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Dynamic behavior and player types in majoritarian multi-battle contests [☆]

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ABSTRACT

In a dynamic contest where it is costly to compete, a player who is behind must decide whether to surrender or keep fighting in the face of bleak odds. We experimentally examine the game theoretic prediction of last stand behavior in a multi-battle contest with a winning prize and losing penalty, as well as the contrasting prediction of surrendering in the corresponding contest with no penalty. We find varied evidence in support of these hypotheses in the aggregate data, but more conclusive evidence when scrutinizing individual player behavior. Players' realized strategies tend to conform to one of several "types". We develop a taxonomy to classify player types and study how types interact and how their incidence varies across treatments. Although last stand and surrendering behaviors arise at rates responsive to the importance of losing penalties, the most prominent behavior is escalation.

1. Introduction

Contests are commonly dynamic in nature. Businesses may spend weeks or months jockeying for a lucrative contract, political campaigns frequently span a year or more, and major wars span several. A unifying feature of many contests is that they are frequently comprised of several smaller battles, and throughout these battles, participants have an awareness of whether they are falling behind or approaching victory. Contests are also inherently costly—whether the cost is denominated in troops, effort, money, or other form of expenditure. Participants must therefore weigh the amount and timing of expenditures against their proximity to and the consequences of victory or defeat. Needless to say, a host of strategies may ensue.

Building on recent theoretical work, we experimentally examine strategic behavior in the two-player best-of-seven tournament with complete information. Battles within the tournament occur sequentially and are modeled as all-pay auctions: the high bidder wins, but both players pay the cost of their own bid (see Hillman and Riley, 1989; and Baye et al., 1996).

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The first player to win four all-pay auctions becomes the tournament winner and receives a positive prize while the loser incurs a nonpositive penalty.[1] Under the assumption that the losing penalty is zero and that tournament winnings and bidding expenditures are not subject to discounting, Konrad and Kovenock (2009) find that the unique sub-game perfect equilibrium entails intense competition when players are symmetrically situated in the tournament. But when a player falls behind by even one battle, he is expected to completely give up.[2] Gelder (2014) shows that this stark pattern of surrendering is not robust to the combined inclusion of a strictly negative losing penalty and the time discounting of potential future earnings or losses. Rather, a player who is behind in the tournament by two or more battles may exhibit last stand behavior—a phenomenon characterized by the laggard bidding more aggressively on average than the frontrunner, despite the poor odds of an ultimate tournament win. A last stand is much more the story of delaying imminent loss than the story of gaining the victor's crown.

We experimentally investigate the contrasting predictions of surrendering versus making a last stand using three prize-penalty combinations: one in which there is a large prize but no penalty, one with a prize and penalty of equal magnitude, and a third in which the penalty is dramatically larger than the prize. The net difference between the prize and penalty is held constant so that in a one-shot contest with risk neutral players, equilibrium behavior would be the same in each case. Because discounting is a central ingredient for the last stand predictions of Gelder (2014), we implement discounting via a probability that the best-of-seven tournament suddenly terminates after each battle; in which case, neither player receives the winning prize or losing penalty, although previous bids are still forfeited.[3]

In accordance with theoretical predictions, along the tournament path where a single player consistently loses each battle, the rate of surrender is conspicuously high in the treatment with no losing penalty. Last stand behavior becomes salient along that same path when penalties are present. From the full set of possible paths, however, the most prominent behavior is to escalate the conflict by engaging in a bidding war. The escalation of highly aggressive bids is theoretically predicted in all treatments when the tournament is tied. Yet returning the tournament to a tied position is remarkably rare in expectation due to the frontrunner's strategic incentive to maintain the lead. The cut-off is sharp mathematically. Once a player falls behind by even one battle, the question of losing becomes largely one of when not if. Behaviorally, lagging by one battle is not such a fatal diagnosis, opening the door for widespread escalation.[4]

Our analysis is twofold and begins by looking at aggregate behavior on a state-by-state basis within the tournament. Although primarily limited to comparisons between current and previous battles, the patterns of escalation, surrender, and last stand are still discernible. We next scrutinize dynamic behavior by examining the full path of each tournament. Here we find that players gravitate toward different strategies and repeatedly use them throughout the experiment. In this regard, players can be categorized according to one of several player types. Since a player's full extensive form strategy is not available in the experimental data, which only contain the history-contingent actions along the realized path of the tournament, we refer to these observable actions as a player's *realized strategy*.[5] Defining a formal taxonomy, we classify the occurrence of different realized strategies across treatments.

Dynamic contest experiments have largely been limited to best-of-three tournaments.[6] That setting, however, is too short to observe players who are behind but not yet imminently facing a tournament loss. Upstream behavior adds crucial context to the dynamic picture and allows us to differentiate the key patterns of competition. Deck and Sheremeta's (2012) game of siege is closely related since it can be reached as an intermediate stage in a best-of-seven tournament. In their experiment, players are positioned asymmetrically so that one player (the defender) needs to win three or four successive battles to be victorious, while the attacker only needs to win one. Instead of automatically positioning one player on the brink of defeat, our experiment allows players to reach that point endogenously.[7]

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[1] This is a special case of what is known more generally as a two-player race, a term reaching back to the patent race model of Harris and Vickers (1987). Instead of using the all-pay auction, Harris and Vickers model component contests with a logit-style lottery contest success function where a player's probability of winning is the ratio of the player's own bid to the sum of both players' bids. They additionally scale the cost of a player's bid by the sum of the bids.

[2] Konrad and Kovenock's analysis covers a more general class of multi-battle contests that allows for the number of all-pay auction victories needed to win the tournament to vary across players, as well as for players to accrue asymmetric prizes for winning the tournament and identical prizes for individual battle victories. If prizes for individual battles are present, a player who is behind will compete, but he will essentially behave as if he were solely competing for the individual battle prize and not for the overall winning prize. An early example of a dynamic contest where players slacken their effort or give up entirely if they fall behind is Fudenberg et al.'s (1983) study of preemption in patent races by firms who have a marginal lead over their competitors.

[3] Under risk neutrality, this adaptation of the tournament is theoretically innocuous.

[4] Once both players have won at least one battle, they act as if the previous winning bid is the minimum bid for the next battle. The reluctance to lower bids may potentially be due to a sunk cost commitment to the tournament; an underlying preference for competing—especially when a player fights back immediately after falling behind; or even because it is a simple heuristic.

[5] The tournament's complex extensive form makes the strategy method (Selten, 1967) difficult to implement without strong and unrealistic restrictions on the information available to players at each stage of the game.

[6] See, for example, Sheremeta, 2010; Mago et al., 2013; Irfanoglu et al., 2014; and Mago and Sheremeta, 2016. A noted exception is the best-of-19 tournament of Zizzo (2002). More broadly, Dechenaux et al. (2015) surveys the growing literature on contests and tournaments.

[7] As we will see, the history of bids leading up to that point is revealing. Some players surrender from the start, others begin by mimicking a surrender and then make a last stand. Still others are clearly aggressive but happen to consistently lose by bad luck. Although Deck and Sheremeta avoid any endogenous self-selection by automatically starting players at this point, they miss both the history and the ability to observe competition at less crucial battles.