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Optimal task assignments ☆

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ABSTRACT

This paper studies optimal task assignments in a risk neutral principal-agent model in which agents are compensated according to an aggregated performance measure. The main trade-off is one in which specialization allows the implementation of any possible effort profile, while multitasking constraint the set of implementable effort profiles. Yet, the implementation of any effort profile in this set is less expensive than the equivalent profile under specialization. The principal prefers multitasking to specialization except when tasks are complements and the output after success is small enough so that it is not second-best optimal to implement high effort in each task. This result is robust to several extensions such as the existence of multiple performance measures.

1. Introduction

The question of how to allocate tasks among different workers to increase productivity was first answered in *The Wealth of Nations* by Adam Smith and it's well exemplified by his description of how pins should be manufactured. This idea paved the way for the "scientific management" philosophy set forth a century ago by Frederick W. Taylor (1911). The basic idea was to view the task assignment problem as a scientific optimization problem, where industrial engineers study the production process and devise the most efficient way to break that process into individual, precisely defined tasks. Economists and psychologists have enriched the theory of task assignments in many different ways such as the role of comparative advantages, incentives, communication failures, motivation and learning problems and coordination costs among others.

In this paper, we revisit the question of what is the optimal task assignment in a setting with moral hazard and limited liability. Mainly, the paper considers a combinatorial agency model in which there is one project whose expected output depends on the effort exerted in several tasks. The outcome of the project can be either success or failure and the probability of success allows for both complementary as well as substitutable tasks. The principal chooses between two different task assignments: multitasking, which means that all tasks are assigned to one agent; and specialization or team work, which means that each task is assigned to a different agent. The principal is risk-neutral, agents are effort averse and face a limited-liability constraint. Effort is dichotomic (high and low effort) and unobservable in each task, and agents' marginal cost of effort is constant and identical in each task.

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In the absence of moral hazard, the principal is completely indifferent between specialization and multitasking. The reason stands for the fact that, regardless of the technology and task assignment chosen, the first-best efficient effort profile, which is assumed to be high effort in each task, can be implemented at no extra cost. Hence, the environment proposed here has been deliberately kept as simple as possible so that if the principal shows strict preferences for a particular task assignment, that must be due to incentive considerations only.

When there is moral hazard and tasks are substitutes, the principal prefers multitasking to specialization. The effort profile implemented depends on the magnitude of the return upon success; the higher it is, the higher the effort profile implemented. In contrast, when tasks are complements, multitasking dominates specialization only when it is second-best optimal to induce the agent in charge of all tasks to work hard in each of them. That is, when the return after success is sufficiently large. Otherwise, the principal adopts a specialized task assignment and the effort profile implemented increases as the return after success rises. Hence, specialization (i.e., team work) arises as the optimal task assignment only if tasks are complements.

The optimal assignment is determined by the following forces. First, task complementarity together with the fact that compensation is based on an aggregated performance measure that confounds the efforts of n non-conflicting tasks imply that there is no contract that implements an effort profile where the agent responsible for all tasks works in less than n tasks and in at least one of them. When the incentive intensity provided to the agent is such that he works hard in one task, he has incentives to work hard in the other tasks as well since the marginal gain from effort rises with the effort exerted in other tasks, while the marginal cost is constant. In other words, the global incentive constraint is the relevant one to determine the effort profile that can be implemented. Second, when tasks are substitutes, the incentive intensity that induces an agent to work hard in k tasks does not induce him to work hard in $k+1$ tasks since the marginal gain from effort falls with the effort exerted in other tasks, while the marginal cost is constant. In other words, the downward local incentive constraints are the relevant ones to determine the agent's optimal effort profile. Third, when a different agent is responsible for each task (i.e., specialization is adopted), the principal can implement any effort profile as a Nash equilibrium. There is a multiplicity of equilibria issue that is dealt with by selecting the Pareto optimal equilibrium. This can be done since the principal has the freedom to customize each agent's incentive intensity so that incentives for hard work given to one agent do not induce other agents to work hard. Fourth, the limited-liability rent needed to implement any effort profile is always at least as large in the case of specialization as it is in the case of multitasking. The reason is twofold: first, an agent's compensation is based on an aggregated performance measure that confounds the effects of several non-conflicting tasks. This induces the agent responsible for several tasks to internalize the losses from not exerting effort in another task under his responsibility; and second, under specialization the bonus must be paid k times in order to induce k agents to work hard.

When tasks are complements, the interaction of these factors results in a trade-off between paying a lower limited-liability rent by making an agent responsible for every task, but restricting the set of implementable effort profiles and paying a higher aggregated limited-liability rent by allocating each task to a different agent and being able to implement any effort profile. This trade-off has been overlooked in the literature since all the papers we are aware of assume that implementing high effort in each task is optimal regardless of the cost that this entails and the number of tasks involved. In contrast, when tasks are substitutes, this trade-off does not arise since multitasking does not restrict the set of implementable effort profiles. Regardless of the task assignment chosen, the principal can implement any effort profile at a lower cost under multitasking. The reason stands for the fact that when tasks are substitutes and a multitask assignment is chosen, the implementation of any effort profile is determined by the local incentive constraints, which are identical to those that arise when a specialized task assignment is chosen. This gives rise to the same limited-liability rent, but under specialization this is paid k times (k being the number of tasks for which the principal wishes to implement high effort) while under multitasking this is paid just once.

This result is shown to be robust to the fact that effort in a given number of tasks is contractible, to the fact that agents might be limited in their ability to work hard in more than one task and to the presence of multiple performance measures. We show that the first two constraints increase the set of parameters under which multitasking is optimal since the former results in a lower limited-liability rent under multitasking, while the latter increases the set of implementable effort profiles under multitasking. Multiple performance measures do not solve the implementation problem that arises under multitasking, but consistent with the informativeness principle, result in lower total compensation costs.

Related literature The optimal assignment of tasks in principal-agent problems with moral hazard has been studied by several authors such as Holmström and Milgrom (1991), Baker (2002), Itoh (1991, 1992, 1994), Dewatripont et al. (1999), Zhang (2003), Corts (2007), Mukherjee and Vasconcelos (2011) and MacDonald and Marx (2001) in a setting where the effort substitution approach pioneered by Holmström and Milgrom (1991) plays a crucial role.[1] However, in the current paper, the multitasking problem is not based on the effort substitution approach and how the number of tasks affects the risk and incentives trade-off under substitution, it is rather based on the ideas that task complementarities create

[1] Zhang (2003) shows, in contrast to the result here, that in the absence of task complementarities, specialization always dominates multitasking. The difference in the result stands for the fact that in his model tasks differ according to its measure difficulty and therefore bundling different tasks within the same job worsen the noisiness of the aggregate signal with respect to the case in which in each job identical tasks are bundled. The noisiness of the signal matters in his model because agents are risk averse, while here agents are risk neutral and this plays no role.