Loss aversion equilibrium*†

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Abstract. The Nash equilibrium solution concept for games is based on the assumption of expected utility maximization. Reference dependent utility functions (in which utility is determined not only by an outcome, but also by the relationship of the outcome to a reference point) are a better predictor of behavior than expected utility. In particular, loss aversion is an important element of such utility functions.

We extend games to include loss aversion characteristics of the players. We define two types of loss-aversion equilibrium, a solution concept endogenizing reference points. The two types reflect different procedures of updating reference points during the game. Reference points emerge as expressions of anticipation which are fulfilled.

We show existence of myopic loss-aversion equilibrium for any extended game, and compare it to Nash equilibrium. Comparative statics show that an increase in loss aversion of one player can affect her and other players’ payoffs in different directions.

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1. Introduction

Expected utility dominates the analysis of game-theoretic situations, despite overwhelming evidence that it fails to adequately describe or predict human behavior. Kahneman and Tversky’s (1979) prospect theory proposes an alternative to expected utility in which outcomes are evaluated with respect to a reference point. Such reference dependent utility functions are successful in explaining many systematic deviations from the maximization of expected utility. Rabin (1996) writes that “reference dependence deserves to be, and is gradually becoming, an important part of economic modeling.”

The most striking result of the investigation of reference-dependent utility functions is the existence of loss aversion. Experimental works in both the psychological and the economic literature suggest that people are motivated to minimize losses (relative to a reference point) much more than they are motivated to maximize gain. For example, Fishburn and Kochenberger (1979) empirically assessed utility functions over changes in wealth. They found that the slope of the utility function below the reference point was on average almost five times as steep as the slope above the reference point. Other examples emphasizing the different treatment of losses and gains (and implicitly or explicitly implying reference dependence) are De Dreu, Emans and Van de Vliert (1992), Kahneman and Tversky (1979), Kahneman, Knetsch and Thaler (1990, 1991), Kramer (1989), Taylor (1991), and Tversky and Kahneman (1992). Gul (1991) axiomatizes disappointment aversion, which is closely related to loss aversion. Gul’s formula is that obtained when using a reference point for a lottery which is based on the evaluation of the lottery. This is the path we take in the definition of consistent reference points in Section 2.

The traditional definition of games ignores the possibility of reference dependent utility functions, assigning for each player a single number to represent each possible (pure) outcome resulting from a profile of pure strategies. These numbers are the von Neumann-Morgenstern utilities of the players for the outcome given by the strategy profile. For any pair of lotteries over outcomes, each player is assumed to prefer the lottery giving her a higher expected utility. This embodies the risk-aversion characteristics of the players, but not the loss-aversion characteristics. The loss-aversion characteristics cannot simply be embodied in the payoff numbers of the game. This is true, as the utility of an outcome in a lottery depends on the reference point, which would usually depend on all the possible outcomes of the lottery. Thus an outcome will usually have different utility values for different lotteries of which it is a component. An example where reference dependence can be of use is the Allais (1953) paradox, which demonstrates a systematic violation of expected utility maximization¹. Using a reference dependent utility function with loss aversion provides a robust justification for the modal choices in the Allais paradox, as demonstrated by Example 1 in Section 4.

We extend the analysis of games to incorporate reference dependence and loss aversion. We first give a formula, based on experimental results, that systematically relates outcomes and reference points to utility. We assume an underlying utility function that translates outcomes into values, and a loss

¹ Using hypothetical questions.