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Harmful transparency in teams

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ABSTRACT

In a two-player team project with efforts over two rounds, we demonstrate that observability of peer efforts can be strictly harmful if preferences are utilitarian. This contrasts with Mohnen et al. (2000) who show in a similar setting that observability of interim efforts induces more efforts, if team members are inequity-averse.

1. Introduction

Mohnen et al. (2008) show that peer transparency in teams, by allowing inequity-averse workers to observe each others' efforts, induces more individual and collective efforts. This is because when workers are averse to inequality of contributions, the observability of efforts creates peer pressure: more first-round effort by a player creates pressure on her team members to reciprocate with increased efforts in later rounds, and similarly less early efforts induces lower efforts in response. When this information is not available, however, inequity-averse workers behave as though they are selfish: the feedback loop from early to later efforts gets broken, making non-transparency worse.

In contrast to the above model of Mohnen et al., we resort to standard utilitarian agents. Now despite the link between early round and later round efforts under effort observability, absence of peer pressure due to utilitarian preferences makes transparency sterile. This has two implications. In one, when marginal cost of effort is constant but marginal benefit of individual efforts is decreasing (due to decreasing marginal probability of the team project's success from higher efforts), transparency and non-transparency yield identical aggregate efforts. Thus the outcome is neutral with respect to peer information. On the other hand, when marginal cost of effort is increasing and marginal benefit is decreasing, induced aggregate efforts under transparency falls below the efforts under non-transparency. This makes transparency harmful. The striking difference (of harmful transparency) from Mohnen et al. arises due to two factors: (i) utilitarian preferences vs. inequity aversion, (ii) technological differences. In Mohnen et al., while marginal cost of effort is increasing, marginal benefit of effort is constant: an agent's wage (i.e. benefit) is linear in aggregate team efforts.

In a related work, Winter (2010) has shown that in team projects with complementary efforts, greater transparency through better peer information in general architectures (where team members observe a subset of the predecessors' efforts) lowers full-efforts implementation costs, whereas effort substitution neutralizes the benefits of transparency.[1] The team production technology in ours and Mohnen et al. is one of perfect substitution.

That observability of players' actions in repeated games can lower cooperation, which is akin to exerting less efforts in the common project of our study, has been earlier noted by Serrano and Zapater (1998).[2] The authors study a finitely repeated

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1 Winter (2006) employs, specifically, sequential architecture in teams, as opposed to the analysis of general architectures in Winter (2010). Some more recent works on peer monitoring and its role in incentives are Rahman (2012) and Gershkov and Winter (2015).

2 Abreu et al. (1991) similarly show beneficial cooperation in repeated partnerships with less public information.

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game of contests among a number of couples, with each couple playing a prisoner's dilemma (PD) game between themselves by either cooperating or defecting. Besides the stage game payoffs, couple(s) who cooperate the maximum number of times receive additionally a reward. In this game couples playing as a unit renegotiate between themselves, so the equilibrium notion is one of renegotiation-proofness. The question is when can cooperation arise in this modified PD-game? It is shown that, when couples can observe other couples' past actions, cooperation vanishes altogether. Observability of actions makes couples "tail chase" by conditioning on histories, depending on whether one is ahead or behind in cooperation counts, thus rendering cooperation unsupportable in equilibrium. In contrast, even when the contest reward for cooperation is very small, under non-observability couples cooperate in every round. If past actions are not observable so that effectively they are in a one-shot game, incentives for deviation from cooperative play are eliminated. In our case, observability of interim efforts allows team members to credibly commit to lower efforts in the early round that is not possible under non-transparency.

In the next two sections, we develop the analysis more formally.

2. The model

Consider a project that consists of a single task that must be completed jointly by the players over two rounds. The probability of the project's success is $p(e)$, where $e = e_i + e_j = e_{i1} + e_{i2} + e_{j1} + e_{j2}$, $p(\cdot)$ is twice differentiable, $p(0) \geq 0$, $p'(e) > 0$, $p''(e) < 0$ for all $e \in [0, \bar{e}]$, $\bar{e} < \infty$, and $p'(\bar{e})$ is small enough (in a sense to become clear below). The project pays each player $v > 0$ if it succeeds and zero if it fails. Denote player i's cost of effort in round t $(= 1, 2)$, by $\psi(e_{it})$, where $\psi : [0, \bar{e}] \to \mathbb{R}_+$, $\psi(0) = 0$, $\psi'(0) = 0$, and $\psi'(\cdot) > 0$ and $\psi''(\cdot) \geq 0$ for all $e_{it} > 0$; further, $\psi'(\bar{e}) > p'(\bar{e})$. Given e_j, player i's utility following effort choices e_{i1} and e_{i2} is $u_i(e_i, e_j) = p(e_i + e_j)v - \sum_{t=1}^{2} \psi(e_{it})$.

3. The analysis

Lemma 1. *Suppose that $\psi(\cdot)$ is strictly convex. Given e_j, for any e_i chosen by player i the payoff-maximizing breakdown of overall effort in the non-transparent environment is $e^*_{i1} = \frac{e_i}{2} = e^*_{i2}$.*

The proof is straightforward. Since, for any given aggregate effort e_j of player j, any (e_{i1}, e_{i2}) combination by player i over two rounds that add up to the same aggregate effort e_i yields the same probability of the project's success, player i would choose the effort combination that minimizes his overall effort costs. Since $\psi(\cdot)$ is strictly convex, splitting the aggregate effort, e_i, equally between the two rounds minimizes i's effort costs, so $e^*_{i1} = \frac{e_i}{2} = e^*_{i2}$.

