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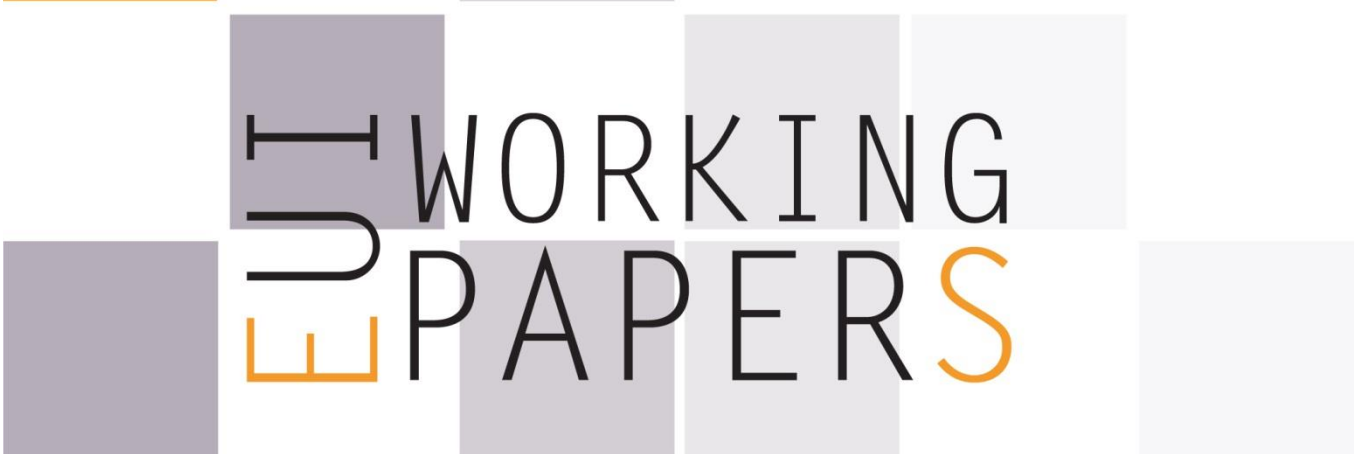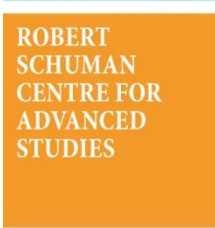
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Self-Regulatory Organizations Under the Shadow of Governmental Oversight: Blossom Or Perish?

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Abstract

Self-Regulatory Organizations (SROs) have been argued to be afflicted with incentive-incompatibility problems and, indeed, they have a mixed record in their ability to curb market abuse. An earlier theoretical study by DeMarzo et al. (2005), however, finds that SROs, under the oversight of the government, may overcome these incentive-incompatibility problems and may deliver the same degree of oversight as the government would have delivered without the SRO, but against lower costs. I find that this result hinges on the assumption that the interaction between the SRO and the government can be characterized as a game of sequential moves with the SRO moving first and the government moving second. For institutional settings where it is more appropriate to characterize the interaction as a game of simultaneous moves, I obtain the inefficient result that oversight by the government fully crowds out oversight by the SRO. A possible remedy is suggested.

Keywords: Self-Regulatory organizations, regulation, governmental oversight, simultaneous versus sequential games, costly state verification.
JEL Classification: C72, G18, G28, K20, L44

1. INTRODUCTION[1]

Self-Regulatory Organizations (SROs) can be found in not-for-profit sectors, education, healthcare, and the energy industry, as well as in the accounting, financial, and legal professions (DeMarzo et al., 2005; Hilary and Lennox, 2005; Maute, 2008; Ortmann and Mysliveček, 2010; Ortmann and Svitkova, 2010; Rees, 1997; Sidel, 2005; Studdert et al., 2004; Welch, Mazur and Bretschneider, 2000). Generally, regulatory oversight by an SRO is considered cheaper than regulatory oversight by the government, as SROs have more information and are better enabled to interpret the information (DeMarzo et al., 2005). Examples of SROs are the Financial Industry Regulatory Authority in the securities industry (DeMarzo et al., 2005), the so-called Donors Forums in not-for-profit sectors in Central and Eastern Europe (Ortmann and Svitkova, 2010), and the Institute of Nuclear Power Operations in the nuclear power industry (Rees, 1997).

DeMarzo et al. (2005) present an influential model of regulatory oversight by a regulator (which can be an SRO or the government) over an interaction between a customer (he) and an agent (she) using the costly-state-verification model of Townsend (1979), Border and Sobel (1987), and Mookherjee and Png (1989).[2] In these models, the agent provides a service that is, on average, wealth-increasing, but can have a low or a high outcome. The outcome is private knowledge of the agent and an opportunistic agent may thus have an incentive to deceive a customer by reporting a low outcome when it is in fact high and keep the pay-off difference herself. The agent thus needs to be incentivized to be honest and DeMarzo et al. (2005) show that both a "whip" and a "carrot" may be used for this purpose. The regulator performs random investigations when the agent reports a low outcome and gives a financial penalty when the agent is found to have deceived a customer (the whip) and the customer gives the agent a bonus in the form of a success fee when the agent reports a high outcome (the carrot). The regulatory regime can thus be modeled as the probability (referred to as the "investigation probability") with which the regulator investigates reports of the low outcome. When customers and agents make contracts, they take into account the regulatory regime. DeMarzo et al. (2005) thus model the oversight as a two-tier problem in which the regulators (the SRO and the government) determine the investigation policy taking into account the effect of that policy on the contracts that are subsequently created by the customer and agent. The two key differences between the SRO and the government are investigation costs and the target group

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[1] The introduction is partly based on Van Koten and Ortmann (2013).
[2] DeMarzo et al. (2005) has been cited 87 times according to Google Scholar and 27 times according to Thomsons Reuters Web of Science (both accessed on 23.11.2014).

for which to maximize utility. Investigations done by the SRO are cheaper than those by the government and the target group is customers for the government and agents for the SRO.

DeMarzo et al. (2005) show that, as investigations are costly, the profit-maximizing investigation probability is generally, both for the SRO and the government, smaller than 100%. They also show that, as a result of the two key differences between the SRO and the government, the optimal regulatory regime of the government generally consists of a different (higher) investigation probability than the one of the SRO. DeMarzo et al. (2005) further show that, *without* governmental oversight, the SRO can create monopoly market power for their affiliated agents by setting the investigation probability very low, but that *with* governmental oversight, the SRO sets the investigation probability at the (relatively high) level deemed optimal by the government, thus eliminating the need for the government to do any investigations. In other words, the mere outside threat of governmental oversight suffices to have the SRO make a welfare-increasing contribution by performing oversight at a relatively high level against relatively low costs, rebutting earlier criticisms (e.g., Shaked and Sutton, 1981; Nunez 2001, 2007; Ortmann and Mysliveček, 2010).

DeMarzo et al. (2005) obtain the results of a welfare-increasing effect of an SRO by modeling the interaction between the SRO and the government as a one-shot sequential game where the SRO moves first and the government moves second. Modeling the interaction as a sequential game rests on the assumption that the government, when choosing its regulatory regime by setting its investigation probability, already knows the regulatory regime of the SRO. A regulatory regime is, however, enacted over a future period – for example, over a period of one year – and the factually implemented regulatory regime can be different from the originally announced regulatory regime. Whether the factually implemented regulatory regime is the same as the announced one can only be verified in the end of a period after the fact. When the SRO is not obliged to make a true announcement, there is thus no reason to assume that the government, when setting its investigation probability, can know the factual regulatory regime of the SRO. The SRO may announce or signal its intended regulatory regime to the government, but I will show that, absent additional sanction mechanisms, the SRO has an incentive to deceive the government by signaling a high investigation probability, but factually implementing a lower one.[3] It can therefore be argued that when the government chooses its investigation probability, it does not know the investigation probability of the

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[3] Additional regulatory mechanisms that enable the SRO to credibly commit to an announcement of its regulatory regime may change the interaction into a game of sequential moves. An example of such an additional regulatory mechanism will be presented in the conclusion of the paper.

SRO, and visa versa. The interaction between the SRO and the government is thus best characterized as a game of simultaneous moves.

In this paper, I analyze the interaction of the government and the SRO as a one-shot simultaneous game and derive the unique Nash equilibrium under fairly general assumptions. To isolate and highlight the effect of the game structure, I use the same assumptions and game structure as in the model of DeMarzo et al. (2005) with the single exception that the game structure has simultaneous instead of sequential moves.[4] I show that the Nash equilibrium outcome of the simultaneous game, in contrast with the one of the sequential game, is Pareto-inefficient: The government does all investigations and the SRO none. The welfare-improving effect of the SRO in DeMarzo et al. (2005) is thus critically dependent on the assumption that the interaction between the SRO and the government can be characterized as a sequential game. The proof is presented in section 2. Section 3 presents a numeric example and section 4 concludes with a discussion of the results and a policy-relevant implication for regulation.

