

# Learning and Corruption on Monitoring Chains<sup>†</sup>

By BRUNO STRULOVICI\*

Many institutions rely on specific agents, or “monitors,” for their enforcement. These monitors are subject to incentive problems such as shirking—emphasized by the inspection games literature (Dresher 1962, Maschler 1966)—fabrication, and corruption (Becker and Stigler 1974).

This issue is fundamental for the enforcement of legal and political institutions as well as for numerous other institutions, such as trade institutions (Milgrom, North, and Weingast 1990), financial markets, and agencies in charge of taxation and auditing.

When monitors cannot merely be trusted to behave ethically, they must also be monitored, their monitors must be monitored, and so on. This issue has been recognized by Hurwicz (2007), who proposed a cyclical incentive structure:  $B$  monitors  $A$ ,  $C$  monitors  $B$ 's monitoring of  $A$ ,  $A$  monitors  $C$ 's monitoring of  $B$ 's monitoring of  $A$ .<sup>1</sup>

However, this structure seems vulnerable to collusion, not least because monitors exert indirect control over their own monitors. In practice, monitors are rarely monitored by their own target, even indirectly. However, collusion between enforcers is a real and well-documented concern.<sup>2</sup>

This paper studies the effect of collusion along *monitoring chains*, along which each monitor is

monitored by a new monitor. The main result is that when (i) monitors are devoid of ethical motives and have quasilinear preferences and (ii) any two consecutive monitors in the chain can make Pareto-improving corruptive arrangements, truthful, collusion-free monitoring is impossible unless rewards and/or punishments are unbounded.

In these monitoring chains, even a local form of collusion suffices to derail monitoring. This result underlines the importance of ethical behavior for the enforcement of institutions. In a separate paper (Strulovici 2020), I consider a decentralized monitoring structure that is immune to collusion but show that learning environments that are subject to *information attrition* also require ethical behavior.

## I. Model

### A. Investigation Structure

We consider a sequence  $\{M_n\}_{n \in \mathbb{N}}$  of agents forming a monitoring chain.

**Round 0:** Agent  $M_0$  decides between committing a crime and abstaining from it.

**Round 1:** Agent  $M_1$  decides between investigating  $M_0$  at cost  $c > 0$  and shirking at no (direct) cost. If  $M_0$  committed the crime and  $M_1$  investigates him,  $M_1$  discovers  $M_0$ 's guilt with probability  $\lambda \in (0, 1]$ . If  $M_1$  shirks, he finds nothing.

Agent  $M_1$  then makes a public announcement:  $M_1$  can either claim that he discovered that  $M_0$  was guilty or say that he found nothing.

If  $M_1$  made no discovery, which happens because  $M_0$  was innocent,  $M_1$  was unlucky (when  $\lambda < 1$ , the investigation does not always succeed even if  $M_0$  is guilty), or because  $M_1$  shirked,  $M_1$  can still claim that  $M_0$  committed a crime, that is, make a *wrongful* accusation. An accusation is wrongful if it is unsubstantiated. It does not imply, per se, that the accused is innocent of the crime.

\*Northwestern University (email: b-strulovici@northwestern.edu). I am grateful to Steve Callander, Théo Durandard, Ariel Rubinstein, Leeat Yariv, and participants of 2019 Summer School of the Econometric Society in Sapporo, Japan, and the ASSA 2021 Virtual Annual Meeting.

<sup>†</sup>Go to <https://doi.org/10.1257/pandp.20211053> to visit the article page for additional materials and author disclosure statement.

<sup>1</sup>See also Levine and Modica (2016). Rahman (2012) proposes an ingenious way to incentivize first-degree monitoring, although this way is vulnerable to corruption between the principal and the monitored agent.

<sup>2</sup>Well-known examples in the United States include the findings of the Knapp and Mollen commissions in New York City. Most countries exhibit significantly more corruption. See, e.g., Transparency International: <https://www.transparency.org/en/cpi>.

