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Incentives in Common Agency

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Incentives in Common Agency

Bernard Sinclair-Desgagné[*]

Résumé / *Abstract*

Nous étudions les situations où (1) un agent doit distribuer ses efforts (qui ne peuvent être observés par des tiers) sur différentes tâches et où (2) plusieurs parties prenantes ont des points de vue divergents quant à la distribution la plus souhaitable. La théorie économique prédit actuellement que chacun de ces ingrédients – la présence de tâches multiples et la concurrence entre parties prenantes - suffit à lui seul à abaisser considérablement la puissance des incitations. Ce papier propose néanmoins un remède simple, via l'utilisation d'audits contingents. Le mécanisme proposé rendrait en effet les tâches complémentaires du point de vue de l'agent ; en même temps, les parties prenantes parviendraient à se coordonner pour le mettre en oeuvre, à condition que l'aversion au risque de l'agent décroisse suffisamment vite avec l'augmentation de sa richesse. Cette coordination pourrait par ailleurs se réaliser d'une manière «libérale», en ce sens que certaines parties prenantes n'auraient besoin de contrôler que les tâches les intéressant directement. Certaines utilisations possibles du mécanisme pour les régimes de conformité des entreprises, l'organisation des gouvernements, et le management de l'innovation sont brièvement esquissées., nous trouvons des changements dans la dynamique et dans la mémoire longue de la volatilité.

This paper considers situations where an agent must allocate his nonobservable effort among several tasks and where several principals hold diverging viewpoints on what the best allocation should be. Economic theory currently sees each of these features as major obstacles to raising the strength of an agent's incentives. This paper proposes a simple scheme - based on contingent monitoring - that can nevertheless mitigate both *of these obstacles simultaneously. Under this scheme, if the agent's absolute risk aversion decreases fast enough with respect to wealth, then the principals would coordinate their respective incentive provision so that the agent would also see his various tasks as complementary (instead of substitute) income-enhancing activities. Furthermore, coordination could be achieved in a somewhat "liberal" or decentralized way, in the sense that some principals would need to control only the tasks they have assigned to the agent. Potential applications to corporate compliance, the organization of government, and the management of innovation are briefly discussed.*

Mots clés : Principal-agent, multi-tâches, plusieurs principaux, audits

Keywords : *Multitasking, several principals, upper-tail audits*

JEL Classification : D82, M52

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"No man ill hold to the one and despise the other"

[St Matthew, 6, 24]

A common agency is a situation where several principals have a stake in the actions of a particular agent. Such a situation occurs frequently in economic life. Shareholders and public regulators, for instance, are both affected by some decisions implemented by a corporate head office. The White House and Members of Congress are jointly concerned by the way public policies are refined and enforced at the Department of Justice or the Environmental Protection Agency. Production and marketing departments of a manufacturing firm must both cope with the designs provided by the R&D department.

In those situations it is natural to expect that each principal will try to influence the agent's actions. The latter will thus face a set of separate contracts, each one being designed in order to align the agent's preferences with those of a specific principal. Several researchers have now examined this set of contracts (see Avinash Dixit, 1996, and Jean Tirole, 2001, for recent surveys). An important conclusion is that it would normally yield low-powered incentives, i.e. the agent's overall payoff would turn out to be relatively insensitive to output.[1] This conclusion is based on the presence of two major obstacles.[2] First, as shown by Dixit (1996), competing principals with different objectives might counter each others' incentive scheme by encouraging effort only on those peculiar tasks that matter to oneself while insuring the risk averse agent against (sometimes even rewarding him for!) underperforming on the remaining tasks. Second, even if the principals

[1] This theoretically-based assertion is consistent, for instance, with the relatively flat wages received by the vast majority of employees in public organizations, and with the relatively weaker managerial incentives that prevail in countries favorable to a stakeholder view of the firm. The former observation is discussed by Dixit, 1996; the latter by Tirole, 2001.

[2] An additional one would be the fuzziness of missions and lack of focus that the presence of several active principals often entails (as argued by Mathias Dewatripont, Ian Jewitt and Tirole, 1999). This obstacle raises important behavioral issues (communication, framing, etc.) that are unfortunately beyond the scope of this paper.

did cooperate, the agent's job would typically consist in a collection of heterogenous tasks, some of which being more difficult to monitor than others; in this context previous work by Oliver E. Williamson (1985), Bengt Holmström and Paul Milgrom (1991), George Baker (2001), and others indicate that strong output-based incentives would lead the agent to neglect all the tasks but those which look relatively easier to appraise.

This paper now proposes a simple incentive scheme that deals with both of these obstacles simultaneously. This scheme can be described briefly as follows. Consider two principals, labeled α and β, who respectively assign task A and task B to a common agent. Let principal α monitor task A and pay the agent according to output on this task. Let principal β commit to measure performance on task B, and to compensate the agent, *only* when current output on task A gets *above* a certain prespecified level. Compensation from principal β varies according to the observed return on both tasks, the agent being penalized after displaying low performance on task B; it is set, however, such that *ex ante* the agent would *seek* principal β's appraisal.

Intuitively, this scheme can mitigate the two obstacles mentioned above - multitasking and competing principals - for the following reasons. First, it makes the amounts of effort expended on tasks A and B complementary in increasing the agent's total compensation. To be sure, the agent is now eager to work harder on task A because this not only raises the expected reward from principal α but also the likelihood of an appraisal by principal β. Seeking principal β's intervention, however, makes little sense if task B is neglected. The agent would therefore not increase his effort on one task without putting more attention as well on the other task. The tendency to overspecialize which characterizes multitasking and hampers incentive provision in that context is henceforth alleviated. As long as the agent sees tasks A and B as complementary, furthermore, the incentives set by one principal on her preferred task will also benefit the other principal. This (designed) positive externality counterbalances an inherent negative one - all things equal, stronger incentives to work on one task raise the agent's opportunity cost of putting extra time elsewhere, making it more expensive to provide incentives on the other task - that competition between principals tends to exacerbate. It then becomes easier for the principals to coordinate their respective incentive provision.

This conclusion departs from the ones suggested by the usual analyses of common agency. In their seminal article, for instance, Douglas Bernheim and Michael D. Whinston (1986) have shown that competing principals can coordinate on a cooperative outcome if and only if there would be no incentive problems were the principals to collude (or if, in other words, nonobservability of the agent's effort *per se* does not cause welfare losses). And more recently, using a multi-principal extension of Holmström and Milgrom (1991)'s multitask principal-agent model, Dixit (1996) has proved that total incentive compensation would exhibit the wage gradient arising under a single principal divided by the number of competing principals. A closer look at these similar conclusions indicates, however, that they might be due to the predominance of one type of externality between principals.[1] In the former article a principal incurs the cost but shares with the other principals the benefit of providing stronger incentives; this creates a free-rider problem which induces a further decrease in the strength of incentives when the principals compete.[2] In the latter, on the other hand, a principal's incentive scheme may not benefit the other principals but it always raises their incentive provision cost. These are instances of respectively positive and negative externalities. In this paper, by contrast, both types of externalities are made to coexist and to offset each other (at least partially).