2. THE MODEL

2.1 *Setup*

As in DeMarzo et al. (2005), the main interaction in the model is between an SRO and the government (GOV). It is common knowledge that the SRO maximizes the total utility of all agents and the GOV maximizes the total utility of all customers. An agent (she) affiliated with an SRO provides a service for a customer (he), such as making an investment. The outcome of the investment is modeled as a random variable W that can have realizations high (w^H) or low (w^L) with probability π^H and π^L, respectively. The realized outcomes are observed by the agent. The realized outcomes are not directly observable by the customer, but can be verified by the SRO or the GOV for a cost of c_{SRO} or c_{GOV}, respectively, where $c_{GOV} > c_{SRO}$. The regulatory environment consists of the regulatory regimes of the SRO and the GOV, where each of them performs, when the low outcome is reported, an investigation with probabilities p_{SRO} and p_{GOV}, respectively.[5] When the agent is found to have deceived a customer, she will receive a financial penalty from the SRO or the GOV in the amount of x_{SRO} or x_{GOV}, respectively. Given this regulatory environment, customers can offer a contract $z[W]$ that obliges the agent to return the customer $z[w^L]$ ($z[w^H]$) when the outcome is low

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[4] The proofs of Lemmas 2a), 2c), 3a), 3b), 4b), and Proposition 2 follow those in DeMarzo et al. (2005) fairly closely, being adapted for a game with simultaneous moves. The proofs of Lemmas 1a), 1b), 2b), 4a), 4c), and 4d) and Propositions 1a) and 1b) are unique to this paper.

[5] Note that the agent has no reason to be deceptive with the low realization as reporting the high realization when it is actually low results in a negative income.

(high). The contract thus implies that agents may keep a success fee, a part of the investment returns, equal to $w^L - z[w^L](w^H - z[w^H])$ when the outcome is low (high). The customer offers the contract as a take-it-or-leave-it offer to the agent. Without loss of generality (using the revelation theorem), the analysis can be restricted to contracts that are incentive-compatible and agents thus, in equilibrium, accept the contract.

Two polar cases for the regulatory environment are of particular interest: When only the GOV is exerting regulatory oversight (also referred to as "GOV-only") and when only the SRO is exerting regulatory oversight (also referred to as "SRO-only"). DeMarzo et al. (2005) show that the SRO under SRO-only sets its investigation probability inefficiently low, leaving the "stick" in the form of financial penalties mostly ineffective as an incentive for the agent to report truthfully. As a result the customer is forced to use "carrots": He must offer the agent a large proportion of the outcome as a success fee to incentivize her to report truthfully. When customers are homogeneous in their outside options, the SRO will set its investigation probability so low that the necessary success fee will extract all the surplus of the investment, thus leaving customers with an expected utility equal to their outside option. When customers are heterogeneous in their outside options, a low investigation probability may dissuade customers with high outside options from entering. The SRO therefore sets an investigation probability that maximizes the product of the expected fee and the number of customers that will participate. Customers with low outside options will now keep some of the surplus, but, from a welfare point of view, the resulting outcome is undesirable.

By also exerting oversight, the GOV can affect the SRO's optimal investigation probability, provided the investigation cost of the GOV is not too much higher than the one of the SRO. Namely, as the expected investigation cost is borne by the customer, the higher the GOV investigation cost, the lower the optimal GOV investigation probability. For extremely high cost differentials between the GOV and the SRO, the investigation probability set by the GOV under GOV-only is lower than the investigation probability set by the SRO under SRO-only. For such a high cost differential, oversight by the GOV in addition to oversight by the SRO is ineffective as it would decrease the welfare of customers and the GOV thus refrains from exercising oversight. As in DeMarzo et al. (2005), I assume that the cost differential is small enough to make oversight by the GOV effective.[6]

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[6] Oversight by the GOV is thus defined as effective when the GOV, under GOV-only, sets a higher investigation probability than the SRO under SRO-only. The effectiveness of oversight by the GOV is a necessary condition for the results in Proposition 1.

	Prime decision makers	The present model (Simultaneous moves)	DeMarzo et al. (2005) (Sequential moves)
Stage 1	**SRO** and **GOV** (set investigation probability)	The SRO and the GOV simultaneously set their regulatory regimes by each choosing an investigation probability p_{SRO} and p_{GOV}, respectively.	The SRO sets its regulatory regime by choosing the investigation probability p_{SRO}, which is observed by the GOV. The GOV then sets its regulatory regime by choosing the investigation probability p_{GOV}.
Stage 2	**Customers** (either take outside option or offer an incentive-compatible contract)	Customers offer agents, as a take-it-or-leave-it offer, an incentive-compatible contract $z[W]$ that result in a success fee for the agent in the amount of $w^L - z[w^L]$ when the outcome is low and $w^H - z[w^H]$ when the outcome is high. Customers pay transaction fees $t_{SRO} + t_{GOV}$. Only customers that expect a utility (net of the transaction fees) larger than their outside option offer agents a contract. Agents accept the contracts.	
Stage 3	**Nature:** (decide, at random, the investment outcome)	With probability π^L the low outcome, w^L, is realized. With probability π^H the high outcome, w^H, is realized. The outcome is private knowledge of the agent. As customers offer incentive-compatible contracts in Stage 2, agents report the outcome truthfully.	
Stage 4	**Nature:** (decide, at random, if the agent with low outcomes are investigated and by whom)	First it is determined, with probability p_{SRO}, for each agent with a low outcome if she will be investigated by the SRO. For each agent the SRO investigates, the SRO pays investigation cost c_{SRO}. Agents that deceive pay penalty x_{SRO}.[7] Then it is determined, with probability p_{GOV}, for each agent with a low outcome that has not been investigated by the SRO if she will be investigated by the GOV. For each agent the GOV investigates, the GOV pays the investigation cost $c_{GOV} > c_{SRO}$. Agents that deceive pay penalty x_{GOV}. The transaction fee t_{SRO} (t_{GOV}) has to cover the expected investigation cost of the SRO (GOV), net of the expected penalty x_{SRO} (x_{GOV}).	

TABLE 1

Timing and order of moves

The effect of the regulatory regime by the GOV depends on whether, in Stage 1 (see Table 1), the GOV sets, as in the present model, an investigation probability at the same time as the SRO (a simultaneous move) or, as in DeMarzo et al. (2005), after as the SRO (a sequential

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[7] Note that, as the offers of customers in Stage 2 are assumed to be incentive-compatible, no agents deceive in equilibrium and therefore agents pay zero in penalties in equilibrium.

move). Table 1 shows the timing and order of moves, both for the present model (on the left) and the model of DeMarzo et al. (2005) (on the right).

In stage 1, the GOV and the SRO set their investigation probability simultaneously in the present model, while they set it sequentially in the model of DeMarzo et al. (2005). The remaining stages are identical for both models.

In stage 2, customers can make a take-it-or-leave-it offer of an incentive-compatible contract $z[W]$ that, when the outcome is low (high), obliges agents to return customer $z[w^L]$ ($z[w^H]$) and leave agents a success fee equal to $w^L - z[w^L]$ ($w^H - z[w^H]$). Given the investigation probabilities p_{SRO} and p_{GOV}, customers calculate the lowest success fee $W - z[W]$ that is incentive-compatible. In addition, customers take in account the transaction fees $t_{SRO} + t_{GOV}$ they must pay to cover the expected investigation costs of the SRO and the GOV. Let variable a refer to the customers' expected utility with such a contract. The proportion of customers with outside options larger than a will not make an offer and take their outside options. The proportion of customers with outside options smaller than a will offer the contract to the agents, who accept the offers (as we focus on incentive-compatible contracts) and customers pay the transaction fees $t_{SRO} + t_{GOV}$.[8]

In stage 3, by a random move of nature, the low (high) outcome, w^L (w^H), is realized with probability π^L (π^H). The realized outcomes are private knowledge of the agents. As the offers of customers in Stage 2 are incentive-compatible, agents report the outcomes truthfully to their customer.

In stage 4, by a random move of nature, it is decided if the agents with low outcomes are investigated and by whom. Agents are first investigated by the SRO with probability p_{SRO}.[9] If the SRO investigates the agent, the SRO pays the investigation cost c_{SRO} and the agent pays the penalty x_S if she is found to have been deceptive. If the SRO doesn't investigate the agent, the GOV investigates the agent with probability p_{GOV}. If the GOV investigates the agent, the GOV pays the investigation cost $c_{GOV} > c_{SRO}$ and the agent pays the penalty x_{GOV} if she is

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[8] The transaction fees are needed to cover the expected investigationl. While it may be surprising that customers may potentially pay a fee for the GOV *and* the SRO, the GOV never repeats an investigation done by the SRO, so wasteful duplication is avoided. Moreover, we will see that, in equilibrium, only one regulator does all investigations and the customer then pays a positive fee to this regulator only.

[9] This assumption could be rationalized assuming that the low outcome is reported both to the SRO and the GOV, but that the SRO is quicker to react than the GOV. This is not unreasonable, as governmental, bureaucratic organizations are often much slower than private ones. Moreover, it is rational for the GOV to move slower and give the SRO a chance to do the investigation first as the SRO has lower investigation costs. Alternatively, assuming that the GOV moves first does not change the results.

found to have been deceptive. The total probability of an investigation when the low outcome occurs is thus equal to $p_S + p_G$.[10] The expected investigation costs for the SRO (GOV) are equal to the probability of the low outcome times the probability of investigation by the SRO (GOV) times the cost per investigation, $\pi^L \cdot p_{SRO} \cdot c_{SRO}$ ($\pi^L \cdot p_{GOV} \cdot c_{GOV}$). The transaction fee t_{SRO} (t_{GOV}) has to cover the expected investigation cost of the SRO (GOV), net of the expected penalty x_{SRO} (x_{GOV}). Due to the focus on incentive-compatible contracts, agents don't deceive and the expected penalties are equal to zero. The transaction fees are thus equal to the expected investigation costs, $t_{SRO} = \pi^L \cdot p_{SRO} \cdot c_{SRO}$ and $t_{GOV} = \pi^L \cdot p_{GOV} \cdot c_{GOV}$.