If  $M_1$  announces that he found nothing, the game ends.<sup>3</sup> Otherwise, it moves to round 2, and another agent,  $M_2$ , is tasked to investigate  $M_1$ 's claim that  $M_0$  committed a crime.

**Round 2:**  $M_2$  decides between investigating  $M_1$  at cost  $c$  and shirking. If  $M_1$  accused  $M_0$  without proof and  $M_2$  investigates him,  $M_2$  discovers  $M_1$ 's wrongdoing with probability  $\lambda$ .

Agent  $M_2$  then makes a public announcement:  $M_2$  can either claim that he discovered that  $M_1$  wrongfully accused  $M_0$  or announce that he discovered nothing against  $M_1$ . If  $M_2$  made no discovery (which can arise if  $M_1$  is innocent,  $M_2$  was unlucky, or  $M_2$  shirked),  $M_2$  can still accuse  $M_1$  of making an unsubstantiated claim.

If  $M_2$  announces that he has found nothing against  $M_1$ , the game ends. Otherwise, the game moves to round 3. Another agent,  $M_3$ , is tasked with investigating  $M_2$ 's claim, and so on.

**Collusion:** If  $M_n$  discovers wrongdoing by  $M_{n-1}$ , he can offer to hide his discovery in exchange for a transfer  $\tau_n$  from  $M_{n-1}$ . This possibility captures a local form of collusion between  $M_n$  and  $M_{n-1}$ . While we focus on a take-it-or-leave-it offer by  $M_n$ , other efficient bargaining protocols, in which  $M_{n-1}$  has some bargaining power, would yield similar results.<sup>4</sup>

### B. Payoffs

If  $M_n$  claims to have discovered that  $M_{n-1}$  has made a wrongful accusation, he receives a monetary reward  $R_n \geq 0$  for his discovery, and  $M_{n-1}$  receives a punishment  $P_{n-1} \geq 0$ . By making this claim,  $M_n$  exposes himself to the risk of being accused (rightly or not) of wrongful behavior.

Players are assumed to be risk neutral, and all payoffs (investigation costs, rewards,

punishments, and transfers) are additively separable. A monitor's payoff if the game ends before his round is normalized to 0.

It is simplest to think of the punishment  $P_{n-1}$  as a fine, but  $P_{n-1}$  could alternatively represent a nonmonetary, additively separable punishment. In principle, we could allow  $M_{n-1}$  to be exonerated if  $M_n$ 's accusation is claimed (rightly or not) to be unsubstantiated by  $M_{n+1}$ , punished again if  $M_n$ 's accuser is found to have lied, and so on. We rule this out for simplicity and assume that  $M_{n-1}$  is punished whenever he is accused.<sup>5</sup>

We start with the following observation. Let  $\alpha_{n+1}$  denote the probability that  $M_{n+1}$  wrongfully accuses  $M_n$  conditional on reaching round  $n + 1$ .

**LEMMA 1:** *Suppose that  $M_n$  discovers that  $M_{n-1}$  made a wrongful claim. Then,  $M_n$  surely hides his discovery unless*

