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Bargaining with incomplete information: Evolutionary stability in finite populations[☆]

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ABSTRACT

This paper considers evolutionarily stable strategies (ESS) in a take-it-or-leave-it offer bargaining game with incomplete information. We find responders reject offers which yield a higher positive material payoff than their outside option. Proposers, in turn, may make more attractive offers than in the perfect Bayesian equilibrium. Efficiency-enhancing trade can break down even when the responder has no private information. Overall, the probability of trade and ex post efficiency are lower in the ESS than in the corresponding perfect Bayesian equilibrium. The results are observationally equivalent to behavioral explanations such as in-group favoritism and a preference for punishing selfish proposers but are driven by concerns about evolutionary fitness in finite populations.

1. Introduction

We study evolutionary stability of ultimatum bargaining behavior in a context with incomplete information and within a finite population. The core analysis considers an evolutionary setup with a sequence of generations of individuals. In each period, a given generation constitutes a population of time-invariant and finite size. Members of a given generation interact in a state game. The outcomes of these interactions determine the evolutionary fitness, which governs the population dynamics. In each of these state games, the agents are grouped in pairs of an (informed) seller and an (uninformed) buyer and interact in an ultimatum bargaining game with incomplete information. We derive the evolutionarily stable offer-making and offer-responding behavior in this game. Also, we ask how this behavior relates to the outcome of a perfect Bayesian equilibrium (PBE). We find that the evolutionarily stable price offers are more generous than the offers in the PBE, but the responder is more reluctant to accept than in the PBE. Overall, trade becomes less likely for evolutionarily stable strategies (ESS) than for PBE behavior.

We also consider several extensions. One of these is bargaining if the informed player – the seller in our context – makes an offer and the uninformed buyer accepts or rejects. In the context of evolutionarily stable strategies this case has some surprising features, and mutually beneficial trades in terms of material payoffs may not be realized. This contrasts with a corresponding PBE in this case which implements full efficiency. Another extension considers the importance of trading within, rather than across populations.

The research question and our analysis relate to two main areas of research: the study of bargaining, particularly under incomplete information; and the study of evolutionary stability. The ultimatum bargaining game has been studied theoretically and empirically (see Güth et al., 1982; Güth and Kocher, 2014, for a recent survey) and has been used as one of the major tools to describe the settlement of a distributional conflict. Incomplete information has been identified as a main source of inefficiency in such conflicts (see, e.g. Chatterjee and Samuelson, 1983; Myerson and Satterthwaite, 1983). Bargaining under incomplete information may systematically fail to reach an efficient outcome. We consider how the outcome of bargaining games with incomplete information is modified if players pursue evolutionarily stable strategies, based on the characterization of evolutionary stability in finite populations developed by Schaffer (1988) and by Nowak et al. (2004). In the PBE of ultimatum bargaining with incomplete information, the uninformed buyer as proposer maximizes expected material payoff. When making a price offer the buyer faces the following trade-off. If he offers a high price, this may increase the likelihood of acceptance, but it also increases what he has to pay in case trade

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takes place. If the price offer is below the seller's reservation price, this leads to failure of trade, even though mutually beneficial trade would be possible. Evolutionary fitness as the objective that drives players' behavior brings in a different logic of optimization. We find that trade becomes even less likely in finite populations when players apply evolutionarily stable strategies. Our main analysis demonstrates this result under the assumption of uniformly distributed reservation prices of the sellers; Section 4.2 discusses the logic of evolutionarily stable behavior for the case of a more general probability distribution.

Previous research in this area has described a large set of bargaining games that differ from ultimatum bargaining (see, e.g. Osborne and Rubinstein, 1990, for an overview). Some of these develop a very different kind of 'population dynamics' than in our framework. An important example is Wolinsky (2000), who studies the dynamics and steady-state properties of a population of workers in a multi-period framework with individual wage negotiations, assuming Nash bargaining. We focus on ultimatum bargaining for several reasons. First, repeated interaction between players in a setup with incomplete information increases complexity along dimensions which are orthogonal to our research question. Second, ultimatum bargaining is the underlying game in some of the seminal contributions on the role of incomplete information for the breakdown of trade in PBE. We analyze whether this breakdown becomes more or less likely if players follow evolutionarily stable strategies.