Utility of customers and agents

As in DeMarzo et al. (2005, p. 690), I assume that agents are risk averse, have zero initial wealth, face a limited liability constraint and have preferences that can be represented by a strictly concave utility function u_{agent} that is twice differentiable and has been normalized such that $u_{agent}[0] = 0$. Customers are assumed to be risk neutral and can thus be modeled to maximize a profit function, denoted by $u_{customer}$.[11]

Following DeMarzo et al. (2005), I assume that there is a continuum of customers where a customer i has the outside option $a^i \in [\underline{a}, \overline{a}]$ and that a cumulative distribution function $F[a]$, assumed to be log-concave, gives the fraction of customers with an outside option below a. There are at least as many (identical) agents as customers, such that for each customer i an agent (indexed by i) is available for dealing. The profit of the contract, a, is the same for all customers (it is equal to the expected value of the investment minus the expected success fee minus the expected investigation costs of the SRO and GOV). A customer will only offer a contract to an agent when the contract brings him an expected profit higher than his outside option. The profit of the customer is thus equal to the maximum of his outside option and the

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[10] The total probability of an investigation when the low outcome occurs is thus equal to the probability of the SRO investigating, p_{SRO}, plus the probability of the SRO not investigating, $1 - p_{SRO}$, times the conditional probability of the GOV investigating conditional on the SRO deciding not to investigate, $\dfrac{p_{GOV}}{(1 - p_{SRO})}$. This results in $p_{SRO} + (1 - p_{SRO})\dfrac{p_{GOV}}{(1 - p_{SRO})} = p_{SRO} + p_{GOV}$. See also footnote 17 in DeMarzo et al. (2005).

[11] The zero initial wealth and limited liability of agents imply that the maximum penalty on agents is bound and that agents cannot compete away all rents by paying customers to do business with them. The risk neutrality of customers abstracts from their demand for insurance in the optimal contract. See also DeMarzo et al. (2005) for more details.

profit of the contract. Let the outside option of a customer be given by a^i. The profit of the contract, a, and the customer's final profit, $u^i_{customer}$, are given by:

(1) $a = \pi^L \cdot (z[w^L] - p_{SRO}c_{SRO} - p_{GOV}c_{GOV}) + \pi^H \cdot z[w^H]$

(2) $u^i_{customer} = Max[a, a^i]$

The customer thus maximizes his profit $u^i_{customer}$ by maximizing a as given in Equation (1) by choosing a contract z, respecting the restrictions that the contract must be feasible and incentive-compatible for the agent. Thus, the customer maximizes the consumer problem (CP) in Table 2. The constraint AF assures that the contract is feasible and the constraint AIC assures that the contract is incentive-compatible for the agent. As the offered contracts are incentive-compatible, agents accept the contracts and report the realized outcomes truthfully.

The expected utility of agent i (who is matched with a customer with outside option a^i) is equal to the expectation of the utility of the success fees if the utility for the customer is higher than his outside option and zero otherwise:

(3) $u^i_{agent} = \begin{cases} \pi^L \cdot (w^L - z[w^L]) + \pi^H \cdot (w^H - z[w^H]) & \text{if } a \geq a^i \\ 0 & \text{if } a < a^i \end{cases}$

Pay-offs of the SRO and the GOV

As mentioned above, the SRO has a pay-off equal to the total utility of all agents and the GOV has a pay-off equal to the total of profits of all customers. The pay-offs of the SRO and the GOV are therefore:

(4) $\Pi_{SRO} = \int_{\underline{a}}^{\overline{a}} u_{agent} dF[\gamma]$

(5) $\Pi_{GOV} = \int_{\underline{a}}^{\overline{a}} u_{customer} dF[\gamma]$

The maximization problems of the SRO and the GOV can now be further analyzed in Lemma 1.

Lemma 1

a) The maximization problem of the SRO can be solved by solving $Max_a [F[a] \cdot V[a]]$, *where*

$V[a] = Max_{z_{SRO}, p_{SRO}, x_{SRO}} u_{agent}$ *such that* $u^i_{customer} \geq a$ *and the parameters solve CP.*

b) The maximization problem of the GOV can be solved by maximizing the customer's profit of the contract, $Max_{z_{GOV}, p_{GOV}, x_{GOV}} [a]$ *such that the parameters solve CP.*

Proofs. See the Appendix.

Customer Problem ($CP[p_{SRO}, p_{GOV}, x_{SRO}, x_{GOV}]$ **)**

$\text{Max}_z \left[\pi^L z[w^L] + \pi^H z[w^H] \right] - \pi^L (p_{SRO} c_{SRO} + p_{GOV} c_{GOV})$, s.t:

    AF: $z[w^L] \leq w^L$, $z[w^H] \leq w^H$

    AIC: $u_{agent}\left[w^H - z[w^H] \right] \geq \left\{ \begin{array}{l} p_{SRO} \cdot u_{agent}\left[\text{Max}\left[w^H - z[w^L] - x_{SRO}, 0 \right] \right] \\ + p_{GOV} \cdot u_{agent}\left[\text{Max}\left[w^H - z[w^L] - x_{GOV}, 0 \right] \right] \\ + (1 - p_{GOV} - p_{SRO}) \cdot u_{agent}\left[w^H - z[w^L] \right) \right] \end{array} \right\}$

SRO Problem (SROP)

Stage 1: $V[a] = \text{Max}_{z_{SRO}, p_{SRO}, x_{SRO}} \left[\pi^L \left(w^L - z_{SRO}[w^L] \right) + \pi^H \left(w^H - z_{SRO}[w^H] \right) \right]$, s.t:

    CIC: z_{SRO} solves $CP[p_{SRO}, p_{GOV}, x_{SRO}, x_{GOV}]$

    CIR: $\pi^L z_{SRO}[w^L] + \pi^H z_{SRO}[w^H] - (p_{SRO} c_{SRO} + p_{GOV} c_{GOV}) \geq a$

Stage 2: $\text{Max}_a F[a] \cdot V[a]$

GOV Problem (GOVP)

$\text{Max}_{z_{GOV}, p_{GOV}, x_{GOV}} \pi^L z[w^L] + \pi^H z[w^H] - \pi^L (p_{SRO} c_{SRO} + p_{GOV} c_{GOV})$, s.t:

    CIC: z_{GOV} solves $CP[p_{SRO}, p_{GOV}, x_{SRO}, x_{GOV}]$

TABLE 2

The customer, the SRO and the GOV problems

Using Lemma 1a, the SRO maximizes the SROP problem as in Table 2. In stage 1, the SRO maximizes $V[a]$ by choosing $(z_{SRO}, p_{SRO}, x_{SRO})$, respecting that the expected customer profits net of the fees are at least as big as a parameter a (CIR). The resulting parameters must also solve CP (CIC). In stage two, the SRO maximizes the product of the cumulative distribution of outside options times the value function, $F[a] \cdot V[a]$ by choosing the optimal level of parameter a. Using Lemma 1b, the GOV maximizes the problem GOVP as in Table 2. The GOV maximizes the expected profit of a customer from the contract net of fees by choosing $(z_{GOV}, p_{GOV}, x_{GOV})$. The resulting optimal parameters must also solve CP (CIC) and CIR.

Before giving a definition of the simultaneous Nash equilibrium, it is useful to first apply simplifications to the problems in Table 2. Lemma 2 summarizes the regularities that can be used for a first simplification.

Lemma 2

a) In CP, customers offer a contract that, when the low outcome is realized, pays everything to customers and zero to agents, $z[w^L] = w^L$.

b) AF can be disregarded.

c) AIC is binding.

Proofs. See the Appendix.

Using Lemma 2, the problems can now be written in a simpler form. The optimal contract for the low realization has been determined as $z[w^L] = w^L$ (Lemma 2a). I further simplify notation by writing $z^H \equiv z[w^H]$, where, when the high outcome is realized, z^H is the money the agent has to return to the customer and $w^H - z^H$ is the money the agent may keep as a success fee. For the consumer problem (CP), constraint AF can be disregarded (using Lemma 1b), while the solution of CP will be given by AIC (using Lemma 1c). Replacing the constraints CIC in the SRO problem (SROP) and the GOV problem (GOVP) by AIC makes it possible to further focus only on the SRO and GOV problems. The simplified set of problems is shown in Table 3.

SRO Problem (SROP')

Stage 1: $V[a] = \text{Max}_{z_{SRO}^H, p_{SRO}, x_{SRO}} \left[\pi^H \cdot u_{agent}[w^H - z_{SRO}^H] \right]$, s.t.

CIR: $\pi^L w^L + \pi^H z_{SRO}^H - \pi^L (p_{SRO} c_{SRO} + p_{GOV} c_{GOV}) \geq a$

AIC: $u_{agent}[w^H - z_{SRO}^H] = \begin{cases} p_{SRO} \cdot u_{agent}\left[\text{Max}[w^H - w^L - x_{SRO}, 0] \right] \\ + p_{GOV} \cdot u_{agent}\left[\text{Max}[w^H - w^L - x_{GOV}, 0] \right] \\ + (1 - p_{GOV} - p_{SRO}) \cdot u_{agent}[w^H - w^L] \end{cases}$

Stage 2: $\text{Max}_a F[a]V[a]$

GOV Problem (GOVP')

$\text{Max}_{z_{GOV}^H, p_{GOV}, x_{GOV}} \ \pi^L w^L + \pi^H z_{GOV}^H - \pi^L (p_{SRO} c_{SRO} + p_{GOV} c_{GOV})$

AIC: $u_{agent}[w^H - z_{GOV}^H] = \begin{cases} p_{SRO} \cdot u_{agent}\left[\text{Max}[w^H - w^L - x_{SRO}, 0] \right] \\ + p_{GOV} \cdot u_{agent}\left[\text{Max}[w^H - w^L - x_{GOV}, 0] \right] \\ + (1 - p_{GOV} - p_{SRO}) \cdot u_{agent}[w^H - w^L] \end{cases}$

TABLE 3

The SRO and the GOV problems in a simpler format

Lemma 3 summarizes two regularities that can be used to further simplify the problem.