$$(1) \quad R_n - \alpha_{n+1}P_n \geq P_{n-1}.$$

**PROOF:**

Suppose that  $M_n$  discovers that  $M_{n-1}$  has made a wrongful claim. If  $M_n$  makes his (rightful) discovery public, his payoff increases by an immediate reward  $R_n$ , less an expected fine if he is wrongfully accused by  $M_{n+1}$ , which happens with probability  $\alpha_{n+1}$  and carries an expected cost of  $P_n$  whenever it occurs, while  $M_{n-1}$  receives the fine  $P_{n-1}$ . Therefore, revealing the discovery results in a joint surplus to  $M_n$  and  $M_{n-1}$  of  $R_n - \alpha_{n+1}P_n - P_{n-1}$  relative to the pair's surplus if  $M_n$  hides the discovery, thereby ending the game. Since transfers allow  $M_n$  and  $M_{n-1}$  to maximize their joint surplus,  $M_n$  produces the evidence in equilibrium only if  $R_n - \alpha_{n+1}P_n - P_{n-1} \geq 0$ . Otherwise,  $M_n$  hides the evidence in exchange for a transfer  $\tau_n \in [R_n - \alpha_{n+1}P_n, P_{n-1}]$ . Under a take-it-or-leave-it offer protocol,  $M_n$  gets a transfer  $\tau_n = P_{n-1}$  if he gets to make the offer and a transfer  $\tau_n = R_n - \alpha_{n+1}P_n$  if  $M_{n-1}$  gets to make the offer. When both players have bargaining power, any transfer  $\tau_n$  between these bounds can be microfounded by an efficient bargaining protocol. ■

<sup>5</sup>A simple interpretation of this is that each agent lives for two periods: monitoring in the first period and dying in the second one.

<sup>3</sup>This assumption drastically simplifies the analysis, as it implies that there is only one public history at the beginning of any round that is reached (see Section II). The analysis can be extended to the case in which a monitor who finds nothing can also be investigated. Theorem 1 continues to hold under the additional assumption that  $\lambda < 1/2$ . See Section III.

<sup>4</sup>If two of more agents were used at each level of the monitoring chain, this may make collusion harder, although it would also create a collective decision problem for the findings.

Thus, collusion can be prevented only if  $R_n \geq P_{n-1} + \alpha_{n+1}P_n$ . When this condition is violated, any public accusation made by  $M_n$  must be a lie, because true discoveries by  $M_n$  are always hidden. To avoid this, we focus on the case in which  $R_n \geq P_{n-1} + \alpha_{n+1}P_n$  and assume that agents do not collude (alternatively, we could assume a strict inequality, which implies that collusion does not occur). We call such an equilibrium a *collusion-free* equilibrium. Focusing on collusion-free equilibria simplifies the analysis since monitors' choices are reduced to four possible strategies, described in the next section.

**II. Main Result**

In this game, there is a unique relevant *public* history: conditional on reaching round  $n$ , all monitors have claimed (rightly or not) that past monitors were lying.

In particular, there is a unique sequence of rewards  $\{R_n\}_{n \geq 1}$  along this history.

Let  $\beta_n \in [0, 1]$  denote the probability that  $M_n$  investigates  $M_{n-1}$  and truthfully announces his finding, conditional on reaching round  $n$ . If  $\beta_n = 0$ , this means that  $M_n$  either ends the sequence without performing an investigation or that he accuses  $M_{n-1}$  regardless of  $M_{n-1}$ 's actual guilt. Either way,  $M_n$ 's announcement is uninformative about  $M_{n-1}$ 's actions whenever  $\beta_n = 0$ .

**THEOREM 1:** *Suppose that  $\lambda < 1$  (imperfect signal). If the sequence  $\{R_n\}_{n \geq 1}$  is bounded above, then  $\beta_n = 0$  for all  $n$  in all collusion-free equilibria.*

Theorem 1 shows that truthful investigations are impossible unless an unbounded amount of resources can be devoted to monitoring: regardless of the budget available for monitoring, there is a path of observations, which has positive probability, that will exceed this budget. In particular, sequential monitoring that withstands a local form of collusion is impossible in any society with bounded resources.

To prove this result, we begin by expressing  $M_n$ 's payoffs for each possible strategy.

Let  $\gamma_{n-1}$  denote the probability that  $M_{n-1}$  has made a wrongful claim, conditional on round  $n$  being reached, and  $\delta_{n+1}$  denote the probability that  $M_{n+1}$  accuses  $M_n$  with probability 1

regardless of  $M_n$ 's guilt, conditional on round  $n + 1$  being reached.<sup>6</sup>

Agent  $M_n$  has four pure strategies (which he may, and typically will, randomize over).