[1] This diagnostic was recently spelled out with considerable precision and generality by Ilya Segal (1999).

[2] Bernheim and Whinston (1986)'s analysis of common agency is actually more general than the latter statement suggests. I refer here to the "effort" version of their model that they discuss on pages 935-6.

There is of course a “price” to pay to achieve such a scenario. For instance, the proposed scheme builds on the presumption that the principals have agreed beforehand on which task will be subject to contingent appraisals (i.e. which task will stand as task B) and which task will be monitored continuously. It is also supposed that principal β would be as capable as principal α to observe the output on task A. Furthermore, one key hypothesis had to be brought in so that a rational principal would be willing to use contingent monitoring: the agent’s risk aversion must decrease sufficiently fast with respect to wealth.[1] If this were not the case, then a principal would find it too expensive to offer the agent a sharing rule based on the output on task B that looks attractive *ex ante*. The (albeit stylized) examples which are discussed below suggest nevertheless that the assumptions made here might not exclude some significant applications.

The paper unfolds as follows. Notation, basic definitions and technical assumptions are set out in the following section. Section II analyzes the conflict between principals and argues that the introduction of task complementarity would mitigate this problem. A contingent monitoring scheme that can induce task complementarity is introduced in Section III, and conditions under which it could constitute a common agency equilibrium are spelled out. Section IV outlines potential applications of the proposed scheme to corporate compliance, the internal organization of government, and the management of innovation. Section V contains concluding remarks.

[1] More precisely, the agent’s coefficient of absolute prudence (as defined in Miles S. Kimball, 1990) must be greater than three times his coefficient of absolute risk aversion.

I. NOTATION, DEFINITIONS AND FORMAL ASSUMPTIONS

This section sets the basic formal framework of the paper. The simplest instance of a common agency - that with only two principals and two tasks - is laid out, for it can convey the main ideas while keeping notation and computations to a minimum. Possible generalizations to an arbitrary number of principals and tasks are discussed in a companion paper (Bernard Sinclair-Desgagné, 1999).

From now on let us then consider a one-shot contractual relationship between one agent and two principals. On the one hand, principal α assigns a task A to the agent. The latter's effort on that task - noted a (≥ 0), is imperfectly observable through an output level α_i, where $i = 0, 1, ..., I$ and α_i is increasing in its index; the likelihood of observing output α_i when the agent delivers an effort a is written $p_i(a)$. Principal β, on the other hand, expects the agent to also work on a task B. Again, the agent's effort on B - noted b (≥ 0) - can only be inferred imperfectly from an output level β_j, where $j = 0, 1, ..., J$ and β_j increases in j. The linkage between effort and output in this case is captured by the conditional probability $q_j(b)$ of observing output level j given effort b. Thereafter, the functions $p_i(a)$ and $q_j(b)$ are assumed to be positive and twice continuously differentiable in (a,b).

Each principal seeks to influence the agent's effort allocation via an incentive contract. The agent is risk averse, with positive, strictly concave, strictly increasing and three times differentiable Von Neumann-Morgenstern utility index u( ) defined over monetary payoffs. His expected utility under an effort allocation (a,b) and when principals α and β respectively provide incentive wages x_{ij} and y_{ij} is therefore given by

(1) $$U(a,b;x_{ij},y_{ij};u,c) = \sum_{ij} p_i(a)\,q_j(b)\,u(x_{ij} + y_{ij}) - c(a,b)\,,$$

where c(a,b) denotes the agent's cost of effort. The latter is assumed to be positive, strictly convex and twice continuously differentiable. Furthermore, it exhibits strict substitutability (supermodularity) in effort - that is: $c_{ab} > 0$ at all values of the arguments (a,b),[1] so a higher effort on one task raises the marginal cost of effort on the other task.

The principals are risk neutral. Given principal β's incentive wage y_{ij}, a rational principal α would thus set her incentive wage x_{ij} in order to

$$\underset{x_{ij},\ a,b}{maximize} \sum_{ij} p_i(a)\,q_j(b)\,[\,\alpha_i - x_{ij}\,]$$

(2) $$subject\ to\ :$$

$$(IC)\quad (a,b)\ maximizes\ U(a,b;x_{ij},y_{ij};u,c)$$

$$(PC)\quad U(a,b;x_{ij},y_{ij};u,c) \geq U^*$$

Similarly, principal β's best response to a wage schedule x_{ij} would be a solution to

[1] Throughout this paper, the subscripts $_a$ and $_b$ denote partial derivatives with respect to the arguments a and b respectively.

$$\underset{y_{ij},\, a, b}{maximize} \sum_{ij} p_i(a)\, q_j(b)\, [\, \beta_j - y_{ij} \,]$$

(3) *subject to :*

$$(IC) \quad (a,b) \text{ maximizes } U(a, b\, ; x_{ij}, y_{ij}\, ; u, c)$$

$$(PC) \quad U(a, b\, ; x_{ij}, y_{ij}\, ; u, c) \geq U^*$$

These two problems have different objectives but the same constraints. Constraint (IC) is the so-called *incentive compatibility* constraint: given the incentive wages x_{ij} and y_{ij}, the agent would always select an effort allocation that maximizes his expected utility. Constraint (PC) is the familiar *participation* constraint: the agent is willing to work under incentive wages x_{ij} and y_{ij} only if he can achieve his reservation utility level U*.

Problems (2) and (3) define a game between the principals. The following definition adapts to the present context Bernheim and Whinston (1986)'s formal notion of an equilibrium.

Definition 1: A pair of incentive wages x_{ij} and y_{ij} together with an effort allocation (*a,b*) constitute a *common agency Nash equilibrium* if [x_{ij};(*a,b*)] solves problem (2) and [y_{ij};(*a,b*)] solves problem (3), and if each principal thereby gets her own reservation utility.

In the upcoming sections, equilibrium contracts are studied using a *first-order approach*. The cumbersome - because it is infinite - set of constraints that must be checked in order to satisfy (IC) is thereby replaced by the more tractable first-order necessary conditions for an interior maximum of the agent's expected utility, that is:[1]

[1] Throughout this paper the "prime" symbol ′ denotes first-order derivatives of one-variable functions.