Lemma 3

a)   *Both the SRO and the GOV set, respecting the limited liability of the agents, the penalty at the maximum,* $x_{GOV} = x_{SRO} = w^H - w^L$

b)   *CIR binds.*

Proofs. See the Appendix.

Using Lemma 3a), the penalties are set at the maximum, $x \equiv x_{GOV} = x_{SRO} = w^H - w^L$. Then the first two terms at right-hand side in AIC are equal to zero: $u_{agent}\left[Max[w^H - w^L - x, 0] \right]$ $= u_{agent}\left[Max[w^H - w^L - w^H + w^L, 0] \right] = u_{agent}[0] = 0$. Also, the contract is now endogenously determined in AIC by the investigation probabilities p_{SRO} and p_{GOV} and I therefore write the contract explicitly as $z^H[p_{SRO}, p_{GOV}]$. Table 4 summarizes the problem in the most simplified format.

SRO Problem (SROP'')

Stage 1: $V[a] = Max_{p_{SRO}} \pi^H \cdot u_{agent}\left[w^H - z^H[p_{SRO}, p_{GOV}] \right]$, s.t.

    CIR: $\pi^L w^L + \pi^H z^H[p_{SRO}, p_{GOV}] - \pi^L \left(p_{SRO} c_{SRO} + p_{GOV} c_{GOV} \right) = a$

    AIC: $u_{agent}\left[w^H - z^H[p_{SRO}, p_{GOV}] \right] = \left(1 - p_{GOV} - p_{SRO} \right) \cdot u_{agent}[w^H - w^L]$

Stage 2: $Max_a F[a]V[a]$, $a_{SRO}[p_{GOV}] = ArgMax_a F[a]V[a]$

GOV Problem (GOVP'')

$a_{GOV}[p_{SRO}] = Max_{p_{GOV}} \pi^L w^L + \pi^H z^H[p_{SRO}, p_{GOV}] - \pi^L \left(p_{SRO} c_{SRO} + p_{GOV} c_{GOV} \right)$, s.t.

    AIC: $u_{agent}\left[w^H - z^H[p_{SRO}, p_{GOV}] \right] = \left(1 - p_{GOV} - p_{SRO} \right) \cdot u_{agent}[w^H - w^L]$

TABLE 4

The SRO and the GOV problems in the most simplified format

In Table 4, in SROP'' (GOVP''), the SRO (GOV) maximizes its pay-off by setting its investigation probability p_{SRO} (p_{GOV}) given the investigation probability of the GOV (SRO). Each organization thus maximizes the following expressions:

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(6) $Max_{p_{SRO}} \left[\Pi_{SRO}[p_{SRO}, p_{GOV}] \right]$

(7) $Max_{p_{GOV}} \left[\Pi_{GOV}[p_{SRO}, p_{GOV}] \right]$

The Nash equilibrium with simultaneous moves can now be characterized as follows:

Definition of the Nash equilibrium of the simultaneous game

> The SRO chooses an investigation probability p_{SRO}^* and the GOV chooses an investigation probability p_{GOV}^* such that $\Pi_{SRO}[p_{SRO}, p_{GOV}^*] \leq \Pi_{SRO}[p_{SRO}^*, p_{GOV}^*]$ for all $p_{SRO} \in [0,1]$ and $\Pi_{GOV}[p_{SRO}^*, p_{GOV}] \leq \Pi_{SRO}[p_{SRO}^*, p_{GOV}^*]$ for all $p_{GOV} \in [0,1]$.

2.3 *Model solution*

The Nash equilibrium of the simultaneous-moves game can now be determined. Denote the best response functions for the SRO and the GOV, the optimal investigation probability for SRO (GOV) as a function of the investigation probability chosen by the GOV **(**SRO**)**, as $BR_{SRO}[p_{GOV}]$ and $BR_{GOV}[p_{SRO}]$, respectively. Note that, under SRO-only and under GOV-only, the best response functions are $BR_{SRO}[0]$ and $BR_{GOV}[0]$, respectively. The assumption that the GOV oversight is effective can thus be written with the help of the best response functions as $BR_{GOV}[0] > BR_{SRO}[0]$. Lemma 4 summarizes the main characteristics of the GOVP", SROP" and the best response functions of the SRO and the GOV.

Lemma 4

a) $V[a]$ *is strictly decreasing in* a*,* $V'[a] < 0$*.*

b) *Provided GOVP" and SROP" have solutions, they are unique.*

c) *The best response function of the SRO obeys* $BR_{SRO}[p_{GOV}] \leq \text{Max}[0, BR_{SRO}[0] - p_{GOV}]$*, with a strict inequality when* $BR_{SRO}[0] - p_{GOV} > 0$*.*

d) *The best response function of the GOV is given by* $BR_{GOV}[p_{SRO}] = \text{Max}[0, BR_{GOV}[0] - p_{SRO}]$*.*

 ***Proofs**. See the Appendix.*

Thus, the best response of the SRO fulfills $BR_{SRO}[p_{GOV}] \leq \text{MAX}[0, BR_{SRO}[0] - p_{GOV}]$ and the best response of the GOV is given by $BR_{GOV}[p_{SRO}] = \text{Max}[0, BR_{GOV}[0] - p_{SRO}]$. In other words, the GOV is best off when the fixed level of *total* oversight by the SRO and GOV together is equal to $BR_{GOV}[0]$, and while the GOV prefers the oversight to be done by the SRO, the GOV is willing to provide any necessary level of oversight to make up a shortfall. Figure 1 shows the best response functions of the GOV (the red, solid line) and the SRO (the blue, dashed line). The vertical axis shows the investigation probability of the SRO and the horizontal axis the investigation probability of the GOV. Given Lemmas 4c) and 4d), when the best response function has an interior solution (thus excluding the parts where the best

response functions are either vertical or horizontal in Figure 1), it has, for the GOV, a slope of -1, and, for the SRO, a slope lower than -1.
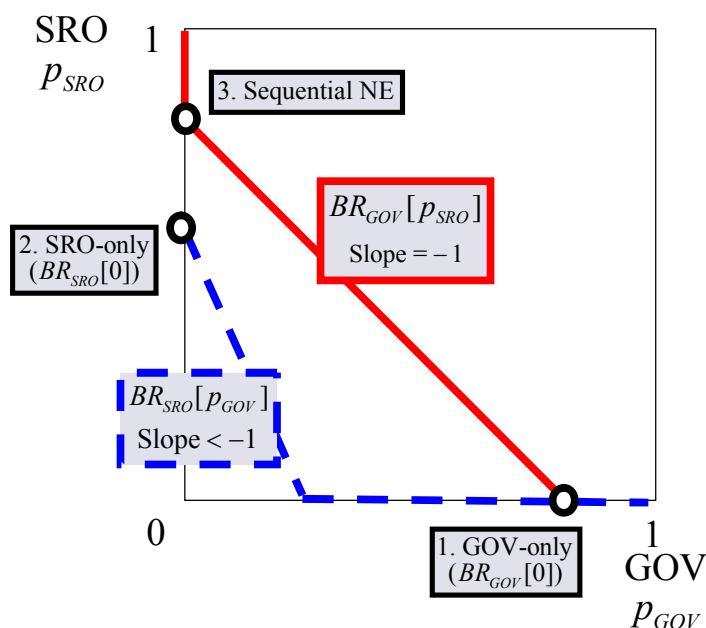

FIGURE 1

Best response functions of the GOV and the SRO

In Figure 1, I marked the choice by the GOV under GOV-only (point 1), the choice by the SRO under SRO-only (point 2) and the sequential Nash equilibrium found by DeMarzo et al. (2005) (point 3). In the Nash equilibrium of the sequential game, the SRO sets its investigation probability equal to the probability the government would have set under GOV-only, $BR_{GOV}[0]$, and the GOV sets its investigation probability equal to zero. I will now prove in Proposition 1 that the only Nash equilibrium of the simultaneous game is an action profile where the GOV does all investigations and the SRO does none (point 1 in Figure 1).

Proposition 1

a) *In the unique Nash equilibrium of the simultaneous game, the GOV does all the investigation and the SRO does none.*

b) *If, in the simultaneous game, the GOV were gullible, in the sense that the GOV believes any investigation probability announced by the SRO, then the SRO deceives the GOV by announcing an investigation probability $p_{SRO} \geq BR_{GOV}[0]$, while implementing $p_{SRO} = BR_{SRO}[0] < BR_{GOV}[0]$.*

Proofs. See the Appendix.

Proposition 1a establishes that, in the unique Nash equilibrium of the simultaneous game, the GOV does all the investigations and the SRO does none. Note that DeMarzo et al. (2005) showed that this outcome is suboptimal not only from the viewpoint of the GOV, but also from the viewpoint of the SRO. Thus if the SRO could make an announcement before the setting of the investigation probabilities and commit itself credibly to this announcement, it would announce and implement $p_{SRO} = BR_{GOV}[0]$. Proposition 1b, however, shows that the SRO has the incentive to make a false announcement: The SRO would announce investigation probability $p_{SRO} \geq BR_{GOV}[0]$, but factually implement $p_{SRO} = BR_{SRO}[0] < BR_{GOV}[0]$. When the GOV is not gullible, the GOV therefore disregards the SRO's announcement as cheap talk and the interaction between GOV and SRO is best characterized as one of simultaneous moves.