*Truthful Investigation.*— $M_n$  investigates  $M_{n-1}$  and reports his finding truthfully. The expected payoff of this strategy is

$$(2) \quad \lambda \gamma_{n-1} (R_n - \delta_{n+1} P_n) - c.$$

Indeed,  $M_n$  incurs the investigation cost  $c$  and, with probability  $\lambda \gamma_{n-1}$ , discovers that  $M_{n-1}$  made a wrongful claim, resulting in expected reward  $R_n$ . However, with probability  $\delta_{n+1}$ ,  $M_n$  is falsely accused by  $M_{n+1}$  of making a wrongful claim.<sup>7</sup>

*Blind Accusation.*— $M_n$  shirks and accuses  $M_{n-1}$ . The resulting expected payoff is

$$(3) \quad R_n - (\lambda \beta_{n+1} + \delta_{n+1}) P_n.$$

Indeed, with probability  $\lambda \beta_{n+1}$ ,  $M_{n+1}$  investigates truthfully  $M_n$  and discovers his wrongful behavior, and with probability  $\delta_{n+1}$ ,  $M_{n+1}$  accuses  $M_n$  with probability 1 (possibly after shirking or after investigating  $M_n$ ).

*“Switching.”*— $M_n$  investigates  $M_{n-1}$  but accuses  $M_{n-1}$  even if he doesn't find anything. The resulting payoff is

$$(4) \quad \lambda \gamma_{n-1} (R_n - \delta_{n+1} P_n) - c + (1 - \lambda \gamma_{n-1}) (R_n - (\lambda \beta_{n+1} + \delta_{n+1}) P_n).$$

Indeed, with probability  $\lambda \gamma_{n-1}$ ,  $M_n$  discovers that  $M_{n-1}$  lied and rightfully accuses him. With probability  $1 - \lambda \gamma_{n-1}$ ,  $M_n$  discovers nothing but makes up an accusation, at the risk of getting himself accused (rightfully or not).

<sup>6</sup>Note that  $\alpha_n$  is smaller than  $\gamma_n$ , because the former is ex ante at round  $n$  and the latter is conditional on round  $n + 1$  being reached.

<sup>7</sup>Since  $M_n$  was truthful, he will be falsely accused if  $M_{n+1}$  uses either the “switching” or the “blind accusation” strategy, which has probability  $\delta_{n+1}$ .

*Closing.*— $M_n$  can save the cost of an investigation and simply end the game by announcing that he found nothing, in which case the payoff is 0.

**Remark:**  $\delta_n$  is the probability that  $M_n$  chooses either the “blind accusation” or the “switching strategy,”  $\beta_n$  is the probability that  $M_n$  chooses the truthful investigation strategy, and  $1 - \beta_n - \delta_n$  is the probability that  $M_n$  chooses the “closing” strategy.

**LEMMA: 2** *If  $R_n - (\lambda\beta_{n+1} + \delta_{n+1})P_n > 0$ ,  $M_n$  always accuses  $M_{n-1}$ , i.e.,  $\delta_n = 1$  and  $\beta_n = 0$ .*

**PROOF:**

From payoff equations (2)–(4) and the zero payoff from closing the case, the lemma’s inequality implies that blindly accusing  $M_{n-1}$  dominates closing the case and that switching dominates truthfully investigating  $M_{n-1}$ , which proves the lemma. ■

**LEMMA 3:** *If  $\beta_n = 0$ , then  $\beta_k = 0$  for all  $k \in \{1, \dots, n - 1\}$ .*

**PROOF:**

If  $\beta_n = 0$ , it is optimal for  $M_{n-1}$  to end the game or to blindly accuse  $M_{n-2}$  at no cost: if  $M_{n-1}$  makes an accusation,  $M_n$  will either close the investigation or accuse  $M_{n-1}$  regardless of the veracity of  $M_{n-1}$ ’s claim. Either way,  $\beta_{n-1} = 0$ . The result follows by backward induction. ■

