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# MISPERCEPTIONS, MORAL HAZARD, AND INCENTIVES IN GROUPS

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ABSTRACT

Recent work has shown that, in the presence of moral hazard, balanced budget Nash equilibria in groups are not pareto-optimal. This work shows that when agents misperceive the effects of their actions on the joint outcome, there exist a set of sharing rules which balance the budget and lead to a pareto-optimal Nash equilibria.

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## I. Introduction

With the growing interest among economists in the internal workings of organizations, a dense literature has sprouted examining the optimality of incentive systems within private and public goods clubs or cooperatives. Results from work by Groves [4], and Holmström [5], among others, indicate that a pareto-optimal equilibrium cannot be obtained in the presence of moral hazard without a principal to break a balanced budget. This implies that separation of ownership and labor is required to achieve efficiency when moral hazard is present. This paper shows that in the case of some organizations there is an exception to that rule and partnerships among agents can be efficient. Specifically, if the agents who are members of that organization misperceive[1] the effect of their individual actions on the joint outcome, there may exist a sharing rule for which a Nash equilibrium is pareto-optimal.[2]

An example of this type of organization is a cooperative. In the cooperative literature (e.g., Sen [9], Meade [7], Furubotn [2]), the members of a cooperative underestimate the effect of their actions on the joint outcome. Members will shirk, assuming others don't react, and in equilibrium everyone is shirking and everyone is worse off. The equilibrium is not pareto-optimal and leaves the cooperative with a monitoring problem calling for a principal. The same result obtains in models of regulated industries with variable product quality (e.g., White [11], Vander Weide and Zalkind [10]). In the regulation literature agents compete over quality and Nash behavior is present, so every agent perceives a greater effect of his production of quality on his (produced) share of the joint outcome, say profit. The resulting equilibrium will have a greater than optimal production of quality, due to this misperception. Gaynor [3] synthesizes the material from the cooperative and regulation literature. In this model members of a co-op produce a product of variable quality. The Nash equilibrium without sharing is not pareto-optimal.

In this model, sharing serves to rationalize the agents' misperceptions if they overestimate the effects of their actions on the joint outcome. If agents' misperceptions run in the other direction, if they underestimate the effect of their actions, then it is not possible to design a pareto-optimal sharing rule for which a Nash equilibrium obtains.

## II. The Model

Consider the following static model under certainty.[3] Suppose $\exists$ n agents indexed by i = 1, ..., n. The actions of the agents are $a_i \in A_i = [0, \infty)$, the set of all possible actions by agent i.

There is a private, non-monetary cost of each action,

$$V_i : A_i \rightarrow \mathbf{R}, \qquad V_i(0) = 0,$$

and $V_i$ is strictly convex, differentiable and increasing.

Let

$$a = (a_1, \ldots, a_n) \in A \equiv \mathop{X}_{i=1}^{n} A_i,$$

be the vector of all agents' actions, which must be a member of the set of all possible actions by all agents.

The agents perceive their actions to determine a joint monetary outcome

$$Z : A \rightarrow \mathbf{R},$$

which must be allocated among all agents. Z is assumed to be strictly increasing, concave and differentiable and

$$Z(0) = 0.$$

The true joint monetary outcome is $X : A \rightarrow \mathbf{R}$, where X is assumed strictly increasing, concave, differentiable, and $X(0) = 0$. Further, since agents misperceive the effects of their actions,

$$X_i' \equiv \frac{\partial X}{\partial a_i} \neq Z_i' \equiv \frac{\partial Z}{\partial a_i}, \qquad \forall\, a_i \in A.$$

Let $S_i(X)$ be i's share of X. Let $S_i$ be differentiable and

let $\sum_{i=1}^{n} S_i(X) = X$. When this is true, the budget is balanced

and $\sum_{i=1}^{n} S_i' = 1$, where $S_i' \equiv \frac{\partial S_i}{\partial X} \cdot \frac{\partial X}{\partial a_i}$.

Each agent has a preference function in income and action. Assume it to be linear in income and additively separable in action so

$$u_i(y_i, a_i) = y_i - V_i(a_i).$$

## III. Equilibrium

In an organization with many agents and no principal the agents will play the game with the perceived joint outcome Z,

$$S_i(Z(a)) - V_i(a_i).$$

The Nash equilibrium of this game is $\tilde{a} = (\tilde{a}_1, \tilde{a}_2, \ldots, \tilde{a}_n)$,

where $\tilde{a} = \underset{a \in A}{\text{argmax}} \, [S_i(Z(a)) - V_i(a_i)]$, and the first order conditions are

$$S_i' Z_i' - V_i' = 0 \; .$$

The true payoff is X, and the organization faces the objective function

$$X(a) - \sum_{i=1}^{n} V_i(a_i).$$

The pareto-optimal equilibrium for the organization is

$$a^* = (a_1^*, a_2^*, \ldots, a_n^*) = \underset{a \in A}{\text{argmax}} \, [X(a) - \sum_{i=1}^{n} V_i(a_i)],$$

with first order conditions

$$X_i' - V_i' = 0.$$

The Nash equilibrium is not pareto-optimal in general, because $a^* \neq \tilde{a}$ (i.e., $a_i^* \neq \tilde{a}_i$, $\forall$ i) in general. This result corresponds to previous results pointing to the inefficiency of sharing rules in cooperative organizations, but it is possible here for a pareto-optimal sharing rule to exist.