As the SRO does no investigations, the investigation probability of the GOV is given by $p_{GOV} = BR_{GOV}[0]$. The solution has earlier been presented in DeMarzo et al. (2005)[12] and I present it here, for completeness, as Proposition 2.

Proposition 2. In the Nash equilibrium of the simultaneous game, the GOV sets its investigation probability given by $-\dfrac{u_{agent}[w^H - w^L]}{u'_{agent}\left[\left(1 - p_{GOV}\right) \cdot u_{agent}[w^H - w^L]\right]} = -\dfrac{\pi^L}{\pi^H} c_{GOV}$.

Proof. See the Appendix.

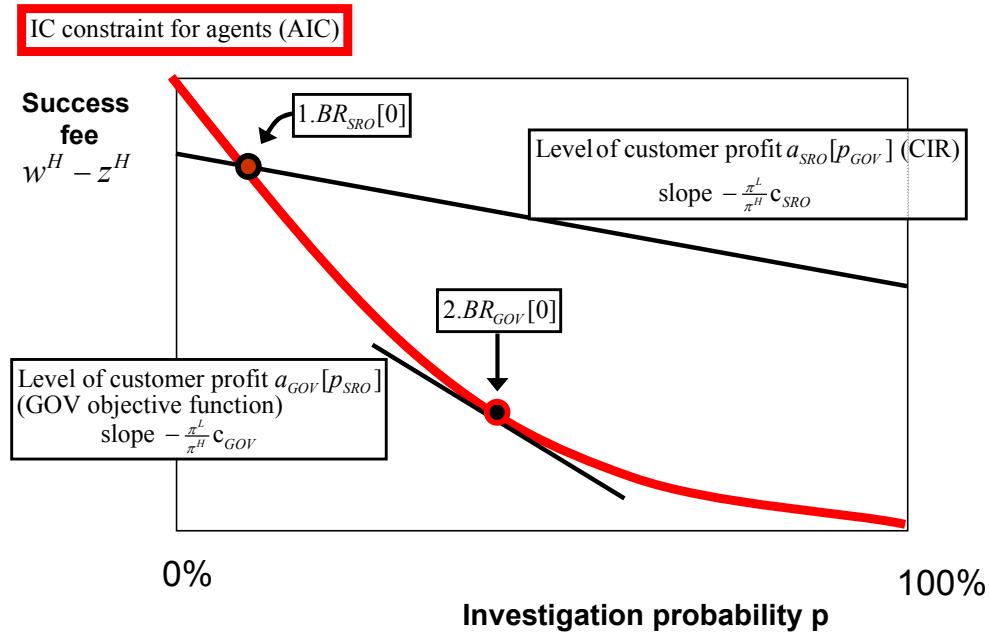[12] Proposition 6, notated as p^{cg}.

FIGURE 2

Optimization

Figure 2 illustrates the optimization problems for the SRO and the GOV. The horizontal axis shows the investigation probability and the vertical axis shows the success fee $w^H - z^H$ when the high outcome is realized. The customer's utility increases by moving in the South-Western direction, while the agent's utility increases by moving in the Northern direction. The thick, red, curved, downwards sloping line is the incentive-compatibility constraint for agents (AIC in SROP" and GOVP"). Any solution, both in GOVP" and SROP", must be on the AIC line to make truthful reporting incentive-compatible for the agents.

The thin, black, straight, downwards sloping line is the level of customer utility $a_{SRO}[p_{GOV}]$ (CIR in SROP"). More such lines could be drawn for different values of the customer utility. Under SRO-only, the SRO selects a level of customer utility relatively far in the Northern direction, as this increases the utility level of the agent. The intersection of this level of customer utility with the IC constraint for agents determines the optimal point under SRO-only, indicated by $BR_{SRO}[0]$ (point 1). Under GOV-only, the GOV selects the highest possible level of its objective function (the customer utility) that still fulfills AIC. The objective function of the GOV is identical to CIR in SROP", except that is has a steeper slope, reflecting the fact that the costs of investigations by the GOV are more expensive than by the SRO. The highest level of the customers utility is determined by a tangency condition where the slope of the AIC with respect to p_{GOV} (the left-hand side of the condition in Proposition 2)

is equal to $\dfrac{\pi^L}{\pi^H} c_{GOV}$ (the right-hand side of the condition in Proposition 2) indicated by

$BR_{GOV}[0]$ (point 2).

3. EXAMPLE

As an example, I use the same parameters and procedures to translate the decision problems of the SRO and the GOV into a 3x3 matrix game as we used in Van Koten and Ortmann (2013). Thus, I use, for the agents, an utility function with constant relative risk-aversion, $u[x] = 10 \cdot \dfrac{x^{1-RA}}{RA}$, with *RA=0.5*, and, for the customers, the linear (and thus risk-neutral) function, $u[x] = x$. Customers have outside options that are uniformly distributed between 5 and 105. The uniform distribution is log-concave and thus fulfills the assumptions of the model. The low (high) outcome is given by $w^L = 20$ ($w^H = 200$), and occurs with probability $\pi^L = 0.75$ ($\pi^H = 0.25$). The investigation cost of the SRO (GOV) is $c_S = 10$ ($c_G = 40$). Table 5 summarizes the parameters.

Utility function customers	Linear ($u[x] = x$)
Utility function agents	$u[x] = 10 \cdot \dfrac{x^{1-RA}}{RA}$
Risk Aversion agents (RA)	=0.5
Outside option	UD over [5,105]
Low investment outcome (w^L)	=20
High investment outcome (w^H)	=200
Probability low outcome (π^L)	= 75%
Probability high outcome (π^H)	= 25%
Investigation cost of SRO (c_S)	= 10
Investigation cost of GOV (c_G)	= 40

TABLE 5
Parameter overview

The optimal choices are, for the GOV under GOV-alone, $BR_G[0] = 0.67$, and for the SRO under SRO-alone, $BR_S[0] = 0.32$. As $BR_G[0] = 0.67 > 0.32 = BR_S[0]$, the assumption that oversight by the GOV is effective is thus fulfilled.[13] Using the values zero ("NONE"), $BR_S[0] = 0.32$ ("LOW") and $BR_G[0] = 0.67$ ("HIGH"), a 3x3 matrix game can be generated

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[13] A numerical simulation shows that, keeping the other parameters constant, oversight by the GOV loses its effectiveness once the cost of GOV reaches 81.8, thus about eight times the cost of investigation by the SRO.

with the payoffs for the SRO and the GOV (divided by 100) in each of the cells. Table 6 shows the 3x3 matrix game.

		GOV		
		NONE	LOW	HIGH
S	NONE	(10, 1)	(14, 4)	**(8, 6)***
R	LOW	(17, 7)	(10, 9)	(0, 7)
O	HIGH	**(11, 13)#**	(0, 10)	(0, 9)

Nash equilibrium of the sequential game (SRO moves first, GOV second) as in DeMarzo et al. (2005)
* Nash equilibrium of the simultaneous game

TABLE 6
3x3 Matrix game

The matrix game illustrates the effect of changing the game from one with sequential moves to one with simultaneous moves. When the game is sequential, the SRO knows that, after it has made its choice, the GOV will choose the option that maximizes the GOV's profits. Thus when the SRO chooses NONE, the GOV chooses HIGH, when the SRO chooses LOW, the GOV chooses LOW and when the SRO chooses HIGH, the GOV chooses NONE. The SRO can thus choose between the outcomes for (NONE, HIGH), (LOW, LOW), and (HIGH, NONE). The last outcome brings the highest profit for SRO, 11. Thus, in the sequential game, the SRO chooses HIGH and the GOV chooses NONE.

When the interaction between the GOV and the SRO is simultaneous, the strategy profile (HIGH, NONE) is not a Nash equilibrium. When the GOV chose NONE, the SRO would deviate to the choice LOW (a payoff for the SRO of 17 versus 11). But when the SRO chose LOW, the GOV would deviate to the choice LOW (a payoff for the GOV of 9 versus 7). This process continues with the SRO reducing and the GOV increasing the investigation probability. The only strategy profile that is not dominated is the one where the SRO chooses none and the GOV chooses HIGH.

Note that the Nash equilibrium payoffs in the simultaneous game are Pareto-dominated by those in the sequential game. Both the SRO and the GOV would thus gain from institutional design changes that could change the interaction between the SRO and the GOV into one of sequential moves with the SRO moving first and the GOV moving second.

4. CONCLUSION

DeMarzo et al. (2005) reported that adding governmental oversight may increase the oversight activity of the SRO to an efficient level. This study adds an important qualification: When the interaction between an SRO and a government is best described as one of

simultaneous moves, then the oversight by the government completely crowds out the oversight by the SRO and the SRO becomes superfluous. This outcome is Pareto-inefficient as the government has a higher cost of investigation than the SRO. The result is of importance since many industries have been trying to rely on self-regulation.

DeMarzo et al. (2005) assert that the interaction between the SRO and government can be characterized as sequential moves as the SRO can announce its investigation probability to the government and so become a first mover. However, the announced investigation probability may be different from the investigation probability that is factually implemented. Proposition 1b) showed that the SRO has indeed the incentive to deceive the government by announcing a high investigation probability but implementing a lower one. Assuming that the government is not gullible, the government will disregarded the SRO's announcement as an uninformative signal. This makes the interaction between the SRO and government one of simultaneous moves, resulting in the inefficient outcome as derived in this paper.