(4) $$U_a(a,b;x_{ij},y_{ij};u,c) = \sum_{ij} p_i'(a)\,q_j(b)\,u(x_{ij}+y_{ij}) - c_a \geq 0, \text{ and}$$

(5) $$U_b(a,b;x_{ij},y_{ij};u,c) = \sum_{ij} p_i(a)\,q_j'(b)\,u(x_{ij}+y_{ij}) - c_b \geq 0\,.$$

This method is not misleading in the present context - meaning that the effort allocation (*a,b*) engineered by the principals would always be a global maximum of the agent's expected utility - provided the following assumptions are met.[1]

ASSUMPTION 1 [MLRP - Monotone Likelihood Ratio Property]: *The ratios* $p_i'(a)/p_i(a)$ *and* $q_j'(b)/q_j(b)$ *are nondecreasing in i and j.*

ASSUMPTION 2 [Generalized CDFC - Convexity of the Distribution Function Condition]: *The matrices* $[G_{ab}(i_1, j_1)]$ *of second-order derivatives of the functions*

$$G(i_1, j_1|a,b) = \sum_{i=i_1}^{I} \sum_{j=j_1}^{J} p_i(a)\; q_j(b)$$

are negative semi-definite, for all i_1, j_1*, a, b.*

ASSUMPTION 3 [Diverging Preferences]: *In problems (2) and (3) the incentive compatibility constraints represented by (4) and (5) are strictly binding.*

The latter assumption entails in particular that the principals would like to see the agent dedicate some positive effort level to each task (not the same level, of course; the desired level might be quite large or rather small, depending on the principal). It can be met, for instance, by having the agent's cost of effort function decrease strictly when *a* and *b* are

[1] The stated assumptions are tailored to this paper, and they are generally stronger than necessary. For weaker assumptions that still guarantee the validity of the first-order approach in multi-dimensional settings, see Sinclair-Desgagné (1994).

equal to zero, meaning that the agent exhibits some intrinsic motivation to work. Assumption 2 is a two-dimensional version of the well-known Convexity of the Distribution Function Condition, which captures a form of decreasing returns to effort. Assumption 1 means, finally, that higher assessments *i* and *j* make the expense of larger effort levels *a* and *b* by the agent more likely.

The following intuitive property is a straightforward consequence of Assumption 1. It supports the standard interpretation given above and plays an important role in validating the first-order approach.

LEMMA 1 [Stochastic Dominance Condition (SDC)]: *Under Assumption 1, we have that:*

$$\sum_{i=i_1}^{I} p_i'(a) \geq 0 \quad and \quad \sum_{j=j_1}^{J} q_j'(b) \geq 0 ,$$

for all $i_1 = 0, 1, \ldots, I$ *and* $j_1 = 0, 1, \ldots, J$.

PROOF:

Let us concentrate on the p_i's. The proof for the q_j's would be similar.

Since $\sum_0^I p_i(a) \equiv 1$, we have that $\sum_0^I p_i'(a) \equiv 0$. Consequently, if $\sum_k^I p_i'(a) < 0$ for some k > 0, then it must be the case that $\sum_0^{k-1} p_i'(a) > 0$. The former implies that $p_{i*}'(a) < 0$ at some i* between k and I, and the latter that $p_{i**}'(a) > 0$ at an i** ≤ k-1 < i*, which contradicts Assumption 1.

This section will now end on a few clarifying remarks. First, the expected utility defined in (1) does not mean that the agent cares exclusively about effort and money. While intrinsic preferences for some positive amount of effort, for one of the tasks, or for attending to a particular principal are not explicitly modelled, such preferences could be represented within the present framework via a more specific function $c(a,b)$. Second, it is implicitly assumed that the first-order approach always yields some solutions to the principals' respective problems. Constraints (4) and (5), furthermore, preclude a given solution to be such that $a = 0$ and $U_a < 0$, or $b = 0$ and $U_b < 0$; a multitask problem that would only give the latter would seem rather ill-defined. Third, the fact that the joint likelihood distribution of (i,j) is a product $p_i(a)q_j(b)$ does not entail that nothing can be inferred about, say, effort b after output i only is observed, for the principals' respective prior would reflect the fact that a and b are linked through the agent's cost of effort. This implies, however, that i and j are sufficient statistics for a and b respectively. Finally, the inherent conflict between principals is emphasized here by making their respective income depend on either i or j. On the other hand, while the principals may have conceived and own separately the monitoring technologies $p_i(a)$ and $q_j(b)$, it is assumed that, once an output level, say i, is observed by principal α, it is also observed without additional cost by principal β. In this context the upcoming sections will develop a scheme that would alleviate the present conflict, thereby allowing to raise the power of the agent's incentives.

II. TASK COMPLEMENTARITY AND THE MITIGATION OF CONFLICT

Someone usually (and too often rightly) expects that diverging preferences amongst possibly interfering principals produce bilateral contracts that altogether deliver poor incentives to the agent. A closer look at the properties of common agency equilibria, however, may suggest some remedy.

First note that, according to definition 1 and the first-order approach, the wage schedule set by principal α in a common agency Nash equilibrium must satisfy the following first-order condition:

$$\textbf{(6)} \qquad \textit{for all } x_{ij} : \frac{1}{u'(x_{ij} + y_{ij})} = \mu^{\alpha} + \gamma^{\alpha} \frac{p_i'(a)}{p_i(a)} + \lambda^{\alpha} \frac{q_j'(b)}{q_j(b)} ,$$

where μ^{α}, γ^{α}, and λ^{α} are the Lagrange multipliers associated respectively with the participation constraint (PC) and with the incentive compatibility constraints given by (4) and (5). A similar condition should hold for principal β, that is:

$$\textbf{(7)} \qquad \textit{for all } y_{ij} : \frac{1}{u'(x_{ij} + y_{ij})} = \mu^{\beta} + \gamma^{\beta} \frac{p_i'(a)}{p_i(a)} + \lambda^{\beta} \frac{q_j'(b)}{q_j(b)} ,$$

with μ^{β}, γ^{β}, and λ^{β} being the corresponding Lagrange multipliers. Notice that the multipliers are nonnegative by construction. The monotonicity of rewards with respect to output, which is a standard result in principal-agent analysis, thus follows directly from assumption 1 and the fact that the function $1/u'(\ )$ is increasing. This important property will be stated as a lemma.

