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# Coalition-proof full efficient implementation

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## Abstract

The Vickrey–Clarke–Groves and d’Aspremont–Gerard-Varet mechanisms implement efficient social choice by compensating each agent for the externalities that his report imposes on all other agents. Instead of aggregate compensations, which may lead to profitable coalitional deviations, this paper provides an alternative mechanism, in which each pair of agents directly compensate each other for the pairwise externalities they impose. Under the assumption of independent private values, any agent is guaranteed to receive his ex ante efficient payoff by reporting truthfully, regardless of others’ strategies. This absence of ex ante externalities makes the mechanism coalition-proof, and makes all equilibria efficient.

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## 1. Introduction

The problem of externalities which cause economic inefficiency can be solved if there exists a procedure for internalizing the externalities. This paper develops such a procedure in a benevolent social planner's problem in which agents have independent private values and quasilinear preferences. The social planner (she) asks each agent (he) to report his preferences, and then she implements the social outcome which maximizes the total payoff of the agents. Since any agent's report affects the social outcome, the agents impose externalities on each other and may benefit from misreporting their types (preferences). In order to induce truthful reports, the agents should be required to compensate each other for these externalities.

The idea of internalizing the externalities has been used in the classic Vickrey–Clarke–Groves (VCG) and d'Aspremont–Gerard-Varet (AGV) mechanisms, though in these mechanisms agents do not directly compensate each other. In the VCG mechanism, it is the social planner who compensates the agents for the externalities. In the AGV mechanism, the compensation is unfair: if agent  $i$ 's report imposes externalities on agent  $j$  and no externalities on agent  $k$ , agent  $k$  still has to partially compensate agent  $i$  for the former externalities. As a result, both of these mechanisms internalize the aggregate—not the pairwise—externalities and are not resistant to group deviation. In these mechanisms, each agent individually prefers to report truthfully, but a group of agents can coordinate on a misreport and jointly benefit.

The current paper presents an alternative mechanism, which improves upon the VCG and AGV mechanisms by being resistant to coalitional deviations. The mechanism is built assuming *independent private values*—the environment of the AGV mechanism. There are two equivalent versions of the mechanism: the direct mechanism and the sequential mechanism. This paper mainly focuses on the direct mechanism. Agents simultaneously report their types. Then the social planner orders the agents in an *arbitrary* sequence, and she treats the agents' reports as if they were arriving one by one, according to that sequence. When the report of agent  $i$  “arrives”, the social planner updates her beliefs over the efficient social outcome she will choose at the end, and she updates the expected payoffs of the agents from that outcome. The mechanism prescribes any other agent  $j \neq i$  to pay agent  $i$  the change in  $j$ 's expected payoff which occurs as a result of  $i$ 's report. These payments are made for the report of each agent, that is, each pair of agents  $i, j$  compensate each other for the *pairwise* externalities of their reports. The sequential (version of the) mechanism is equivalent to the direct version, except that the agents report their types sequentially and publicly.

In the new (direct) mechanism, each pair of agents directly compensate each other for the pairwise marginal externalities caused by their reports. As a result, all externalities are removed at the ex ante level. If any agent  $i$ , before learning his type, commits to reporting truthfully, he is guaranteed to get his ex ante efficient payoff, regardless of others' strategies. This result follows from the way the payments are made. First, agent  $i$  receives a payment from every other agent  $j$ , equal to the change in  $j$ 's expected payoff caused by  $i$ 's report. Since agent  $i$  reports truthfully, in expectation over  $i$ 's report that change is zero, and so is  $j$ 's payment to  $i$ . Second, agent  $i$  makes a payment to  $j$ , equal to the change in  $i$ 's expected payoff caused by  $j$ 's report. Effectively, the utility of agent  $i$  (his payoff from social choice plus payments received in the mechanism) does not change with  $j$ 's report. Therefore,  $i$ 's utility does not change with reports of other agents and is equal to its ex ante value, that is, to  $i$ 's ex ante efficient payoff.

The idea behind this mechanism is similar to that of property rights in the Coase theorem. Before the mechanism is announced, the social planner expects each agent  $i$  to obtain his ex ante efficient payoff. She guarantees that agent  $i$  will receive that payoff if he reports truthfully:

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