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Technology choice, relative performance pay, and worker heterogeneity☆

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ABSTRACT

We identify a new problem that may arise when heterogeneous workers are motivated by relative performance pay: if workers' abilities and the production technology are complements, the firm may prefer not to adopt a more advanced technology even though this technology would costlessly increase each worker's productivity. Due to the complementarity between ability and technology, under technology adoption the productivity of a more able worker increases more strongly than the productivity of a less able colleague. As a consequence, both workers' motivation to exert effort is reduced. We show that this adverse incentive effect is dominant and, consequently, keeps the firm from introducing a better production technology if talent uncertainty is sufficiently high and/or monitoring of workers is sufficiently precise.

1. Introduction

A fundamental incentive problem in organizations arises from the fact that a firm often has only coarse information on its workers' effort. In particular, performance signals are often only ordinal and/or unverifiable. In the first case, the firm only observes an ordinal ranking of worker performance. In the latter case, performance is observable by the firm but not by a third party. In such situations, incentive schemes like individual bonuses or piece rates are not feasible because they require individual performance signals or they are subject to potential employer opportunism. If worker performance is unverifiable, ex-post the firm can save labor costs by wrongly claiming that workers have performed poorly. Since workers anticipate such opportunistic behavior, incentives would be completely erased.

However, when only ordinal and/or unverifiable performance signals are available, the firm can still rely on relative incentive schemes that distribute a fixed amount of money among the workers according to their relative performance

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(Malcomson, 1984, 1986).[2] In practice, we can observe diverse variants of such incentive schemes, e.g., bonus pools (Kanemoto and MacLeod, 1992; Rajan and Reichelstein, 2006, 2009; Budde, 2007), job-promotion tournaments (Baker et al., 1994; Treble et al., 2001), sales contests (Kalra and Shi, 2001; Murphy et al., 2004; Lim et al., 2009), and forced-distribution systems (Murphy, 1992; Thomas, 2002). Under each variant, the firm commits to pay a certain collective amount of money to the workers. Such a commitment is credible because a third party can verify whether the entire amount has been paid out by the firm. Since the firm is forced to pay out the total amount of money, it has no incentive to misrepresent the workers' performance. This important self-commitment property assures worker incentives.

In this paper, we point out that the use of relative performance pay can be highly problematic if the firm can choose between different production technologies. We characterize situations in which the firm foregoes to install a new technology although this technology would increase each worker's productivity and is costlessly available. When choosing the technology, the firm faces the following trade-off: On the one hand, a more advanced technology enhances each worker's productivity (*productivity effect*). On the other hand, if worker ability and firm technology are complements and workers differ in their abilities, the new technology increases the productivity of a more able worker more strongly than the productivity of a less able worker. Thus, the outcome of worker competition for bonus shares is less responsive to changes in effort and, consequently, both workers exert less effort (*adverse incentive effect*). If the adverse incentive effect dominates the productivity effect, the firm will not adopt the advanced technology.

In a next step, we use a parameterized example to highlight the impact of worker heterogeneity on technology choice. We show that, the higher the degree of worker heterogeneity and the higher the uncertainty about workers' ex-ante unknown talents, the more likely the firm is to choose the less productive technology. In particular, we compare two labor market situations that differ in the expected ability of the workers. We demonstrate that the firm may adopt the more advanced technology only in the situation with lower expected worker ability. Such a scenario occurs if talent uncertainty in the situation with higher average ability is sufficiently high compared to the situation with lower average ability. Furthermore, if workers' equilibrium efforts are rather small under either technology due to imprecise performance measurement or steep marginal effort costs, the adverse incentive effect of technology adoption is not severe. As a result, if the firm's monitoring technology is imprecise, the firm is more inclined to invest in a better production technology. Hence, if worker ability and production technology are complements in the firm's production function, monitoring technology and production technology are substitutes.

Theoretic contributions to moral hazard in principal–agent relationships typically consider either limited liability or risk aversion of workers as contractual frictions (e.g., Laffont and Martimort, 2002, chapter 4). Until Section 4, the paper focuses on the case where workers are risk neutral and protected by limited liability. To check the robustness of our findings, Section 5 turns to the case of risk averse workers. There, we analyze both the case of limitedly liable workers and of unlimited liability. Whereas limited liability of risk-averse workers leads to the same two opposite effects as the case of risk neutral workers – a positive productivity effect and an adverse incentive effect, switching to unlimited liability adds a third effect: if a better technology decreases effort due to more uneven worker competition, effort costs will be reduced as well. Under unlimited liability, this cost reduction directly benefits the firm, which can then lower expected wage payments since the workers' participation constraint can always be made binding. Hence, the firm is in favor of introducing the better technology under unlimited liability rather than under limited one.

The theoretical setting with ability and technology being complements fits well with the situation observed in the last decades where firms intensely invested in information technologies (IT). Initially, investment in IT was used to save labor and to substitute capital for low-ability work. However, nowadays IT and workers' abilities are mainly seen as complements (see, among many others, Applegate et al., 1988; Berndt et al., 1992; Hitt and Snir, 1999; Bresnahan et al., 2002). IT is used by high-ability workers for improving time to market in research and development and improving service to key customers, for example. In other words, rather complex IT is used by firms for intensively exploiting the potential of their high-ability workers, hence making them more productive.

Besides the literature cited above, our paper is related to the work on rank-order tournaments starting with the seminal articles by Lazear and Rosen (1981), Green and Stokey (1983) and Nalebuff and Stiglitz (1983). Subsequent papers pointed to specific disadvantages of tournaments. Two major problems of tournaments have been emphasized in the literature. First, workers can improve their relative positions in the ranking by investing in counterproductive effort or sabotage (Lazear, 1989; Konrad, 2000; Chen, 2003; Münster, 2007; Amegashie and Runkel, 2007; Gürtler, 2008). Second, similar to cartels in market competition, tournament participants can collectively gain by a stable collusion that minimizes effort costs (Ishiguro, 2004; Chen, 2006; Sutter and Strassmair, 2009). In this paper, we identify a further problem of bonus pools or tournaments – an adverse effect on technology choice given that worker ability and production technology are complements.

The remainder of the paper is organized as follows. In the next section, we introduce the model setup. Section 3 solves the workers' problem of effort choice under a given bonus-pool incentive scheme. Section 4 focuses on the firm's problems of designing the optimal bonus-pool contract and choosing the optimal production technology. Section 5 extends the analysis to the case of risk averse workers. Section 6 concludes.

[2] Another well-known solution to the unverifiability problem are relational (or self-enforcing) contracts (see, e.g., Bull, 1987; Baker et al., 2002). For a relational contract to be feasible, the firm's loss from reneging must be sufficiently large, e.g., the employer-employee relationship needs to be sustained with sufficiently high probability in the future and the associated future profit must not be discounted heavily.