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Optimal effort incentives in dynamic tournaments [☆]

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ABSTRACT

This paper analyzes two-stage rank-order tournaments. To influence efforts in the two periods, a principal can use the intertemporal prize structure and the weight of first-period performance in the second-period prize. These two instruments implement different sets of effort vectors. We characterize the optimal combination of prizes and weights as a function of parameters. For large parameter regions, the principal should only give a second-period prize, but use positive first-period performance weights. This holds no matter whether efforts in different periods are perfect or imperfect substitutes and whether the principal gives feedback on performance or not. We also generalize existing results on whether giving feedback is beneficial for the principal.

1. Introduction

Firms and other organizations often use dynamic tournaments to incentivize repeated effort provision.[1] For instance, promotion tournaments and bonus systems are common. When designing such contests, a principal must ask how to induce the best possible intertemporal effort vector with a given budget. She can affect total effort and its distribution across periods though the prize structure, i.e., the division of a given prize sum between several periods. She can give one big prize after a long time or several small prizes in different periods. Apart from this *prize policy*, she has an alternative instrument for influencing the intertemporal effort distribution, namely the weight she gives to past performance when assigning prizes in later periods. We will show that, in spite of their superficial similarity, this *weight policy* and the prize policy have very different effects on effort streams, and we will identify the optimal combination of both instruments.

Specifically, we consider a two-period rank-order tournament with two risk-neutral agents with identical and known abilities.[2] The principal can split the prize money across two periods arbitrarily. If she awards a second-period prize, she also chooses a first-period performance weight. After the announcement of prize and weight policies, the agents choose

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[1] A well-known argument for tournaments is as follows. When performance is not verifiable, a principal who contracts directly on performance may claim that performance was low to save on performance pay. Tournaments reduce this incentive, because the total payments to the agents are independent of performance.

[2] To see the incentive effects of such tournaments most clearly, we abstract from the important issue of selecting the agent with the highest innate ability for a particular task.

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effort levels in each period. The principal observes each agent's performance, a noisy measure of effort. In period 1, she awards the prize (if any) to the agent who performed better. In our benchmark case *with feedback*, she publicly announces the performance of both agents in the first period. In period 2, the agents choose efforts again. The principal then allocates the second-period prize to the agent for whom the weighted sum of first- and second-period performance is highest.

In line with the literature, we consider the case that a principal regards efforts in different periods and by different agents as perfect substitutes and thus maximizes total effort. Contrary to most of the literature, we also analyze the optimal policy for a principal who treats efforts in different periods as imperfect substitutes and wants to balance them across periods. This is important, because excessively low efforts in some period may cause large harm, which cannot even be compensated by an extremely large effort in other periods.

Our main contribution is that we compare the effects of prize and weight policies on effort streams. Moreover, we identify the optimal combination of both policies, depending on parameters. We use a simple example to show that a principal can induce the same maximal first-period effort and the same maximal second-period effort with each instrument. However, the two instruments implement different sets of effort vectors with positive efforts in both periods.

Next, we show that, under quite general conditions, the principal should give only a second-period prize, but with a positive first-period performance weight. The optimal first-period prize is positive only if the first-period performance measure is sufficiently precise. We then show that for quadratic cost functions and normally distributed observation errors, this condition never holds. Even with more general distributional assumptions, the optimal first-period prize is never higher than the second-period prize for imperfect substitutes and quadratic cost functions.

For the normal-quadratic example, we identify large gains from good design. The expected effort is at least 40% higher when a principal chooses prizes and weights optimally than when she carries out two identical independent tournaments with the same total prize sum.

Finally, we compare the results of the benchmark model with the *no feedback* case without communication of performance.[3] We obtain similar results on the optimal combination of prizes and weights. Moreover, we generalize some existing results on whether a principle should give feedback.

The organization of the paper is as follows. Section 2 discusses related literature. In Section 3, we introduce the model. In Section 4, we analyze agent behavior. Section 5 uses a simple example to compare the incentive effects of pure prize policies and pure weight policies. Sections 6 and 7 characterize the optimal policy. Section 8 discusses the feedback policy. Section 9 concludes. The Appendix contains all non-trivial proofs.

2. Relation to the literature

Our paper focuses on the optimal choice of prizes and weights in dynamic tournaments.[4] We are not aware of any work on the trade-off between these two instruments and their optimal combination. A small number of papers (Möller, 2012; Clark et al., 2012; Clark and Nilssen, 2013) derives the optimal prize structure in Tullock contests when good performers in period one have an *exogenous* advantage in period two, creating an asymmetry between the agents in the second period.[5] However, these papers do not deal with the choice between prize and weight policies as alternatives for influencing the effort streams, which is central in our paper. Moreover, they neither analyze feedback policies nor do they allow for imperfect substitutes.[6]

Our results on optimal weights are closely related to the literature, but they provide additional insights. For instance, Meyer (1992) considers a setting similar to our case with feedback and a single prize, but with risk-averse agents. She shows that cost minimization requires a bias towards the first-period winner.[7] Our analysis shows that the principal should also give a headstart when the first-period prize is higher than the second-period prize, when efforts are imperfect substitutes and when there is no feedback. Finally, we provide results on the determinants of the size of the bias.[8]

Several recent papers have dealt with feedback in dynamic tournaments (see Section 8). Aoyagi (2010) considers a two-period tournament similar to ours. However, he takes prizes and weights as exogenous: Unlike in our paper, there is only one prize, and first and second-period performance receive the same weight. He shows that the expected effort is

3 In the no revelation case, the game is static. The model thus becomes a special case of a multi-battle contest where agents compete simultaneously in a multiplicity of dimensions (see, e.g., Clark and Konrad, 2007 and Kovenock and Roberson, 2010).

4 Nitzan (1994) and Konrad (2009) provide surveys of the literature on tournaments. Another broadly related literature analyzes dynamic principal-agent relationships with moral hazard in a non-competitive setting. Lewis and Sappington (1997) examine how current incentives should optimally depend on past performance. Hansen (2013) and Chen and Chiu (2013) deal with the optimal revelation policy.

5 These technological assumptions are also made by some authors who do not deal with the optimal prize structure (e.g., Schmitt et al., 2004; Grossmann and Dietl, 2009; Grossmann, 2011 and Baik and Lee, 2000).

6 Some papers derive the optimal distribution of prize money across stages in a two-period elimination tournament, where only the winners of the current period compete again in the next period. A seminal paper is Moldovanu and Sela (2006). Because elimination tournaments have a very different structure than our model, the results are difficult to compare to ours.

7 See also Ridlon and Shin (2013).

8 Contrary to us, Meyer (1992) assumes that the size of the bias is fixed ex ante rather than a function of the performance difference in period 1.

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