LEMMA 2 [Monotonous incentives]: *At an equilibrium, total wage must be increasing in i and j.*

This statement is of course valid only for the *aggregate* wage schedule $x_{ij} + y_{ij}$. To see what may happen for x_{ij} alone, say, let us consider principal α's first-order necessary conditions for implementing an effort allocation (*a*,*b*). Since the incentive compatibility constraints are assumed to be binding, these conditions reduce to:

(8)

$$\sum_{i\,j} p_i'(a)\,q_j(b)\,[\,\alpha_i - x_{i\,j}\,] + \gamma^{\alpha} U_{a\,a}(a\,,b\,;x_{i\,j}\,,y_{i\,j}\,;u\,,c) + \lambda^{\alpha}\, U_{a\,b}(a\,,b\,;x_{i\,j}\,,y_{i\,j}\,;u\,,c) \;\; \begin{array}{l} \leq 0 \quad \text{if} \quad a = 0 \\ = 0 \quad \text{if} \quad a > 0 \end{array}$$

and

(9)

$$-\sum_{i\,j} p_i(a)\,q_j'(b)\,x_{i\,j} + \gamma^{\alpha} U_{a\,b}(a\,,b\,;x_{i\,j}\,,y_{i\,j}\,;u\,,c) + \lambda^{\alpha} U_{b\,b}(a\,,b\,;x_{i\,j}\,,y_{i\,j}\,;u\,,c) \;\; \begin{array}{l} \leq 0 \quad \text{if} \quad b = 0 \\ = 0 \quad \text{if} \quad b > 0 \end{array}$$

after applying the Envelope Theorem. Note that the second-order partial derivatives $U_{a\,a}$ and $U_{b\,b}$ must be negative, because the assumptions supporting the first-order approach imply that the agent's expected utility is concave.

Suppose now that the cross-derivative $U_{a\,b}$ is also negative, and consider the latter condition which has principal α implement an amount of effort *b* on the task that was assigned by the other principal. Let $x(a,b) = \sum p_i(a) q_j(b) x_{i\,j}$ be the expected wage paid by principal α given the effort allocation (*a*,*b*) ; condition (9) then indicates that an equilibrium at a positive amount of effort $b > 0$ must have

(10)

$$x_b(a,b) = \sum_{i\,j} p_i(a)\,q_j'(b)\,x_{i\,j} < 0 \;,$$

i.e., the agent's expected compensation from principal α *decreases* when more effort is devoted to task B. This clearly affects principal β's incentive provision: in view of the statement of Lemma 2 principal β has therefore to deliver incentives which are sufficiently powerful to counter the impact of (10). A symmetric situation occurs at task A. At an equilibrium with positive effort levels, each principal thus provides *disincentives* to work for the other principal and finds it at the same time harder and more costly to motivate the agent on the task she cares about; low-powered incentives are naturally the overall result.

Clearly, a different conclusion could hold if the cross-derivative $U_{a\,b}$ were instead positive. In this case tasks A and B would exhibit some complementarity, in the sense that the agent's marginal utility of effort on one task would increase after putting more effort on the other task.

Definition 2: Tasks A and B are called *complementary* (*substitutes*) for the agent if $U_{a\,b} > 0$ (< 0).

To get a positive cross-derivative $U_{a\,b}$, however, one needs to overcome the assumed supermodularity (i.e. $c_{a\,b} > 0$) of the cost function, which makes the agent tend to decrease effort on one task after increasing it on the other task. Some solutions have recently been proposed in principal-agent settings (see Sinclair-Desgagné, 1999, and Glen A. MacDonald and Leslie M. Marx, 2001). But common agency bears the additional challenge to make competing principals actually coordinate in creating complementarity between tasks. This challenge is taken up in the upcoming section.

III. IMPLEMENTING TASK COMPLEMENTARITY

This section will now formalize the contingent-monitoring scheme outlined in the introduction. The scheme's precise structure is first explained, together with the reasons it may create complementarity between tasks. Another subsection then derives sufficient conditions for the scheme to be implemented by competing principals.

A. *Upper-Tail Contingent Monitoring*

In the preceding sections, as in most instances of common agency, the principals would always observe the output on each task. From now on let this be true for task A only, and let principal β appraise the agent's performance on task B and share this information with principal α according to a probability n_i that depends on the observed output level *i*. This defines a *contingent monitoring scheme*. Under this scheme, principal α offers wages s_i while the output on task B remains unknown, and w_{ij} otherwise; and principal β rewards the agent through a schedule t_{ij} only after seeing *j*.

The agent's expected utility under an effort allocation (*a*,*b*) and a pair of contracts involving two wage schedules (s_i,w_{ij}) on part of principal α, and a monitoring probability plus a conditional wage schedule (n_i,t_{ij}) from principal β, is now given by:

$$U(a,b;s_i,w_{ij},n_i,t_{ij};u,c) = \tag{11}$$
$$\sum_{ij} p_i(a)\,q_j(b)\,[\,n_i\,u(w_{ij}+t_{ij}) + (1-n_i)\,u(s_i)] - c(a,b)\,.$$

Take the cross-partial derivative of this expression. This gives:

$$U_{ab}(a, b; s_i, w_{ij}, n_i, t_{ij}; u, c) = \tag{12}$$

$$\sum_{ij} p_i'(a)\ q_j'(b)\ n_i\ [u(w_{ij} + t_{ij}) - u(s_i)] - c_{ab}\ .$$

Since $c_{ab} > 0$, the latter can only be positive if the sum on the right-hand side is made positive. A combination of monitoring probabilities and incentive wages that satisfy the following conditions would clearly achieve this.

- *Upper-Tail Monitoring*: $n_i > 0$ only if $p_i'(a) > 0$.
- •• *Joint Incentives on task* B: For all i, $[u(w_{ij} + t_{ij}) - u(s_i)]$ has the same sign as $q_j'(b)$.

According to Lemma 1, $p_i'(a)$ and $q_j'(b)$ are positive (resp. negative) at larger (resp. smaller) values of *i* and *j*. The proposed scheme thus corresponds to the one described previously: it is made up, first, of *upper-tail* contingent appraisals (i.e., $n_i > 0$ if and only if *i* is strictly *larger* than some threshold $\hat{\imath}$), and second, of appraisals that penalize low output on task B but that also *reward* good showing on that task (to be sure, $w_{ij} + t_{ij} > s_i$ if and only if *j* is greater than the output level *j** above which $q_j'(b)$ becomes positive).

The next subsection will now examine whether and when such a scheme would arise as a common agency equilibrium.