Lemma - The Nash equilibrium will only be pareto-optimal when

$$S_i' Z_i' = X_i', \qquad \forall\ i.$$

Proof - A. The Nash equilibrium, $\tilde{a}$, occurs when $S_i' Z_i' = V_i'$, $\forall$ i.

B. The pareto-optimal equilibrium, $a^*$, occurs when $X_i' = V_i'$, $\forall$ i.

A. and B. $\Longrightarrow \tilde{a} = a^*$ when $S_i' Z_i' = X_i'$.

□

When $Z_i' > X_i'$, that implies that $S_i' < 1$ leads to a pareto-optimum, but it may not be true that $\sum_{i=1}^{n} S_i' = 1$. A pareto-optimal sharing rule may exist for organizations whose members overestimate the effects of their actions on the group outcomes. When $X_i' > Z_i'$, then $S_i' > 1$ would make the Nash Equilibrium pareto-optimal, but the budget is broken, since $\sum_{i=1}^{n} S_i' > 1$. When agents underestimate the effect of their actions on the joint monetary outcome, there is no possible pareto-optimal sharing rule, unless a principal exists who is willing to pay a bonus and subsidize the organization.

Theorem 1 - It is not in general true that there exist sharing rules $S_i(X)$ such that $S_i'Z_i' = X_i'$ and $\sum_{i=1}^{n} S_i' = 1$.

Proof -

1. When $Z_i' > X_i'$.

Suppose $Z_i' = \alpha X_i'$ for all $i = 1, \ldots, n$ where $\alpha$ is a scalar greater than one and less than n. Then for

$$S_i'Z_i' = X_i',$$

$S_i'$ must equal $\frac{1}{\alpha}$ and

$$\sum_{i=1}^{n} S_i' = \frac{n}{\alpha} > 1.$$

□

2. When $Z_i' < X_i'$. $S_i'$ must be greater than one for all i for $S_i'Z_i' = X_i'$,

$$\therefore \quad \sum_{i=1}^{n} S_i' > 1.$$

□

When agents overestimate the effects of their actions on the joint outcome (e.g., as in a cartel), there exists a situation for which a pareto-optimal sharing rule would break the budget. When the effects of agents' actions are underestimated, only bonus payments will lead to pareto-optimality. For the case of overestimation, however, there do exist situations for which pareto-optimal, balanced budget sharing rules exist.

Theorem 2 - A sharing rule for which a Nash equilibrium is pareto-optimal exists and balances the budget when

$$\sum_{i=1}^{n} \frac{X_i'}{Z_i'} = 1.$$

Proof -

If $\sum_{i=1}^{n} \frac{X_i'}{Z_i'} = 1$

then since $S_i' Z_i' = X_i'$,

$$\sum_{i=1}^{n} S_i' = \sum_{i=1}^{n} \frac{X_i'}{Z_i'} = 1.$$

□

So there does exist a class of balanced budget pareto-optimal sharing rules for a group when members overestimate the effect of their actions on the group outcome.[4] It is simple to see that there are no optimal budget-breaking sharing rules which do not require subsidies when members underestimate the effects of their actions.

<u>Theorem 3</u> - There are no possible optimal budget-breaking sharing rules when $Z_i' < X_i'$ which do not require subsidies.

<u>Proof</u> - When $Z_i' < X_i'$, a budget-breaking sharing rule will lead to pareto-optimality when

$$\sum_{i=1}^{n} \frac{X_i'}{Z_i'} > 1,$$

but since $\sum_{i=1}^{n} S_i' = \sum_{i=1}^{n} \frac{X_i'}{Z_i'}$,

$\sum_{i=1}^{n} S_i' > 1$, which requires subsidization.

□

In this case, breaking the budget does not help. Adding a principal to break the budget will not lead to pareto-optimality unless that principal is willing to subsidize the organization.

## III. Conclusions

This paper has examined optimal sharing rules within an organization in which agents' perceptions of the effects of their actions do not match reality. It has been shown that there are no balanced or broken budget pareto-optimal sharing rules which exist in general for such organizations. There is a class of pareto-optimal balanced budget sharing rules which do exist, however, when agents overestimate the effect of their actions, as is the case in the classic treatment of a cartel. Groups where this is true may be able to design sharing rules which lead to pareto-optimal outcomes in the absence of a principal. A partnership among the agents can be efficient in this setting. When agents underestimate the effects of their actions there is no pareto-optimal sharing rule which does not exceed the budget of the organization. Separating ownership and labor would only be advantageous here if ownership is willing to subsidize labor.

Footnotes

[1]A number of papers by psychologists have found the misperception is a common human phenomenon, e.g., Fischoff, Slovic, and Lichtenstein [1].

[2]A paper by Kleindorfer and Kunreuther [6] has examined the problem of adverse selection in a competitive insurance market with consumer misperceptions.

[3]The model is similar to section 2 of Hölmstrom [4].

[4]Note that although a pareto-optimal sharing rule exists, no agent would vote for it, if sharing rules are determined by voting, since every agent would vote for $S_i' = 1$. If agents recognize that a balanced budget is required, they will choose from among the set $S \equiv \{S_i' : \sum_{i=1}^{n} S_i' = 1\}$. Since the set of pareto-optimal sharing rules, $S_p \subset S$, a pareto-optimal sharing rule $S_i' \varepsilon S_p$ may be chosen.

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