When efforts are not observable, Lemma 1 allows us to write player i's $(i = 1, 2)$ maximization problem as

$$\max_{e_i} \quad u_i = p(e_i + e_j)v - 2\psi\left(\frac{e_i}{2}\right), \ i \neq j.$$

The first-order conditions,

$$p'(e_i + e_j)v = \psi'\left(\frac{e_i}{2}\right), \quad i \neq j,$$

uniquely solve for $\frac{e^*_i}{2} = \frac{e^*_j}{2} > 0$, or $e^*_i = e^*_j = \epsilon^*$ (second-order conditions are satisfied). That is, in the unique one-shot equilibrium, (ϵ^*, ϵ^*), each player chooses an overall effort so that the marginal effort cost in each round equals the private marginal benefit:

$$p'(2\epsilon^*)v = \psi'\left(\frac{\epsilon^*}{2}\right). \tag{1}$$

With observable efforts, players i and j engage in a two-round repeated effort investment game. The game is solved backwards. Given the first-round efforts e_{i1} and e_{j1} and the aggregate effort $e_{i1} + e_{j1}$ denoted as ξ_1, player i's second-round choice of e_{i2}, taking player j's second-round choice e_{j2} as given, solves

$$\max_{e_{i2}} \quad p(\xi_1 + e_{i2} + e_{j2})v - \psi(e_{i2}).$$

The first-order conditions implicitly define the players' reaction functions in Round 2:

$$p'(\xi_1 + e_{i2} + e_{j2})v = \psi'(e_{i2}), \tag{2}$$

$$p'(\xi_1 + e_{i2} + e_{j2})v = \psi'(e_{j2}). \tag{3}$$

The Nash equilibrium strategies in round 2 obtained by solving (2) and (3) depend on the first-round aggregate effort ξ_1, and are denoted as $e^{**}_{i2}(\xi_1)$ and $e^{**}_{j2}(\xi_1)$. The solutions are symmetric: $e^{**}_{i2} = e^{**}_{j2}$.[3]

How do equilibrium second-round effort choices respond to changes in ξ_1? Using the Implicit Function Theorem, we obtain:

$$\frac{de^{**}_{j2}}{d\xi_1} = \frac{\partial e^{**}_{j2}}{\partial e_{i1}} = \frac{\partial e^{**}_{j2}}{\partial e_{j1}} = -\frac{\begin{vmatrix} p'' - \psi'' & p'' \\ p'' & p'' \end{vmatrix}}{\begin{vmatrix} p'' - \psi'' & p'' \\ p'' & p'' - \psi'' \end{vmatrix}}$$

$$= -\frac{(p'')^2 - p''\psi'' - (p'')^2}{(p'')^2 - 2p''\psi'' + (\psi'')^2 - (p'')^2} = \frac{1}{-2 + \frac{\psi''}{p''}} < 0.$$

That is, the players' first- and second-round efforts (with respect to both own and the other player's first-round effort) are strategic substitutes. It is straightforward to check that $\frac{de^{**}_{j2}}{d\xi_1} = \frac{de^{**}_{i2}}{d\xi_1}$, and that

$$\left|\frac{de^{**}_{j2}}{d\xi_1}\right| = \left|\frac{de^{**}_{i2}}{d\xi_1}\right| < \frac{1}{2}, \quad \text{if } \psi''(\cdot) > 0.$$

These last comparative statics show that if the first-round aggregate effort were to decrease by one unit, in the second round the increased efforts of the two players combined will be less than one; this is so because the marginal cost of effort function is increasing in effort.

Agent i's overall utility as evaluated in the first round, given first-round choices (e_{i1}, e_{j1}) and that both players follow their equilibrium strategies in the continuation game, is

$$u_i = p(e_{i1} + e_{j1} + e^{**}_{i2}(e_{i1} + e_{j1}) + e^{**}_{j2}(e_{i1} + e_{j1}))v - \psi(e_{i1}) - \psi(e^{**}_{i2}(e_{i1} + e_{j1})).$$

This is maximized by choosing e_{i1} such that

$$\frac{\partial u_i}{\partial e_{i1}} = 0 \Rightarrow p'(\cdot)\left[1 + \frac{\partial e^{**}_{i2}}{\partial e_{i1}} + \frac{\partial e^{**}_{j2}}{\partial e_{i1}}\right]v - \psi'(e_{i1}) - \psi'(e_{i2})\frac{\partial e^{**}_{i2}}{\partial e_{i1}} = 0.$$

Rewriting, and using the second-round first-order condition (2), yields

$$p'(\cdot)v + \left[p'(\cdot)v - \psi'(e_{i2})\right]\frac{\partial e^{**}_{i2}}{\partial e_{i1}} - \psi'(e_{i1}) + p'(\cdot)v\frac{\partial e^{**}_{j2}}{\partial e_{i1}} = 0,$$

$$\text{i.e.,} \quad p'(\cdot)v - \psi'(e_{i1}) + p'(\cdot)v\frac{\partial e^{**}_{j2}}{\partial e_{i1}} = 0,$$

$$\text{i.e.,} \quad p'(\cdot)\left[1 - \left|\frac{de^{**}_{j2}}{d\xi_1}\right|\right]v - \psi'(e_{i1}) = 0. \tag{4}$$

[3] Note that the solutions to (2) and (3) certainly exist for $\xi_1 = 0$, and for $\xi_1 = 2\epsilon^*$ there will be no solutions. It will be shown below that in any equilibrium of the two-round game, $\xi_1 + e_{i2} + e_{j2}$ will be strictly less than $2\epsilon^*$. And we can make this last observation assuming that (2) and (3) have interior solutions for an appropriate range of ξ_1.