B. *Wealth Effects and Sufficient Conditions*

Under contingent monitoring by principal β (and using the above first-order approach), principal α's incentive wages s_i and w_{ij} will be set as if they were solutions to the following optimization problem:

$$\underset{s_i, w_{ij}, a, b}{maximize} \sum_i p_i(a) q_j(b)(\alpha_i - n_i w_{ij} - (1-n_i) s_i) \text{ , subject to :}$$

(13)

$$\sum_{ij} p_i'(a) q_j(b) [n_i u(w_{ij} + t_{ij}) + (1-n_i) u(s_i)] - c_a(a,b) \geq 0$$

$$\sum_{ij} p_i(a) q_j'(b) [n_i u(w_{ij} + t_{ij}) + (1-n_i) u(s_i)] - c_b(a,b) \geq 0$$

$$\sum_{ij} p_i(a) q_j(b) [n_i u(w_{ij} + t_{ij}) + (1-n_i) u(s_i)] - c(a,b) \geq U^* .$$

Let γ^α, λ^α and μ^α be the Lagrange multipliers associated with the incentive and the participation constraints respectively.[1] The first-order conditions for a selected contract are given this time by:

(14)
$$\text{for all } s_i: \frac{1}{u'(s_i)} = \mu^\alpha + \gamma^\alpha \frac{p_i'(a)}{p_i(a)}$$

and

(15)
$$\text{for all } w_{ij}: \frac{1}{u'(w_{ij} + t_{ij})} = \mu^\alpha + \gamma^\alpha \frac{p_i'(a)}{p_i(a)} + \lambda^\alpha \frac{q_j'(b)}{q_j(b)} .$$

[1] Although the same notation as in the preceding section is used, the reader should be aware that the above Lagrange multipliers, which are the only ones to be referred to from now on, would generally take different values from those introduced in Section II.

Meanwhile, if K denotes the (*unsunk*) cost borne by principal β for monitoring task B, then this principal will select monitoring probabilities n_i and incentive wages t_{ij} which

$$\underset{n_i, t_{ij}, a, b}{maximize} \sum_{ij} p_i(a) q_j(b) [\beta_j - n_i (t_{ij} + K)] \text{ , subject to :}$$

(16)

$$\sum_{ij} p_i'(a) q_j(b) [n_i u(w_{ij} + t_{ij}) + (1-n_i) u(s_i)] - c_a(a,b) \geq 0$$

$$\sum_{ij} p_i(a) q_j'(b) [n_i u(w_{ij} + t_{ij}) + (1-n_i) u(s_i)] - c_b(a,b) \geq 0$$

$$\sum_{ij} p_i(a) q_j(b) [n_i u(w_{ij} + t_{ij}) + (1-n_i) u(s_i)] - c(a,b) \geq U^* \text{ .}$$

The corresponding Lagrange multipliers being given by γ^β, λ^β and μ^β, the first-order conditions for a solution to this problem entail the following relationships:

(17)

$$\text{for all } t_{ij} : \frac{1}{u'(w_{ij} + t_{ij})} = \mu^\beta + \gamma^\beta \frac{p_i'(a)}{p_i(a)} + \lambda^\beta \frac{q_j'(b)}{q_j(b)} \text{ ,}$$

and

(18)

$$\sum_j [-(t_{ij} + K) + (u(w_{ij} + t_{ij}) - u(s_i))(\gamma^\beta \frac{p_i'(a)}{p_i(a)} + \lambda^\beta \frac{q_j'(b)}{q_j(b)} + \mu^\beta)] q_j(b)$$

$$\begin{array}{lll} \geq 0 & & n_i = 1 \\ = 0 & \text{if } 0 < & n_i < 1 \\ \leq 0 & & n_i = 0 \text{ ,} \end{array}$$

for the probability n_i of monitoring task B.

Again, the Lagrange multipliers must be nonnegative by construction. Considering (14), (15) and (17), therefore, a conclusion similar to the one of Lemma 2 holds.

LEMMA 2*: *The wage schedules* s_i *and* $(w_{ij} + t_{ij})$ *are nondecreasing in an equilibrium of the common agency defined by problems (13) and (16).*

Subtract (14) from (15), furthermore. This gives:

$$\textbf{(19)} \qquad \frac{1}{u'(w_{ij} + t_{ij})} - \frac{1}{u'(s_i)} = \lambda^{\alpha} \frac{q_j'(b)}{q_j(b)} \ .$$

The upshot is that the second property of the proposed scheme will necessarily hold at an equilibrium, by Lemma 1. This fact is stated as a proposition.

PROPOSITION 1 [Joint incentives on task B]: *In a common agency equilibrium,* $s_i < w_{ij} + t_{ij}$ *if and only if* $q_j'(b) > 0$.

In the present rather general context, however, a common agency Nash equilibrium may not feature upper-tail contingent appraisals. Intuitively, those appraisals constitute a lottery which must give the risk averse agent an expected payoff that is *positive* enough, for they would otherwise have the undesirable effect to deter high performance on task A. Using such a device therefore involves an additional cost for principal β. This cost will remain acceptable provided the agent's risk aversion decreases sufficiently fast with his wealth (which is greater at higher levels of *i*).

Let then $\rho(z) = -u''(z)/u'(z)$ denote the agent's *coefficient of absolute risk aversion*, and observe that

$$\textbf{(20)} \qquad \frac{\rho'(z)}{\rho(z)} = \frac{d}{dz} \, ln\left(\frac{-u''(z)}{u'(z)}\right) = \frac{u'''(z)}{u''(z)} - \frac{u''(z)}{u'(z)} \ .$$

The rate of decrease of the agent's risk aversion with respect to wealth can thus be measured by the difference between $\rho(z)$ and $\varsigma(z) = -u'''(z)/u''(z)$. The term $\varsigma(z)$ is precisely the *coefficient of absolute prudence* introduced by Kimball (1990). It can be shown that $\varsigma(z) > \rho(z)$ is actually necessary and sufficient for the agent to increase his holding of an uncertain asset after an exogenous increase in wealth (see Kenneth J. Arrow, 1965, and the recent discussion by John M. Hartwick, 1999). A more stringent inequality must hold here, however, because in the present context the agent's wealth is endogenous and stochastic (via the incentives put on task A).[1]

ASSUMPTION 4 [Fast Decreasing Absolute Risk Aversion]: *For all* $z \in \mathbb{R}_+ : \varsigma(z) > 3\,\rho(z)$.

This assumption amounts to requiring that the inverse of the agent's utility function have a third derivative which is negative. It is obviously violated when the agent exhibits constant absolute risk aversion (CARA), as in Holmstrom and Milgrom (1991) and Dixit (1996). It is satisfied, on the other hand, if the agent's utility takes the constant *relative* risk aversion (CRRA) form $u(z) = z^{1-\omega}$ with a coefficient ω smaller than 0.5.

Under Assumption 4 the following lemma asserts that the agent will indeed seek to have his performance monitored on task B.

