m}) > K.$$

Contradiction. ||

Proof of Proposition 2: *Allocation Rule $\mathcal{A}$ – sophisticated case.* Suppose that any corruption target $\bar{b} \in (0, 1)$ can be implemented through Allocation $\mathcal{A}$, when the principal is sophisticated. Then using (8$\mathcal{A}$S) where $R_h^{\mathcal{A}} = R_l^{\mathcal{A}} = \overline{R}$, we must have

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

[30] Crucial to the determination of implementation costs is the induced effort $m_z^{\mathcal{A}}$. There can be more than one combination of $(R_h^{\mathcal{A}}, R_l^{\mathcal{A}})$ that are consistent with $m_z^{\mathcal{A}}$, and we mentioned only one such combination.

[31] A similar argument holds for either $R^j \equiv (R_h^{\mathcal{A}}, R_l^{\mathcal{A}})$ or $R^j = R_{lh}^{\mathcal{A}}$, as long as the rewards can be chosen to be sufficiently large.

and taking $\overline{b} \to 0$ conclude that

$$\overline{R} \geq \frac{1}{(1-r_i)} \frac{c'(m_z^{\mathcal{A}})}{\mu'(m_z^{\mathcal{A}})}. \tag{A4}$$

We claim that $(A4)$ is sufficient for (full) collusion-proof implementation of any $\overline{b} \in (0,\, 1)$. To see this, write the ex-ante collusion-proofness constraint (A2) as

$$\mu(m_z^{\mathcal{A}})[c'(m_z^{\mathcal{A}})/\mu'(m_z^{\mathcal{A}})] \geq c(m_z^{\mathcal{A}}) + z + w_A^{\mathcal{A}} = c(m_z^{\mathcal{A}}) + z + (1-r_i)z/p^{\mathcal{A}}.$$

By (A4) there exist rewards $R_h^{\mathcal{A}}$ and $R_l^{\mathcal{A}}$ that induce the effort $m_z^{\mathcal{A}}$ satisfying this condition. Furthermore, using $(A4)$ in the above condition we obtain

$$\overline{R} \geq \frac{1}{(1-r_i)} \frac{c'(m_z^{\mathcal{A}})}{\mu'(m_z^{\mathcal{A}})} > \frac{1}{\mu(m_z^{\mathcal{A}})} \{\frac{z}{(1-r_i)} + \frac{z}{p^{\mathcal{A}}}\} = \frac{z}{\mu(m_z^{\mathcal{A}})(1-r_i)} + F^{\mathcal{A}}.$$

Therefore $\overline{R} > F^{\mathcal{A}}$, and it is possible to find rewards $R_h^{\mathcal{A}}, R_l^{\mathcal{A}} \leq \overline{R}$ such that ex-post collusion-proofness constraints hold and all other optimality conditions are satisfied.

Allocation Rule $\mathcal{A}$ – unsophisticated case. The arguments are similar to the sophisticated case. The critical upper bound $\overline{R}$ can established from (8$\mathcal{A}$U) as

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

Condition $(A4)$ implies that all $\overline{b} \in (0,1)$ can be implemented.

Allocation Rule $\mathcal{S}$. Suppose that any corruption target $\overline{b} \in (0,\, 1)$ can be implemented through the Allocation $\mathcal{S}$. Then using (8$\mathcal{S}$) we conclude that

$$\overline{R} \geq \frac{1}{\overline{b}p_g^h} \frac{c'(m_z^{\mathcal{S}})}{\mu'(m_z^{\mathcal{S}})}. \tag{A5}$$

That this condition is also sufficient for implementation of a specific $\overline{b} \in (0,\, 1)$, follows directly from Proposition 1. Now since

$$\lim_{\overline{b} \to 0} \frac{1}{\overline{b}p_g^h} \frac{c'(m_z^{\mathcal{S}})}{\mu'(m_z^{\mathcal{S}})} = \infty,$$

the constraint $(A5)$ cannot be satisfied for low $\overline{b}$-values given an upper bound reward $\overline{R}$. In particular, given a fixed, finite $\overline{R} \geq [1/(1-r_i)][c'(m_z^{\mathcal{A}})/\mu'(m_z^{\mathcal{A}})]$, though all $\overline{b} \in (0,\, 1)$ can be implemented through Allocation $\mathcal{A}$, no

$$\overline{b} \in (0,\ \frac{1}{\overline{R}p_g^h} \frac{c'(m_z^{\mathcal{S}})}{\mu'(m_z^{\mathcal{S}})}),$$

can be implemented through Allocation $\mathcal{S}$. **Q.E.D.**

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