**LEMMA 4:** *If  $\beta_{n+1} < c/P_n$ , then  $\beta_n = 0$ .*

**PROOF:**

From payoff equations (2) and (3),  $M_n$  strictly prefers blindly accusing  $M_{n-1}$  over investigating  $M_{n-1}$  truthfully unless

$$\begin{aligned} &\lambda\gamma_{n-1}(R_n - \delta_{n+1}P_n) - c \\ &\geq R_n - (\lambda\beta_{n+1} + \delta_{n+1})P_n, \end{aligned}$$

which is possible only if

$$\beta_{n+1}\lambda P_n \geq c + (1 - \lambda\gamma_{n-1})(R_n - \delta_{n+1}P_n).$$

The last term is nonnegative, and  $\lambda \leq 1$ . The claim follows. ■

**PROOF OF THEOREM 1:**

From Lemmas 2 and 3, either there exists a round  $N_1$  beyond which  $R_n - (\lambda\beta_{n+1} + \delta_{n+1})P_n > 0$  for all  $n > N$  or  $\beta_n = 0$  for all  $n \geq 1$ . From (1),  $R_{n+1} \geq P_n$  for all  $n$ . This implies that truthful investigation is possible only if for all  $n \geq N_1$ ,

$$R_n \leq (\lambda\beta_{n+1} + \delta_{n+1})R_{n+1}.$$

Likewise, from Lemmas 3 and 4, either there exists a round  $N_2$  beyond which  $\beta_{n+1} \geq c/P_n$  for all  $n \geq N_2$  or  $\beta_n = 0$  for all  $n \geq 1$ . From (1),  $R_{n+1} \geq P_n$  for all  $n$ . Therefore, truthful investigation is possible only if

$$\beta_{n+1} \geq c/R_{n+1}$$

for all  $n \geq N_2$ . In particular, this implies that  $R_n \geq c$  for all  $n \geq N_2 + 1$ .

Now suppose that  $\{R_n\}$  is bounded above by some constant  $\bar{R}$  (which, as noted, must exceed  $c$ ). Combining previous observations and letting  $N = \max\{N_1, N_2\} + 1$ , truthful investigation is possible only if

- $\beta_n \geq c/\bar{R}$ ,
- $\frac{1}{\lambda\beta_{n+1} + \delta_{n+1}}R_n \leq R_{n+1}$ ,

for all  $n \geq N$ . Since  $\delta_{n+1} \leq 1 - \beta_{n+1}$  and the function  $x \mapsto \lambda x + (1 - x)$  is decreasing on  $[0, 1]$  for  $\lambda \leq 1$ , this implies that

$$(5) \quad R_{n+1} \geq GR_n$$

for all  $n \geq N$ , where  $G = 1/(\lambda(c/\bar{R}) + (1 - c/\bar{R}))$  is strictly greater than 1 because  $\lambda < 1$ . Iterating (5) from  $N$  to  $N + T - 1$ , we get

$$R_{N+T} \geq G^T R_N,$$

and hence  $R_{N+T}$  diverges to  $+\infty$  as  $T \rightarrow +\infty$ , which contradicts the assumption that  $\{R_n\}$  was bounded above.

This shows that either  $\{R_n\}_{n \geq 1}$  is unbounded or  $\beta_n = 0$  for all  $n \geq 1$ , as claimed by the theorem. ■

III. Extension

This section sketches a simple extension of the analysis, in which  $M_n$  is investigated even if he does not accuse  $M_{n-1}$ . Monitors no longer have the ability to end the game, and a public history now consists of a sequence of declarations, one for each round  $n$ , in which  $M_n$  either accuses  $M_{n-1}$  (denoted “ $a$ ”) or doesn’t (denoted “ $d$ ”).