LEMMA 3: *At a common agency equilibrium,* $\sum_j q_j(b)\,u(w_{ij} + t_{ij}) > u(s_i)$ *for all i and b.*

[1] In a recent paper, Marie-Cécile Fagart and Sinclair-Desgagné (2001) show that Assumption 4 is sufficient and "almost" necessary (in a precise sense) for the optimality of upper-tail contingent monitoring in principal-agent settings, provided K belongs to a plausible interval of positive real numbers. The paper is available from the authors upon request.

PROOF:

Equations (14), (15) and (17) imply that:

$$s_i = \Psi(\mu^{\alpha} + \gamma^{\alpha} \frac{p_i{}'(a)}{p_i(a)}) \text{ and}$$

$$w_{ij} + t_{ij} = \Psi(\mu^{\alpha} + \gamma^{\alpha} \frac{p_i{}'(a)}{p_i(a)} + \lambda^{\alpha} \frac{q_j{}'(b)}{q_j(b)}) \text{ where } \psi^{-1}(\bullet) = \frac{1}{u'(\bullet)} .$$

And when Assumption 4 is true, one can check that the function u(Ψ( )) is convex. The lemma is thus a straightforward consequence of Jensen's inequality.

Lemma 3's proof made use of the fact that, by (15) and (17),

$$\textbf{(21)} \qquad \mu^{\beta} + \gamma^{\beta} \frac{p_i{}'(a)}{p_i(a)} + \lambda^{\beta} \frac{q_j{}'(b)}{q_j(b)} = \mu^{\alpha} + \gamma^{\alpha} \frac{p_i{}'(a)}{p_i(a)} + \lambda^{\alpha} \frac{q_j{}'(b)}{q_j(b)}$$

for all *i*, *j* , which means that the wage gradients respectively set by the two principals must coincide at an equilibrium. Together with (14) and (15), this property allows to rewrite the left-hand side of condition (18) as follows:

$$\textbf{(22)} \qquad N(i) = (- \frac{u(s_i)}{u'(s_i)} - K) + \sum_j [- t_{ij} + \frac{u(w_{ij} + t_{ij})}{u'(w_{ij} + t_{ij})}] q_j(b) .$$

Using a standard line of reasoning first adopted by Stanley Baiman and Joel Demski (1980), and by Ronald A. Dye (1986), let us now treat *i* as if it took its values from a continuum, and assume that the incentive wages are differentiable functions of *i*. The derivative of N(*i*) is then:

(23) $$N'(i) = (-s_i' + \sum q_j w_{.j}') + \frac{u\,u''\,s_i'}{(u')^2} + \sum_j q_j [-\frac{u\,u''(w_{.j}' + t_{.j}')}{(u')^2}] .$$

It follows from Lemma 2* that s_i' and $(w_{.j} + t_{.j})'$ are positive. Differentiating through equation (19) with respect to *i*, furthermore, gives the following identity:

(24) $$\frac{u''(s_i)\; s_i'}{(u'(s_i))^2} = \frac{u''(w_{ij} + t_{ij})\,(w_{.j}' + t_{.j}')}{(u'(w_{ij} + t_j))^2} .$$

The derivative of N(*i*) given by (23) is thus equivalent to

(25) $$N'(i) = (-s_i' + \sum q_j w_{.j}') - \frac{u''(s_i)\; s_i'}{(u'(s_i))^2}[-u(s_i) + \sum_j q_j(b)u(w_{ij} + t_{ij})] .$$

We want $N'(i) > 0$. Through condition (18) this would imply that the appraisals of task B cannot occur upon observing some output level $\hat{\imath}$ while happening with smaller probability at some $i > \hat{\imath}$, so for a suitable range of the cost K we would get upper-tail contingent appraisals. Note that the second term on the right-hand side of (25) is already positive by the above assumptions and Lemma 3. This supports the following statement.

PROPOSITION 2 [No lower-tail monitoring]: *If* $-s_i' + \sum q_j w_{.j}' \geq 0$, *then* $N'(i) > 0$ *so* $\hat{\imath} < i$ *implies that* $n_{\hat{\imath}} \leq n_i$.

In a context where principals fully cooperate it can be shown that $-s_i' + \sum q_j w_{.j}' \equiv 0$ (see Sinclair-Desgagné, 1999). The latter term is then specific to common agency. It actually reflects the presence of externalities between principals. It is positive, which means that principal α provides stronger incentives to work on task A when principal β intervenes, if and only if principal β appraises the output on task B more often than if the two principals cooperated. Such a situation seems rather plausible and would guarantee that N′(*i*) > 0. But there is also an easy way to satisfy Proposition 2's assumption while inducing at the same time an outcome which resembles the cooperative one: just impose that principal α offers wages such that

(26) $$\text{For all } j\,,\quad w_{i\,j} = s_i\,.$$

This condition would bring about a somewhat "liberal" scheme, whereby principal α would need to focus only on task A and would set her own incentive scheme ignoring the other principal's appraisals of task B.

IV. APPLICATIONS

For concreteness and in order to suggest possible refinements, this section will now sketch some applications of upper-tail monitoring in common agency contexts. The outlook is normative, although some analogies with existing schemes will be mentioned. The first two applications pertain respectively to the role of the corporation and to that of public servants in a democratic society, the third one addresses the governance of R&D. Those topics share formal characteristics that agree rather well with those underlying the current common agency model: different principals have a stake in and can monitor different tasks, they are willing to share their appraisals, but they also compete to drive the agent's attention on to their own agenda.

A. *Corporate Compliance*

In the long-standing debate about the aim of the business corporation - whether it ought to concentrate on the benefits of shareholders and creditors or whether it should pursue some wider form of “public interest,” economists have traditionally sided with advocates of the former. The following statement, made several decades ago by Friedrich A. Hayek (1960), is representative of the arguments that support this position.

> The present tendency not only to allow but to encourage such use of corporate resources [in the service of some “public interest”] appears to me as dangerous in its short-run as in its long-run consequences. The immediate effect is greatly to extend the powers of the management of the corporations over cultural, political, and moral issues for which proven ability to use resources efficiently in production does not necessarily confer special competence; and at the same time to substitute a vague and indefinable “social responsibility” for a specific and controllable task.

In other words, asking corporate managers to maximize some “social welfare” function instead of their firm’s profit would generate inefficient biases in resource allocation and would soften up corporate control.[1]

This position never meant, of course, that in the pursuit of their proper aim corporations should not abide by some legal and moral rules. For if managerial decisions affect investors, they certainly also bring externalities on a number of stakeholders - employees, customers, suppliers, local communities, etc. Corporate compliance with regulations that seek to temper those externalities, however, poses a number of theoretical and practical challenges.