It may be worthwhile considering what institutional design elements could transform the interaction between the SRO and the government into one of sequential moves. Namely, if the SRO could credibly commit to its announced investigation probability, then the government could trust the announcement and condition its choice on the announcement. This would transform the interaction between the SRO and the government into one of sequential moves, resulting in the efficient outcome as derived in DeMarzo et al. (2005). As the inefficient outcome is also suboptimal from the viewpoint of the SRO, the SRO could be expected to actively promote implementing institutional design changes that enable the SRO to credibly commit to its announcement.

An example of a design element that could make the announcement of the SRO credible is the addition of another tier of regulation. This could be a relatively light-handed form of regulation, focused on forcing the SRO to make a clear and precise regulatory regime announcement and to implement its announced regulatory regime. For example, the government could oversee the SRO, require it to announce an regulatory regime in the form of a precise numeric investigation probability, monitor the proportion of complaints that are investigated by the SRO and severely sanction the SRO when it underperforms.

Appendix
Lemma 1
a) The maximization problem of the SRO can be solved by solving $Max_a[F[a] \cdot V[a]]$, where $V[a] = Max_{z_{SRO}, p_{SRO}, x_{SRO}} u_{agent}$ such that $u_{customer}^i \geq a$ and the parameters solve CP.

Proof. In stage 1, the SRO chooses the parameters $z_{SRO}, p_{SRO}, x_{SRO}$ to maximize the restricted agent utility, $u_{agent}[z_{SRO}, p_{SRO}, x_{SRO}; a]$, respecting the restriction that the parameters also solve CP. The optimal values of the parameters are thus functions of a. Let us use the notation $\vec{v} = (z_{SRO}, p_{SRO}, x_{SRO})$, $\vec{v}[a] = (z_{SRO}[a], p_{SRO}[a], x_{SRO}[a])$ and $u_{agent}[\vec{v}; a]$. Then:

$$V[a] = Max_{\vec{v}}[u_{agent}] \text{ s.t. } u^i_{customer} \geq a$$

$\vec{v}[a] = (z_{SRO}[a], p_{SRO}[a], x_{SRO}[a]) = ArgMax_{\vec{v}}[u_{agent}]$ s.t. $u^i_{customer} \geq a$ and that the parameters solve CP.

$V[a]$ can thus also be written as:

$$V[a] = u_{agent}[\vec{v}[a]; a]$$

And the SRO's pay-off can be written as:

$$\Pi_{SRO}[\vec{v}] = \Pi_{SRO}[\vec{v}[a]; a]$$

$$= \int_{\underline{a}}^{\bar{a}} u_{agent}[\vec{v}[a]; a] dF[\gamma] \qquad \text{using (4)}$$

$$= \int_{\underline{a}}^{\bar{a}} V[a] dF[\gamma] \qquad \text{using (3)}$$

(A1) $$= \int_{\underline{a}}^{a} V[a] dF[\gamma] + \int_{a}^{\bar{a}} 0 \, dF[\gamma]$$

$$= \int_{\underline{a}}^{a} V[a] dF[\gamma]$$

(A2) $$= V[a] \int_{\underline{a}}^{a} 1 \, dF[\gamma]$$

$$= V[a] F[a] \qquad \text{using } F[\underline{a}] = 0$$

Equation (A1) is obtained using the fact that customers, if their outside option is larger than a, will not deal with the agent, resulting in zero income for the agent. Equation (A2) is obtained using that the optimal conditional agent utility is the same for all customers with an outside option lower than a and $V[a]$ can thus be taken outside of the integration. As a result:

$$Max_{\vec{v}}[\Pi_{SRO}[\vec{v}]] = Max_a[V[a]F[a]], \quad \text{where} \quad V[a] = Max_{z_{SRO}, p_{SRO}, x_{SRO}, t_{SRO}} u_{agent} \text{ s.t. } [u^i_{customer}] \geq a$$
and that the parameters solve CP.

b) The maximization problem of the GOV can be solved by maximizing the customer's profit of the contract, $Max_{z_{GOV}, p_{GOV}, x_{GOV}}[a]$, such that the parameters solve CP.

Proof Reminding that $u^i_{customer} = Max[a, a^i]$, with a being the expected customer profit net of the success fees and the expected investigation costs, $a = \pi^L \cdot (w^L - z_{GOV}[w^L] - p_{SRO}c_{SRO} - p_{GOV}c_{GOV}) + \pi^H \cdot (w^H - z_{GOV}[w^H])$. The pay-off of the GOV is thus given by:

$$\Pi_{GOV} = \int_{\underline{a}}^{\bar{a}} u_{customer} dF[\gamma]$$

$$= \int_{\underline{a}}^{\bar{a}} Max[a, \gamma] dF[\gamma]$$

$$= \int_{\underline{a}}^{a} a \, dF[\gamma] + \int_{a}^{\bar{a}} \gamma \, dF[\gamma]$$

$$= \int_{\underline{a}}^{a} (a - \gamma) dF[\gamma] + \int_{\underline{a}}^{\bar{a}} \gamma \, dF[\gamma]$$

The second term in the resulting equation is now a constant and the GOV thus maximizes its pay-off by maximizing a, the customer's profit of the contract with the agent.

Lemma 2[14]

a) *In CP, customers offer a contract that, when the low outcome is realized, pays everything to customers and zero to agents,* $z[w^L] = w^L$.

Proof. Suppose that customers choose a contract $z[w^L] < w^L$. Then a contract z' with $z'[w^L] = w^L$ and $z'[w^H] = z[w^H]$ would satisfy AF and AIC and would increase the objective function of CP by increasing the pay-off when the low outcome is realized. Thus, a contract $z[w^L] < w^L$ cannot solve the customer problem and therefore, $z[w^L] = w^L$.

b) *AF can be disregarded.*

Proof. As Lemma 2a) established that $z[w^L] = w^L$, the restriction AF would be violated only when $z[w^H] > w^H$. However, in such case the restriction AIC would be violated, as the left-hand side of AIC, $u_{agent}\left[w^H - z[w^H] \right]$, would become negative while the right-hand side would be positive. Thus, as long as AIC is obeyed, AF is never violated. Thus AF can be disregarded in the further analysis.

c) *AIC is binding.*

Proof. Lemma 2a) established that $z[w^L] = w^L$. Suppose there is a contract z that solves CP while AIC is not binding:

$$u_{agent}\left[w^H - z[w^H] \right] > \left\{ \begin{array}{l} p_{SRO} \cdot u_{agent}\left[Max[w^H - w^L - x_{SRO}, 0] \right] \\ + p_{GOV} \cdot u_{agent}\left[Max[w^H - w^L - x_{GOV}, 0] \right] \\ + \left(1 - p_{GOV} - p_{SRO}\right) \cdot u_{agent}[w^H - w^L] \end{array} \right\}$$

Then there exist a new contract z' with $z'[w^H] > z[w^H]$ such that

$$u_{agent}\left[w^H - z'[w^H] \right] \geq \left\{ \begin{array}{l} p_{SRO} \cdot u_{agent}\left[Max[w^H - w^L - x_{SRO}, 0] \right] \\ + p_{GOV} \cdot u_{agent}\left[Max[w^H - w^L - x_{GOV}, 0] \right] \\ + \left(1 - p_{GOV} - p_{SRO}\right) \cdot u_{agent}[w^H - w^L] \end{array} \right\}$$

The new contract z' thus satisfies AIC and AF and strictly increases the value of the objective function. This is a contradiction with the assumption that contract z solved CP. Thus AIC is binding.

Lemma 3[15]

a) *Both the SRO and the GOV set, respecting the limited liability of the agents, the penalty at the maximum thus* $x_{GOV} = x_{SRO} = w^H - w^L$

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[14] The proofs for Lemma 2a) and 2c) follow largely the lines of the proofs in DeMarzo et a. (2005, p.703).
[15] The proofs for Lemma 3 follow mostly the lines of the proof in DeMarzo et all. (2005, p.703-704).

Proof. First I will prove that the SRO sets the penalty at the maximum, $x_{SRO} = w^H - w^L$. Suppose there is a set $\left(z_{SRO}^H, p_{SRO}, x_{SRO}\right)$ that solves SROP' with $x_{SRO} < w^H - w^L$. The set thus maximizes the objective function and satisfies CIR and AIC. Consider $\left(z_{SRO}^H, p'_{SRO}, x'_{SRO}\right)$ with $x'_{SRO} = w^H - w^L > x_{SRO}$: Then there exists a lower investigation probability $p'_{SRO} < p_{SRO}$, such that AIC is satisfied. This leaves AIC unchanged, but relaxes CIR, thus allowing the objective function to reach a higher maximum. This leads to a contradiction with the assumption that the set $\left(z_{SRO}^H, p_{SRO}, x_{SRO}\right)$ solves SROP'. Thus $x_{SRO} = w^H - w^L$.

