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The value of commitment in Stackelberg games with observation costs ☆

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Abstract

We study Stackelberg games in which the follower faces a cost for observing the leader's action. We show that, irrespective of the size of the cost, the leader's value of commitment is lost completely in all pure-strategy equilibria. However, there also exists a mixed-strategy equilibrium that fully preserves the first-mover advantage. In this type of equilibrium, the probability that the follower looks at the leader's action is independent of the cost of looking.

JEL classification: C72; D83; L13

Keywords: Stackelberg duopoly; Observation cost; Value of commitment; First-mover advantage; Leader–follower game

1. Introduction

It is well known that a firm can sometimes gain an advantage by committing to an action ahead of its rivals. Indeed, the familiar Stackelberg quantity-setting duopoly model is a prominent example (Von Stackelberg, 1934). Here, a leader firm obtains an advantage by committing to produce a large quantity of some homogeneous good. The follower, upon observing the leader's choice, then optimally decides to produce less of the good. The leader thereby gains market share and profit at the expense of its rival.

☆ The views presented in this paper are those of the author and do not necessarily reflect the position of the International Monetary Fund.

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Given the prominent role that commitment plays in applied economic theory and in the real world, the robustness of the value of commitment is, of course, quite important.[1] However, in a thought-provoking paper Bagwell (1995) has shown that the value of commitment may in fact be extremely fragile. More specifically, he studies leader–follower games where, with small but positive probability, the follower receives the wrong signal as to the leader's action. The pure-strategy Nash equilibrium outcomes of such a 'noisy leader game' turn out to be equal to the pure-strategy Nash equilibrium outcomes of the simultaneous-move version of the game. In other words, the leader's value of commitment may not be robust at all to noise in the communication technology.[2]

Van Damme and Hurkens (vDH, 1997) partly salvage the value of commitment in such a world by showing that noisy leader games always have a mixed-strategy equilibrium in which the value of commitment is preserved asymptotically when the noise vanishes. vDH call such an equilibrium a 'noisy Stackelberg equilibrium' and develop an equilibrium selection theory according to which noisy Stackelberg equilibria are selected.

Finally, in a continuous-action version of the noisy leader game, Maggi (1999) shows that the value of commitment can be restored when there is private information on the part of the leader.

In this paper we take a somewhat different approach. We show that, in order to undermine the value of commitment, the introduction of exogenous uncertainty through noisy communication is in fact quite unnecessary. The value of commitment can just as well be compromised by uncertainty that arises strictly endogenously, when monitoring the leader's action involves some small cost.

More specifically, we consider a broad class of leader–follower games in which the follower's decision whether to observe the leader's action is determined endogenously. The sequence of moves is as follows. First, the leader takes an action. Then, the follower gets to observe what the leader has done if and only if he expends an amount ε. Finally, the follower takes an action of his own. We shall refer to this class of games as 'costly leader games' and study the properties of their equilibria. Our main findings are as follows:

1. In any pure-strategy subgame perfect equilibrium of a costly leader game, the value of commitment is lost completely, no matter how small the follower's cost of becoming informed (Proposition 2).
2. For sufficiently small costs of becoming informed, there exists a mixed-strategy equilibrium of the costly leader game that perfectly preserves the leader's first-mover advantage (Corollary 8 and Proposition 10).
3. In all equilibria that preserve the leader's first-mover advantage, the probability that the follower chooses to observe the leader's action is independent of the cost of observation (Proposition 9).

[1] In this paper, we use the terms 'value of commitment' and 'first-mover advantage' interchangeably. Both terms refer to the extra equilibrium payoff the leader gets from moving first, as compared to his equilibrium payoff when the players move simultaneously.

[2] In the context of a 2×2 example, Bagwell also describes the set of mixed-strategy equilibria. In one of these equilibria the value of commitment is preserved asymptotically when the noise vanishes.