Consider, for example, the “Sentencing Guidelines” of the United States Sentencing Commission. Enacted in 1991, they now pervade most regulatory regimes, including

[1] Of course, those arguments have since been refined and somewhat qualified. For a recent summary, see Tirole (2001).

securities, environmental and antitrust regulations. Their explicit purpose is to allocate liability for corporate misconduct between the firm and its agents. They actually put substantial responsibilities on firms for monitoring, preventing, detecting, and reporting criminal conduct by their employees or other agents, thereby mandating specific requirements for an effective compliance program which fulfillment can diminish significantly a corporation's risks of indictment and sentencing.[1] Several legal scholars have argued, however, that the Guidelines may not induce appropriate risk sharing and incentives. On the one hand, "Following Congressional passage of the Sentencing Guidelines for Organizations in 1991, there has been a notable shift of liability risk away from the entity, one that now reflects a risk disequilibrium between firms and their agents." (William S. Laufer, 1999). On the other hand, "(...) perhaps in the exercise of bona fide business judgment, firms choose compliance structures in which the values of motivation and cohesion (not to mention out-of-pocket costs) often trump high-powered monitoring, thus opting for higher compliance risk because it is the most sensible strategy." (Donald C. Langevoort, 2001) The upshot may be the so-called "Paradox of compliance," i.e. the observed positive correlation between the number of operating compliance programs and the number of white-collar crime prosecution (see Laufer, 1999).

It seems in fact that "(...) pursuing the basic enforcement goals of (1) inducing efficient activity levels and (2) minimizing the joint costs of misconduct and enforcement (...) places different, and potentially inconsistent, demands on a corporate liability regime." (Jennifer Arlen and Reinier Kraakman, 1997) As far as crime prevention and deterrence is concerned, however, the scheme that is proposed here could be helpful. Imagine that the firm's shareholders and creditors stand as "Principal α," the regulator as "Principal β," and

[1] Dan K. Webb and Steven F. Molo (1993) report, for instance, that "The Sentencing Guidelines reduce a corporation's "culpability score" by three points if the offense occurred notwithstanding an effective compliance program. A three-point reduction can decrease a convicted company's fine range as much as eighty percent (...)."

the firm's top management as the "Agent." Let then "task A" correspond to directly productive activities, while "task B" refers to compliance duties. The above analysis suggests that the incentives set the regulator would actually *reinforce* those already chosen by the firm's shareholders and creditors to enhance financial results, while at the same time the latter incentives would induce more frequent monitoring and so better control by the regulator of corporate behavior and externalities.[1]

B. *The Organization of Government*

A fundamental principle of democracy is the division of powers. One immediate corollary of this is that every agent in a government bureau is likely to have many principals - not only a bureau supervisor but also, for instance, superiors in the Office of Management and Budget, the White House, the courts, and several congressional committees. Moreover, public agencies are likely to be assigned a set of heterogenous tasks to be done simultaneously, such as collecting tax revenues and also answering questions and complaints from the taxpayers. In his well-known analysis of public bureaucracy, James Q. Wilson (1989) provides a typical example of the coordination and incentives problems that may occur in such a context.

> For many years the dominant doctrine of police professionalism was based on the view that the police administrator had to get control of his department (...) to bring to bear on the crime problem the methods of rapid response, scientific investigation, and complete record keeping. (...) This in turn led the officers to emphasize those aspects of their jobs that were most easily standardized and recorded, that could be directed by radio transmissions, and that generated statistics. These included writing reports on crimes (mostly thefts and burglaries that occurred in the past) and making easy arrests (...). In short, one part of the police job, order maintenance, was sacrificed to another part, law enforcement.

[1] Interestingly, an experiment with a scheme bearing the same features as the theoretical one that is studied here and in Sinclair-Desgagné (1999) - i.e. a scheme involving upper-tail contingent inspections which are perceived ex ante by the agent as a carrot rather than a stick - is currently under way in the states of Delaware and Pennsylvania, in the context of industrial risks and public safety regulation. An assessment of this experiment and its first (promising!) results can be found in James C. Belke (2001) and Howard C. Kunreuther, Patrick J. McNulty, and Yong Kang (2001).

> The difficulty was that for many citizens order maintenance was more important than law enforcement (...).

A widely observed and theoretically grounded solution to those problems is to introduce low-powered incentives and control of the agents' behavior via administrative procedures (Tirole, 1994, Dixit, 1996). Applying the above scheme, however, let "Principal α" be a police administrator, "Principal β" represent those citizens who give priority to order maintenance, and the "Agent" be some team of police officers; clearly, strong incentives for law enforcement could now remain in place, but diligence in law enforcement would be fully rewarded only if citizens agree that the team did well also at preserving order, while a team which is successful in crime prevention and conflict resolution would get some recognition and payoff only by contenting as well the police administrator.

This application also suggests a somewhat "proactive" approach to monitor government agencies and public policy, which might alleviate some of the inherent administrative and political costs of this activity. Mathew D. McCubbins, Roger G. Noll and Barry R. Weingast (1987) have pointed out that:

> Policy monitoring in Congress takes two forms. The more apparent, but probably less important, is ongoing oversight and evaluation by congressional subcommittees and agencies that are arms of the Congress, such as the Congressional Budget Office (CBO) and the General Accounting Office (GAO). Less apparent, but probably more important (judging from how members of Congress allocate their time and staff), is "fire-alarm" monitoring. This form of monitoring consists of disappointed constituents pulling a member's fire alarm whenever an agency harms them.

According to this paper's contingent monitoring scheme, an additional "alarm" should also be some high assessment by the CBO or the GAO. In addition to improving the agency's incentives, such a device could prevent some political "fires" from arising, thereby granting members of Congress more time and money for crafting new legislations, setting policies, etc.

C. *The Management of Innovation*

Innovation is rightly seen as a key engine of economic growth. In trying to understand incentives to innovate, economists have traditionally focused on intellectual property. Yet, according to Stephen J. Kline and Nathan Rosenberg (1986), for example, "(...) the overwhelming majority of the inventions recorded at the U.S. Patent Office were never introduced on a commercial basis." This calls for a finer analysis of the ingredients and processes that produce innovations.

Several researchers have now emphasized that the challenge of innovation is to integrate various bits of dispersed information (Martin Fransman, 1994) in a way which "(...) balances the requirements of a new product and its manufacturing processes, the market needs, and the need to maintain an organization that can continue to support all these activities effectively" (Kline and Rosenberg, 1986). Formally speaking, this amounts to considering the management of innovation as a multitask (see Holmstrom, 1989), multi-principal issue.[1] In such a setting the above scheme would point out that low-powered incentives are no necessity and could perhaps supplement other instruments which are often used in the management of innovation, such as stock options and tournaments.

