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# Asymmetric treatment of identical agents in teams

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ABSTRACT

We investigate when identical agents will be treated asymmetrically in a simple team setting. Asymmetric treatment is optimal when the agents' individual contributions to team performance are strategic complements. Symmetric treatment of identical agents is optimal when the agents' contributions are strategic substitutes or when they are independent.



## 1. Introduction

Studies have found that individuals often are averse to inequitable treatment (e.g., Prasnikar and Roth, 1992; Charness and Rabin, 2002) and that the properties of optimal reward structures can change substantially when agents are averse to inequity (e.g., Fehr and Schmidt, 1999; Demougin et al., 2006; Desiraju and Sappington, 2007). In light of these findings, it is important to understand when identical economic agents are likely to be treated asymmetrically in relevant economic circumstances, absent explicit attempts to limit inequity.

The present research examines this issue in a simple team setting where the owner of a project ("the principal") hires two identical workers ("agents") to operate the project. To illustrate, the principal might be the owner of a research and development (R&D) enterprise (e.g., a pharmaceutical company) and the agents might be scientists hired to undertake a specific R&D project (e.g., develop a new drug). The contributions that the agents make to the project (e.g., the scientists' creative research efforts) may be independent, or they may be strategic complements or strategic substitutes (Bulow et al., 1985).[1] In addition, these contributions can be delivered either simultaneously or sequentially.[2] In all cases, the agents' contributions are not contractible. Consequently, a team moral hazard problem arises. The principal induces the agents to contribute to the project by linking their compensation to the observed performance of the project (e.g., whether an

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[1] The contributions may be strategic complements, for example, when a discovery by one scientist provides useful information that increases the productivity of the other scientist's research efforts. The contributions may be strategic substitutes when initial progress by one scientist reduces the chances that the other scientist will be able to provide useful incremental progress.

[2] For example, the scientists might be instructed to conduct their individual experiments simultaneously or sequentially.

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effective new drug is developed successfully). We investigate when, if ever, the principal will implement asymmetric reward structures for the two identical agents.

We find that the principal will implement identical reward structures for the two risk-neutral agents when their contributions to the project are independent or when their contributions are strategic substitutes. In contrast, the principal will present the two identical agents with different reward structures when their contributions are strategic complements.

The finding that the principal optimally implements identical reward structures when the contributions of the identical agents are independent is not surprising. The actions of one agent do not influence the relevant incentive problem that the principal faces in motivating the other agent when the agents' contributions are independent. Therefore, the principal optimally presents the two identical agents with the same reward structure. This is the case whether the agents deliver their contributions simultaneously or sequentially.[3]

When the agents' contributions are strategic complements, the principal optimally directs one agent (the first mover) to deliver his contribution before the other agent (the second mover) makes his contribution. This sequential arrangement motivates the first mover to increase his contribution in order to increase the productivity of the second mover's contribution and thereby induce the second mover to increase his contribution to the project. When the first mover faces this natural incentive to increase his contribution to the project, the principal can reduce the compensation that she delivers to the first mover without unduly reducing his contribution to the project. Therefore, the principal optimally implements a less generous reward structure for the (identical) first mover when the agents' contributions are strategic complements.[4]

When the agents' contributions are strategic substitutes, a first mover would be reluctant to deliver a large contribution because it would reduce the productivity of the second mover's contribution and thereby induce the second mover to reduce his contribution. To avoid this disincentive for the first mover, the principal directs the two agents to deliver their contributions simultaneously. When the agents act simultaneously, the principal effectively faces the same incentive problem in motivating each of the identical agents and so implements the same reward structure for the two agents.

Our study is not the first to point out that identical agents may be treated asymmetrically in equilibrium.[5] We are also not the first to observe that more favorable outcomes can be secured by directing agents to conduct their activities sequentially rather than simultaneously (or *vice versa*).[6] Our primary contribution to the literature is the simple, systematic link that we identify between the nature of the inputs delivered by members of a team and the optimal structuring of rewards and timing of actions within the team.[7] Our findings also suggest when aversion to inequity is particularly likely to pose problems for the optimal design of reward structures within teams.

The analysis proceeds as follows. Section 2 reviews the key elements of our model. Section 3 presents our main findings. Section 4 concludes and suggests directions for future research. The proofs of all formal conclusions are presented in the Appendix.

## 2. The model

A principal hires two identical agents (A and B) to operate a project. The project ultimately succeeds or fails. Success generates value $V_S > 0$. Failure generates the smaller value $V_F$. The probability that the project succeeds is

$$p(p^A, p^B) = maximum\{minimum\{p^A + p^B + \gamma p^A p^B, 1\}, 0\}, \tag{1}$$

where $p^i \geq 0$ is the contribution (e.g., the effort) delivered by agent $i \in \{A, B\}$.[8] $\gamma$ is a parameter that reflects the interaction between the contributions of the two agents. When $\gamma = 0$, these contributions are independent, and the probability of project success is simply the sum of the contributions of the two agents, so $p(\cdot) = minimum\{p^A + p^B, 1\}$. When $\gamma > 0$, the

[3] Hermalin (1998) demonstrates that the sequential delivery of effort can produce welfare gains in a team setting where the agents' contributions to team performance are independent. The gains arise in Hermalin's model because the agent that delivers his effort first has private information about the marginal productivity of the efforts of all agents. We abstract from such information asymmetries among agents.

[4] The first mover also may supply substantial effort in return for a relatively small share of the team output in Hermalin's (1998) model, where the first mover has private knowledge about the productivity of the efforts of all agents. In Hermalin's model, the first mover's substantial effort can convince other agents that the marginal productivity of their effort is high, and can thereby induce these agents to increase their effort supply.

[5] Hermalin (1994), for example, observes that identical Cournot competitors may implement distinct intra-firm reward structures. The distinct reward structures in Hermalin's model reflect the different output levels that the firms produce in equilibrium. In our model, there is only a single output produced by a single team. Consequently, the asymmetry in our model reflects different payments to agents who are innately identical and who (necessarily) deliver identical performance.

[6] This is an important theme, for example, in the literature on the financing of public goods (e.g., Varian, 1994; Andreoni, 2006; Yildirim, 2006). The analyses in this literature differ from our analysis in many respects. For example, the analyses typically do not consider the optimal design of reward structures, which is the focus of our analysis. Furthermore, moral hazard problems generally are not central in these analyses. The analyses typically assume that the individual (monetary) contributions of "agents" are readily observed or can be revealed costlessly when such revelation is advantageous. Strausz (1999) identifies conditions under which sequential operation can limit moral hazard concerns in a team setting. The continuous performance variable in Strausz's model allows the team to create identifiable "zones of responsibility" for distinct agents. Such zones are not feasible in our model because the performance variable is binary (i.e., the team project either succeeds or fails).

[7] Because we allow for the possibility that one agent's contribution to the team's performance might diminish the impact of another agent's contribution, the interaction among agents that we analyze may not faithfully reflect Alchian and Demsetz's (1972) view of team activity. We use the term "team" to reflect the fact that only a single, aggregate measure of the agents' performance is contractible in our model.

[8] This formulation is employed in Che and Gale (2000).