Now I will prove that the GOV sets the penalty at the maximum, $x_{GOV}[w^L, w^H] = w^H - w^L$. Suppose there is a set $\left(z_{SRO}^H, p_{GOV}, x_{GOV}\right)$ that solves GOVP' with $x_{GOV} < w^H - w^L$. The set thus maximizes the objective function and satisfies AIC and AF. Consider $\left(z_{GOV}^H, p'_{GOV}, x'_{GOV}\right)$ with $x'_{GOV} = w^H - w^L > x_{GOV}$: Then there exists and a lower investigation probability $p'_{GOV} < p_{GOV}$ such that AIC is satisfied. This increases the objective function to reach a higher maximum. This leads to a contradiction with the assumption that the set $\left(z_{GOV}^H, p_{GOV}, x_{GOV}\right)$ solves the GOV problem. Thus $x_{GOV} = w^H - w^L$.

b) *CIR binds.*

Proof. Suppose there is a set $\left(z_{SRO}^H, p_{SRO}\right)$ that solves SROP' and $\pi^L w^L + \pi^H z_{SRO}^H - \pi^L \left(p_{SRO} c_{SRO} + p_{GOV} c_{GOV}\right) > a$, then there exist $z_{SRO}^{H}{}' < z_{SRO}^H$ and $p'_{SRO} < p_{SRO}$ such that $\pi^L w^L + \pi^H z_{SRO}^{H}{}' - \pi^L \left(p'_{SRO} c_{SRO} - p_{GOV} c_{GOV}\right) \geq a$ and the constraint AIC still holds. The objective function would thus be higher with the set $\left(z_{SRO}^{H}{}', p'_{SRO}\right)$. This leads to a contradiction with the assumption that the set $\left(z_{SRO}^H, p_{SRO}\right)$ solves SROP'. For a set solving SROP': $\pi^L w^L + \pi^H z_{SRO}^H - \pi^L \left(p_{SRO} c_{SRO} + p_{GOV} c_{GOV}\right) = a$.

Lemma 4[16]

a) $V[a]$ *is strictly decreasing in* a, $V'[a] < 0$.

Proof. The SRO maximizes in stage 1 of SROP'' its value function by choosing, respecting constraints CIR and AIC, its optimal investigation probability p_{SRO}^*. Thus

(A3) $V[a] = \pi^H \cdot u_{agent}\left[w^H - z^H\left[p_{SRO}^*, p_{SRO}\right]\right]$

Using CIR to express the contract gives

$\pi^L w^L + \pi^H z^H\left[p_{SRO}^*, p_{SRO}\right] - \pi^L\left(p_{SRO}^* c_{SRO} + p_{GOV} c_{GOV}\right) = a \Leftrightarrow$

(A4) $z^H\left[p_{SRO}^*, p_{SRO}\right] = \frac{1}{\pi^H}\left(a - \pi^L w^L + \pi^L\left(p_{SRO}^* c_{SRO} + p_{GOV} c_{GOV}\right)\right)$

---

[16] The proof for Lemma 4b) follows mostly the lines of the proofs in DeMarzo et al. (2005, p.706).

Using Equation (A4) to substitute for the contract in Equation (A3) gives

$$V[a] = \pi^H \cdot u_{agent}\left[w^H - \frac{1}{\pi^H}\left(a - \pi^L w^L + \pi^L \left(p^*_{SRO}c_{SRO} + p_{GOV}c_{GOV} \right) \right) \right]$$

Differentiating with respect to the customer utility level a, using envelope theorem, gives

$$V'[a] = -u'_{agent}\left[w^H - \frac{1}{\pi^H}\left(a - \pi^L w^L + \pi^L \left(p^*_{SRO}c_{SRO} + p_{GOV}c_{GOV} \right) \right) \right] < 0$$

b) *Provided GOVP″ and SROP″ have solutions, they are unique.*
Proof. GOVP″ is a concave problem and thus the solution, provided it exists, will be unique. Also, if $F[a]V[a]$ is concave, $F[a]V[a]$ has a unique interior solution and thus SROP″ has a unique solution. The remainder of the proof establishes the concavity of $F[a]V[a]$.

The concavity of $F[a]V[a]$ can be derived by showing that $V[a]$ can be written as $V[a] = k_1 + k_2 \cdot \left(a + W[V[a]] \right)$ with k_1 and k_2 constants and W an increasing, convex function. Then I can show that $V''[a] < 0$, which, together with the fact from Lemma 4a), $V'[a] < 0$, gives that $V[a]$ is concave. Together with the assumption that $F[a]$ is log-concave, it follows that $F[a]V[a]$ is concave.

When the SRO chooses the optimal investigation probability, the first stage of SROP″, given a parameter a and the investigation probability of the GOV, p_{GOV}, consists of three equations:

(A5) $V[a] = \pi^H \cdot u_{agent}[w^H - z^H]$
(A6) $a = \pi^L w^L + \pi^H z^H - \pi^L (p^*_{SRO}c_{SRO} + p_{GOV}c_{GOV})$,
(A7) $u_{agent}[w^H - z^H] = (1 - p^*_{SRO} - p_{GOV})u_{agent}[w^H - w^L]$

Use (A5) to substitute in (A7) gives

(A7') $V[a] = \pi^H(1 - p^*_{SRO} - p_{GOV}) \cdot u_{agent}[w^H - w^L]$

Rewrite (A5) as

(A5') $z^H = w^H - u_{agent}^{-1}\left[\frac{V[a]}{\pi^H} \right]$

Rewrite (A6) as

(A6') $p^*_{SRO} = \frac{1}{c_{SRO}\pi^L}(\pi^L w^L + \pi^H z^H - a) - \frac{p_{GOV}c_{GOV}}{c_{SRO}}$

Using (A6') to substitute for p^*_S in (A7') gives

(A7'') $V[a] = \pi^H\left(1 - \frac{1}{c_{SRO}\pi^L}(\pi^L w^L + \pi^H z^H - a) + \frac{p_{GOV}c_{GOV}}{c_{SRO}} - p_{GOV} \right) \cdot u_{agent}[w^H - w^L]$

Using (A5') to substitute for z^H in (A7'') gives

$$V[a] = \pi^H \left(1 - \frac{1}{c_{SRO}\pi^L}(\pi^L w^L + \pi^H \left(w^H - u_{agent}^{-1} \left[\frac{V[a]}{\pi^H} \right] \right) - a) + \frac{p_{GOV}c_{GOV}}{c_{SRO}} - p_{GOV} \right) u_{agent}[w^H - w^L]$$

$$\leftrightarrow V[a] = u_{agent}[w^H - w^L]\pi^H \left(1 + \left(\frac{c_{GOV}}{c_{SRO}} - 1 \right) p_{GOV} + \frac{a - \pi^L w^L - \pi^H \left(w^H - u_{agent}^{-1} \left[\frac{V[\gamma]}{\pi^H} \right] \right)}{c_{SRO}\pi^L} \right)$$

(A8) $\leftrightarrow V[a] = k_1 + k_2 \cdot (a + W[V[a]])$

Where: $k_1 = u_{agent}[w^H - w^L]\pi^H \cdot \left(1 + \left(\frac{c_{GOV}}{c_{SRO}} - 1 \right) p_{GOV} \right)$, $k_2 = u_{agent}[w^H - w^L]\pi^H \frac{1}{c_{SRO}\pi^L}$,

and $W[V[a]] = -\pi^L w^L + \pi^H \left(u_{agent}^{-1} \left[\frac{V[a]}{\pi^H} \right] - w^H \right)$ and thus $W'[\cdot] = u_{agent}^{-1}{}' \left[\frac{\cdot}{\pi^H} \right] > 0$ and

$W''[\cdot] = u_{agent}^{-1}{}'' \left[\frac{\cdot}{\pi^H} \right] > 0$ as u_{agent} is a strictly concave utility function. $W[\cdot]$ is thus strictly increasing and convex.

Differentiating (A8) with respect to a, using envelope theorem, gives:

$$V'[a] = k_2 \left(1 + V'[a]W'[V[a]] \right)$$

(A9) $\leftrightarrow V'[a] = \frac{k_2}{1 - k_2 W'[V[a]]}$

Differentiating (A9) with respect to a, using envelope theorem, gives:

$$V''[a] = \frac{k^2 V'[a]W''[V[a]]}{\left(-1 + kW'[V[a]] \right)^2} < 0$$

$V''[a]$ is negative as the denominator is larger than zero, $W''[\cdot] > 0$, and, by Lemma 4a), $V'[a] < 0$. Thus, as $V'[a] < 0$ and $V''[a] < 0$, $V[a]$ is strictly concave.

c) *The best response function of the SRO obeys* $BR_{SRO}[p_{GOV}] \leq MAX[0, BR_{SRO}[0] - p_{GOV}]$, *with a strict inequality for* $BR_{SRO}[0] - p_{GOV} > 0$.