[1] Multi-principal analyses of innovation management have appeared only recently in the literature. One nice example is a recent paper by Bruno Versaevel (2001), in which a common agency model with complete information is used to analyze the contracting externalities and appropriability problems involved in the relationship between a research laboratory and two user-firms seeking innovations that fit their respective specific demand and cost conditions.

V. CONCLUDING REMARKS

This paper has shown that, in many circumstances, one agent can be facing relatively strong incentives to serve several noncooperating principals. The proposed contingent monitoring scheme, which is optimal if the agent's risk aversion decreases sufficiently fast with respect to wealth, allows in fact the principals to coordinate in making the tasks they respectively require *complementary* in the agent's utility.

Several extensions and refinements of the present paper can now be foreseen. First, the range of the cost K for which upper-tail contingent appraisals are still optimal needs to be spelled out and compared with what would happen if the principals cooperated (an objective akin to trying to assess the value of information in common agency and in principal-agent contexts). Second, given the high level of commitment that is required on the part of whoever consents to undertake contingent appraisals, some means to achieve that commitment and ways to possibly relax it would be welcome. Third, in contexts where it is not obvious who will monitor the agent continuously and who will make contingent appraisals - as in the management of innovation application that was sketched above, for instance -, one would need some guidelines in order to select the right principal to do the right thing. In practice, finally, the performance threshold on task A above which contingent appraisals occur should also depend on the available context and on the agent's intrinsic ability; the latter suggests an extension of the current model where the agent would have privately-known type.

REFERENCES

Arlen, Jennifer and Kraakman, Reinier. "Controlling Corporate Misconduct: An Analysis of Corporate Liability Regimes." *New York University Law Review*, Summer 1997, 72, pp. 687-779.

Arrow, Kenneth J. *Aspects of a Theory of Risk Bearing*. Yrjo Jahnsson Lectures, Helsinki, 1965.

Baiman, Stanley and Demski, Joel. "Economically Optimal Performance Evaluation and Control Systems." *Journal of Accounting Research*, 1980, 18 (Supplement), pp. 184-220.

Baker, George. "Distortion and Risk in Optimal Incentive Contracts." *Journal of Human Resources*, 2001 (Forthcoming).

Belke, James C. "The Case for Voluntary Third Party Risk Management Program Audits." United States Environmental Protection Agency, Chemical Emergency Preparedness and Prevention Office, March 7, 2001.

Bernheim, Douglas B. and Whinston, Michael D. "Common Agency." *Econometrica*, 1986, 54(4), pp. 923-942.

Dewatripont, Mathias; Jewitt, Ian and Tirole, Jean. "The Economics of Career Concerns, Part II: Application to Missions and Accountability of Government Agencies." *Review of Economic Studies*, 1999, 66(1), pp. 199-217.

Dixit, Avinash K. *The Making of Economic Policy: A Transaction-Cost Politics Perspective*. Cambridge, MA: MIT Press, 1996.

Dye, Ronald A. "Optimal Monitoring Policies in Agencies." *Rand Journal of Economics*, Autumn 1986, 17(3), pp. 339-350.

Fagart, Marie-Cécile and Sinclair-Desgagné, Bernard. "Auditing Policies and Information Systems in a Principal-Agent Model." Working paper, CIRANO, 2001.

Fransman, Martin, "Knowledge Segmentation - Integration in Theory and in Japanese Companies," in Ove Granstrand, ed., *Economics of Technology*. Amsterdam: Elsevier Science, 1994, pp. 165-187.

Hartwick, John M. "Insuring and $u'''(y)$." *Economics Letters*, 1999, 65(2), pp. 205-212.

Hayek, Friedrich A. "The Corporation in a Democratic Society: In Whose Interest Ought It To and Will It Be Run?," in M. Anshen and G.L. Bach, eds., *Management and Corporations*. New York: McGraw-Hill, 1960.

Holmstrom, Bengt. "Agency Costs and Innovation," *Journal of Economic Behavior and Organiztion*, 1989, 12(3), pp. 305-327.

Holmström, Bengt and Milgrom, Paul. "Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design." *Journal of Law, Economics and Organization*, 1991, 7 (Special Issue), pp. 24-52.

Kimball, Miles S. "Precautionary Savings in the Small and in the Large." *Econometrica*, 1990, 58(1), pp. 53-73.

Kline, Stephen J. and Rosenberg, Nathan. "An Overview of Innovation," in Stephen J. Kline and Nathan Rosenberg, eds., *The Positive Sum Strategy. Harnessing Technology for Economic Growth*. Washington, D.C.: National Academy Press, 1986, pp. 275-305.

Kunreuther, Howard C.; McNulty, Patrick J. And Kang, Yong. "Improving Environmental Safety through Third Party Inspection." The Risk Management and Decision Processes Center, The Wharton School of the University of Pennsylvania, May 2001.

Langevoort, Donald C. "Monitoring: The Behavioral Economics of Inducing Agents' Compliance with Legal Rules." Mimeo, Georgetown University. 2001.

Laufer, William S. "Corporate Liability, Risk Shifting and the Paradox of Compliance." *Vanderbilt Law Review*, October 1999, 52, pp. 1343-1420.

MacDonald, Glen M. and Marx, Leslie M. "Adverse Specialization." *Journal of Political Economy*, August 2001, 109 (forthcoming).

McCubbins, Mathew D.; Noll, Roger G. and Weingast, Barry R. "Administrative Procedures as Instruments of Political Control." *Journal of Law, Economics and Organization*, Fall 1987, 3(2), pp. 243-277.

Segal, Ilya. "Contracting with Externalities." *Quarterly Journal of Economics*, 1999, 104(2), pp. 337-388.

Sinclair-Desgagné, Bernard. "How to Restore Higher-Powered Incentives in Multitask Agencies." *Journal of Law, Economics and Organization*, 1999, 15(2), pp. 418-433.

________________________. "The First-Order Approach to Multi-Signal Principal-Agent Problem." *Econometrica*, 1994, 62(2), pp. 459-465.

Tirole, Jean. "Corporate Governance." *Econometrica*, January 2001, 69(1), pp. 1-36.

__________. "The Internal Organization of Government." *Oxford Economic Papers*, 1994, 46, pp. 1-29.

Webb, Dan and Molo, Stephen. "Some Practical Considerations in Developing Effective Compliance Programs: A Framework for Meeting the Requirements of the Sentencing Guidelines." *Washington University Law Quarterly*, Summer 1993, 71, pp. 375-396.

Williamson, Oliver E. *The Economic Institutions of Capitalism*. New York: The Free Press, 1985.

Wilson, James Q. *Bureaucracy. What Government Agencies Do and Why They Do It.* New York: Basic Books, 1989.

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