The rewards, punishment, and strategies can depend arbitrarily on past history. To capture this, we modify earlier notation as follows. Fixing a history up to round  $n$ , let  $P_n^a$  denote  $M_n$ ’s punishment in round  $n + 1$  if he accused  $M_{n-1}$  in round  $n$  and  $M_{n+1}$  claims that this accusation was wrongful and  $P_n^d$  denote  $M_n$ ’s punishment if he did not accuse  $M_{n-1}$  and  $M_{n+1}$  claims that  $M_n$  was either shirking or corrupt. For simplicity, we do not distinguish between these two wrongful behaviors when  $M_n$  made no accusation. Let  $\beta_{n+1}^a$  denote the probability that  $M_{n+1}$  truthfully investigates  $M_n$  conditional on  $M_n$  accusing  $M_{n-1}$  and  $\beta_{n+1}^d$  denote the same probability conditional on  $M_n$  not accusing  $M_{n-1}$ . Let  $\delta_{n+1}^a$  denote the probability that  $M_{n+1}$  surely accuses  $M_n$  without investigating him conditional on  $M_n$  accusing  $M_{n-1}$  and  $\delta_{n+1}^d$  denote the same probability conditional on  $M_n$  not accusing  $M_{n-1}$ . Finally, let  $\lambda^a$  denote the probability that  $M_{n+1}$  discovers  $M_n$  wrongdoing if he investigates  $M_n$  and  $M_n$  wrongfully accused  $M_{n-1}$  and  $\lambda^d$  denote the probability that  $M_{n+1}$  discovers wrongdoing by  $M_n$  if he investigates  $M_n$  and  $M_n$  shirked or hid evidence against  $M_{n-1}$ .

The collusion-free condition in round  $n$  becomes

$$R_n - \delta_{n+1}^a P_n^a - P_{n-1} \geq -(\delta_{n+1}^d + \lambda^d \beta_{n+1}^d) P_n^d$$

and  $M_n$  now prefers truthfully investigating  $M_{n-1}$  over the “switching” strategy (defined previously) if

$$R_n - (\delta_{n+1}^a + \lambda^a \beta_{n+1}^a) P_n^a \leq -\delta_{n+1}^d P_n^d$$

Isolating  $x = R_n + \delta_{n+1}^d P_n^d - \delta_{n+1}^a P_n^a$  in the last two inequalities yields

$$P_{n-1} - \lambda^d \beta_{n+1}^d P_n^d \leq x \leq \lambda^a \beta_{n+1}^a P_n^a,$$

which implies that

$$P_{n-1} \leq \lambda^d \beta_{n+1}^d P_n^d + \lambda^a \beta_{n+1}^a P_n^a.$$

It follows that if  $\lambda^d + \lambda^a < 1$ , there must exist a path along which the punishment sequence is unbounded.

REFERENCES

**Becker, Gary S., and George J. Stigler.** 1974. “Law Enforcement, Malfeasance, and Compensation of Enforcers.” *Journal of Legal Studies* 3 (1): 1–18.

**Dresher, Melvin.** 1962. “A Sampling Inspection Problem in Arms Control Agreements: A Game-Theoretic Analysis.” RAND Corporation Memorandum RM-2972-ARPA.

**Hurwicz, Leonid.** 2007. “But Who Will Guard the Guardians?” Nobel Prize Lecture, Stockholm, December 8.

**Levine, David K., and Salvatore Modica.** 2016. “Peer Discipline and Incentives within Groups.” *Journal of Economic Behavior & Organization* 123: 19–30.

**Maschler, Michael.** 1966. “A Price Leadership Method for Solving the Inspector’s Non-constant-sum Game.” *Naval Research Logistics Quarterly* 13 (1): 11–33.

**Milgrom, Paul R., Douglass C. North, and Barry R. Weingast.** 1990. “The Role of Institutions in the Revival of Trade: The Law Merchant, Private Judges, and the Champagne Fairs.” *Economics & Politics* 2 (1): 1–23.

**Rahman, David.** 2012. “But Who Will Monitor the Monitor?” *American Economic Review* 102 (6): 2767–97.

**Strulovici, Bruno.** 2020. “Can Society Function without Ethical Agents? An Informational Perspective.” Unpublished.