Evolutionary stability is a concept that has been developed to describe and predict population dynamics in biology contexts. Seminal contributions by Maynard Smith and Price (1973) and Maynard Smith (1974) consider such dynamics in the context of very large populations. This concept assumes that individual players follow some behavioral pattern, which is called their evolutionary strategy. Individuals who follow the same pattern are of the same 'type.' Individuals who follow different patterns are of different types. Assuming that types who have a higher material payoff than other types reproduce faster, thereby succeeding to spread their own type in the next generation, this concept studies the evolutionary success of types. In populations with very many individuals, a single individual's behavior has an impact that is too insignificant to have an influence on the average performance of the aggregate population. Hence, in such contexts behavioral patterns that are evolutionarily stable and maximization of absolute material payoff typically coincide. Work of Schaffer (1988) highlighted that this perspective changes in small populations (see also Alós-Ferrer and Ania, 2005; Nowak et al., 2004; Tarnita et al., 2009). In finite populations, single individuals may increase their own reproductive success not only by advancing their own material resources, but also by reducing those of their competitors. In finite populations, the latter reduces the average material resources of other members of the population with whom the individual competes for reproductive success.

As Schaffer (1988) and a number of applications demonstrate, players who apply evolutionarily stable strategies are more "aggressive" than if they simply maximized their own material payoff as in a standard PBE. The evolutionarily stable strategy can yield a lower own material payoff if it yields an even lower average material payoff of the remainder of the population.[1] However, as has been shown by Eaton et al. (2011) and Konrad and Morath (2012), evolutionarily stable strategies may also be described by in-group favoritism: behavior that could mistakenly be interpreted as altruism. The bargaining context studied here has a structure that may provide opportunity for the emergence of such in-group favoritism. The population is grouped into small subgroups that consist of pairs of players, the respective players in each pair interact as an in-group when bargaining with each other, and there are gains from trade. Our results show, however, that considerations of evolutionary stability lead to less trade and lower total material payoffs within a subgroup.

In the bargaining context evolutionarily stable strategies (ESS) make agreement less likely, compared to the PBE with players who maximize their absolute material payoff. The responder behaves "tougher" than in the PBE. As a seller he rejects some offers for which the offered price exceeds his own material valuation of keeping the good. In this case, he sacrifices his own material reward. The proposer behaves more generously and, as buyer, offers a higher price in the ESS than in the PBE. This may look like in-group favoritism, but from the perspective of the proposer it may be seen as an accommodating reaction to the tough behavior of the responder. And the accommodating behavior is not sufficient to overcome the primary, efficiency-reducing effect of tough responder behavior. Thus, the probability of trade and the expected material payoffs of players are lower for evolutionarily stable strategies than in the PBE. This effect is strongest in small populations and becomes less pronounced if the population size is larger.[2] We also show that a similar logic applies for evolutionarily stable strategies if the informed seller makes an ultimatum price offer to the uninformed buyer.

Much related research has been pursued on evolutionarily stable strategies in the context of bargaining. Seminal work by Gale et al. (1995) and Nowak et al. (2000) considers evolutionary analyses of the ultimatum game. Binmore et al. (1998) analyze alternating-offer bargaining and Ellingsen (1997) considers the evolutionary stability of "obstinate" types in a Nash demand game. Abreu and Sethi (2003) study a bargaining model with behavioral types that never concede to the opponent's demand, assuming type unobservability. For work on the evolutionary stability of trading mechanisms (instead of strategies and preferences, respectively) see, for instance, Lu and McAfee (1996). Learning and stochastic convergence has also been studied in other contexts. Seminal contributions include Young (1993) and Kandori et al. (1993).

There are also recent studies that are more closely related to our analysis. Heifetz and Segev (2004) consider the strategic role of "toughness" in a bargaining context. This approach exploits the strategic commitment value of a toughness preference of the responder if the preference type is observed by the proposer.[3] Their bargaining framework is related to ours, but the strategic benefit of being tough relies on type observability in their framework. A proposer who observes that his responding co-player is "tough" accommodates for the toughness and makes a more generous offer. Hence, observed toughness has a strategic effect which benefits the tough player. In our framework, types are unobserved and therefore have no strategic commitment value. Huck and Oechssler (1999) consider a reduced form of the standard

1 Related to this, a literature based on a seminal paper by Mui (1995) highlights the role of envy. Evolutionarily stable strategies in small populations can provide an economic underpinning for envy, and the strength of such emotions may relate to group size and the type of interaction.

2 We show that evolutionarily stable behavior converges toward Nash equilibrium behavior if the population size goes to infinity, a result which is also obtained in various contexts for the case of complete information. See Ania (2008) and Hehenkamp et al. (2010) for discussions on the equivalence of Nash equilibria and evolutionary stable equilibria in finite populations.

3 For an evolutionary underpinning of different types of (other-regarding) preferences based on their strategic effects see also Sethi (1996), Bester and Güth (1998), Koçkesen et al. (2000), Dufwenberg and Güth (2000), Possajennikov (2000), Ok and Vega-Redondo (2001), Sethi and Somanathan (2001) and Dekel et al. (2007). For a recent contribution that addresses the evolutionary stability of preferences under incomplete information in an assortative matching game see Alger and Weibull (2013).