Proof. Let $p_{GOV} > 0$ be given. The optimal choice of the SRO is either an investigation probability $p_{SRO} = 0$ or $p_{SRO} > 0$. In the case $p_{SRO} > 0$, write p_{SRO}^{Total} as the total investigation probability of the SRO and the GOV together. As $p_{SRO} > 0$, the SRO can affect p_{SRO}^{Total} as $\frac{dp_{SRO}^{Total}}{dp_{SRO}} = \frac{dp_{SRO} + p_{GOV}}{dp_{SRO}} = 1$. AIC in SROP'' can now be rewritten as $u_{agent}[w^H - z^H] = (1 - p_{SRO}^{Total}) \cdot u_{agent}[w^H - w^L]$. The term $-\pi^L (p_{SRO}c_{SRO} + p_{GOV}c_{GOV})$ in CIR in SROP'' can be rewritten as follows:

$$-\pi^L\left(p_{SRO}c_{SRO}+p_{GOV}c_{GOV}\right)=-\pi^L\left((p_{SRO}+p_{GOV})c_{SRO}+p_{GOV}(c_{GOV}-c_{SRO})\right)$$
$$=-\pi^L\left(p_{SRO}^{Total}c_{SRO}+p_{GOV}(c_{GOV}-c_{SRO})\right)$$
$$=-\pi^L p_{SRO}^{Total}c_{SRO}-K$$

where $K=\pi^L p_{GOV}(c_{GOV}-c_{SRO})$ is regarded by the SRO as a constant. Further, let $a'=a+K$, then SROP" can be reformulated as SROP"':

SROP"'

Stage 1: $V[a']=\max_{p_{SRO}^{Total}}\pi^H\cdot u_{agent}\left[w^H-z^H[p_{SRO}^{Total}]\right]$, s.t:

    CIR: $\pi^L w^L+\pi^H z^H[p_{SRO}^{Total}]-\pi^L p_{SRO}^{Total}c_{SRO}=a'$

    AIC: $u_{agent}[w^H-z^H]=\left(1-p_{SRO}^{Total}\right)\cdot u_{agent}[w^H-w^L]$

Stage 2: $\max_{a'}F[a']V[a']$, $a_{SRO}=\text{ArgMax}_{a'}F[a']V[a']$

SROP"' has an identical formal setup as SROP" under SRO-only, except that the value function $V[a']$ has been horizontally shifted to the left by K relative to the original $V[a]$, and it thus follows that the SRO will choose an optimal total investigation probability that will be smaller than the optimal investigation probability under SRO-only, $p_{SRO}^{Total}<BR_{SRO}[0]$. As $p_{SRO}+p_{GOV}=p_{SRO}^{Total}<BR_{SRO}[0]$, thus $p_{SRO}<BR_{SRO}[0]-p_{GOV}$. The best response function of the SRO is thus $BR_{SRO}[p_{GOV}]\le\text{MAX}[0,BR_{SRO}[0]-p_{GOV}]$.

d) *The best response function of the GOV is given by* $BR_{GOV}[p_{SRO}]=\text{MAX}[0,BR_{GOV}[0]-p_{SRO}]$.

Proof. Let $p_{SRO}\ge0$ be given. The optimal choice of the GOV is either an investigation probability $p_{GOV}=0$ or $p_{GOV}>0$. In the case $p_{GOV}>0$, write p_{GOV}^{Total} as the total investigation probability of the SRO and the GOV together. As $p_{GOV}>0$, the GOV can affect p_{GOV}^{Total} as $\dfrac{dp_{GOV}^{Total}}{dp_{GOV}}=\dfrac{dp_{SRO}+p_{GOV}}{dp_{GOV}}=1$. AIC in GOVP" can now be rewritten as $u_{agent}[w^H-z^H]=\left(1-p_{GOV}^{Total}\right)\cdot u_{agent}[w^H-w^L]$. The term $-\pi^L\left(p_{SRO}c_{SRO}+p_{GOV}c_{GOV}\right)$ in the objective function can be rewritten as follows:

$$-\pi^L\left(p_{SRO}c_{SRO}+p_{GOV}c_{GOV}\right)=-\pi^L\left(p_{SRO}(c_{SRO}-c_{GOV})+(p_{SRO}+p_{GOV})c_{GOV}\right)$$
$$=-\pi^L\left(-p_{SRO}(c_{GOV}-c_{SRO})+p_G^{Total}c_{GOV}\right)$$
$$=-\pi^L p_{GOV}^{Total}c_{GOV}+K$$

Where $K=\pi^L p_{SRO}(c_{GOV}-c_{SRO})$ is regarded by the GOV as a constant. Further, let $a'=a+K$, then GOVP" can be reformulated as GOVP"':

Government Problem (GOVP³)

$a_{GOV}=\text{Max}_{p_{GOV}}\left[\pi^L w^L+\pi^H z^H[p_{GOV}^{Total}]-\pi^L p_{GOV}^{Total}c_{GOV}+K\right]$

AIC: $u_{agent}\left[w^H-z^H[p_{GOV}^{Total}]\right]=\left(1-p_{GOV}^{Total}\right)\cdot u_{agent}[w^H-w^L]$

Where $K=p_{SRO}(c_{SRO}-c_{GOV})$ is a constant

GOVP³ has an identical formal setup as GOVP" under GOV-only, except that the objective function has been increased by the constant K. As adding a constant to an objective function does not change the optimal choice, the GOV will set the total investigation probability equal to the optimal investigation probability under GOV-only,

$p_{GOV}^{Total} = BR_{GOV}[0]$. Thus, as $p_{GOV} + p_{SRO} = p_{GOV}^{Total} = BR_{GOV}[0]$, it follows that the best response function for the GOV is given by $BR_{GOV}[p_{SRO}] = \text{MAX}[0, BR_{GOV}[0] - p_{SRO}]$.

Proposition 1
a) *In the unique Nash equilibrium of the simultaneous game, the GOV does all the investigation and the SRO does none.*

Proof. Consider investigation probabilities (p_{SRO}, p_{GOV}) such that $0 \le p_{GOV} < BR_{GOV}[0]$. Lemma 3c) shows that p_{SRO} can be part of a Nash equilibrium only if $p_{SRO} \le BR_{SRO}[0] - p_{GOV} < BR_{GOV}[0] - p_{GOV}$ (as $BR_{SRO}[0] < BR_{GOV}[0]$ by assumption). The investigation probability of the GOV and the SRO combined must thus be smaller than $BR_{GOV}[0]$. But Lemma 3b) then implies that p_{GOV} will be dominated for the GOV by a p'_{GOV} such that $p'_{GOV} = BR_{GOV}[0] - p_{SRO} > p_{GOV}$. Thus any action profile with the GOV choosing $p_{GOV} < BR_{GOV}[0]$ cannot be a Nash equilibrium. Now consider investigation probabilities (p_{SRO}, p_{GOV}) such that $p_{GOV} = BR_{GOV}[0]$ and $p_{SRO} = 0$. Obviously, the investigation probability of the GOV is not dominated as the GOV chooses its optimal action. Suppose that there is a $p'_{SRO} \ne p_{SRO}$ that strictly dominates $p_{SRO} = 0$. Using Lemma 3c) implies that then $p'_{SRO} \le \text{MAX}[0, BR_{SRO}[0] - p_{GOV}] = \text{MAX}[0, BR_S[0] - BR_{GOV}[0]]$. Using the assumption that the oversight by the GOV is effective, $BR_{SRO}[0] < BR_{GOV}[0]$, it follows that $p'_{SRO} = 0 = p_{SRO}$, leading to a contradiction. Thus $p_{SRO} = 0$ is the best, unique response of the SRO. The action profile where the GOV does all the investigation and the SRO does none is thus an unique Nash equilibrium in pure strategies.

b) *If, in the simultaneous game, the GOV were gullible, in the sense that the GOV believes any investigation probability announced by the SRO, then the SRO deceives the GOV by announcing an investigation probability $p_{SRO} \ge BR_{GOV}[0]$, while implementing $p_{SRO} = BR_{SRO}[0] < BR_{GOV}[0]$.*

Proof. If the SRO were unable to make false announcements, then the announcement by the SRO would be credible and the outcome as determined by DeMarzo et al. (2005) would result. The SRO would announce and implement $p_{SRO} = BR_{GOV}[0]$ and the GOV would implement $p_{GOV} = BR_{GOV}[BR_{GOV}[0]] = 0$. When the GOV is gullible, the SRO is able to make false announcements, and knows the GOV is gullible, the SRO can obtain a higher pay-off by making a false announcement. By announcing $p_{SRO} \ge BR_{GOV}[0]$, the SRO knows the gullible GOV will set an investigation probability of $p_{GOV} = 0$. The best reply of the SRO to $p_{GOV} = 0$ is $p_{SRO} = BR_{SRO}[0] < BR_{GOV}[0]$. This is the best strategy for the SRO.

The SRO will not announce a lower probability, $p_{SRO} < BR_{GOV}[0]$, as then the GOV will set a strictly positive investigation probability, which makes CIR more binding in SROP" as the investigation cost of the GOV are higher than those of the SRO. The SRO thus announces $p_{SRO} \ge BR_{GOV}[0]$ and implements the lower investigation probability $p_{SRO} = BR_{SRO}[0] < BR_{GOV}[0]$.

Proposition 2. [17]

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[17] The proof for Proposition 2 follows mostly the lines of the proof in DeMarzo et all. (2005, p. 694).

In the Nash equilibrium of the simultaneous game, the GOV sets its investigation probability given by $-\dfrac{u_{agent}[w^H - w^L]}{u'_{agent}\left[(1-p_{GOV})\cdot u_{agent}[w^H-w^L]\right]} = -\dfrac{\pi^L}{\pi^H}c_{GOV}$.

Proof. Use AIC to reformulate

$$u_{agent}\left[w^H - z^H[p_{SRO}, p_{GOV}]\right] = (1 - p_{GOV} - p_{SRO})\cdot u_{agent}[w^H - w^L]$$
$$\Leftrightarrow z^H[p_{GOV}] = w^H - u_{agent}^{-1}\left[(1 - p_{GOV})\cdot u_{agent}[w^H - w^L]\right]$$

Substitute for the contract in the objective function

$$\text{Max}_{p_{GOV}} \; \pi^L w^L + \pi^H\left(w^H - u_{agent}^{-1}\left[(1 - p_{GOV})\cdot u_{agent}[w^H - w^L]\right]\right) - \pi^L(p_{SRO}c_{SRO} + p_{GOV}c_{GOV})$$

The first order condition is then $-\dfrac{u_{agent}[w^H - w^L]}{u'_{agent}\left[(1-p_{GOV})\cdot u_{agent}[w^H-w^L]\right]} = -\dfrac{\pi^L}{\pi^H}c_{GOV}$.

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