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A dynamic model of conflict and appropriation☆

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ABSTRACT

This paper presents an extension of a static model of economic conflict analyzed by Hirshleifer (1991, 1995) and Skaperdas (1992) to an infinite horizon differential game. Our aim is to highlight the strategic role of appropriation among a smaller group of agents in an intertemporal context. The model yields the conclusion that there exists a unique linear/nonlinear Markov perfect equilibrium strategy, even when strategies are defined over the entire state space. We demonstrate that "partial cooperation" can be seen as a long-run response to conflict. Moreover, a decrease in the effectiveness of appropriation, the depreciation rate of a common-pool stock, the rate of time preferences or an increase in the "degree of noise" improves the degree of "partial cooperation" and thus welfare in an anarchic society.

1. Introduction

Conflict and appropriation are increasingly gaining attention among economists as a powerful force driving human interactions. There is ample evidence that economic agents not only engage in purely economic activities like production, consumption or exchange, but also *sometimes* allocate resources to conflict as well as to appropriation activities in order to capture what others have produced or to secure certain rents. There is a relatively small but growing literature in political economics initiated by Hirshleifer (1991, 1995), Skaperdas (1992), and Grossman and Kim (1995) which allows for the

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possibility of conflict and appropriation in games with economic interaction. Their models share four common features. First, they postulate that conflict arises from the choice of rational and self-interested agents. Second, well-defined and enforced property rights over, at least, some goods do not exist. Third, the agents are assumed to be myopic in a way that they maximize only the current payoff. Fourth, their models are static. This paper conducts the analysis of conflict and appropriation by extending the existing static models to a dynamic one.

Hirshleifer (1995) takes an initial step towards a dynamic approach by recognizing successive iterations of the one-shot game, and he focuses on the convergent point of such iterations (he calls such a fixed point "a steady state"). Nevertheless, as Maxwell and Reuveny (2005, p. 31) correctly point out, "However, this approach is not fully dynamic: it does not specify equations of motion for any variables, time is not a variable in the model, and the condition for dynamic stability is not derived based on standard dynamic analysis".

In response to such long-term desires, there have been several papers which attempt to construct a dynamic variation of the one-shot conflicting game analyzed by the above-mentioned authors. Garfinkel (1990) examines a dynamic model in which agents make choices between productive and fighting activities. She uses a repeated game setting where threats and punishments are available. Existence of cooperative, disarmament equilibria can be established using Folk Theorem arguments. Skaperdas and Syropoulos (1996) discuss a two-period model of conflict in which time-dependence is introduced by the assumption that second period resources of each agent are increasing in first-period's payoff. As a result, "the shadow of the future" may impede the possibilities for cooperation. In other words, competing agents engage more in appropriation in order to capture a bigger share of today's pie. The equilibrium solution concept we employ in this paper allows us to identify possible cooperative outcomes as a result of decentralized decision-making by rational and forward-looking agents, without having to rely on the Folk Theorem of repeated games or enforceable commitments.[1] Notice, moreover, that true dynamic situations are not "stationary". Thus, simple repetition of the one-shot game is quite unsatisfactory.

More recently, Maxwell and Reuveny (2005) construct a conflict model with two competing groups in which each group's population and a stock of common (natural) resources both change over time. They resort to numerical simulation, since three non-linear differential equations characterizing the dynamic paths of these stock variables impedes an analytical solution. These exercises reveal that *mild* appropriation activity depresses the use of natural resources for production, thus possibly creating a Pareto improvement compared to cooperative situations where there is no appropriation activity, and, moreover, tends to reduce the volatility of those stocks in the transition. Although their model generates interesting insights, they follow the earlier literature assuming myopic agents. Thus, the literature still misses a full dynamic and multi-period model of the Skaperdas–Hirshleifer based literature to analyze behavior of non-myopic agents who are taking into account the consequences of their future actions.[2] More recently, Hafer (2006) develops a large-population infinite-horizon dynamic game in which players are randomly matched in each period to play the war of attrition. She shows that although the distribution of types among the winners and losers changes with each round of conflict, in a steady state there is no conflict. Although the motivation is the same as ours, her main assumption in a war of attrition between two players is that there is only one, indivisible parcel of land. This assumption significantly distinguishes her model from the models of Skaperdas and Hirshleifer in which a prize is divisible and the war of attrition never takes place.

We develop a forward-looking agent-based infinite horizon, general-equilibrium model to study the dynamic evolution of self-enforcing property rights. There are various approaches to extending one-shot, static models of Skaperdas and Hirshleifer towards a dynamic setting, and we follow the existing contest models assuming that the initial resource endowment is fixed over time. The interpretation here is that there exists an initial time or labor endowment as a time or labor supply. The relevant state variable in our dynamic model is a durable stock which accumulates over time according to the production process which requires collective efforts of all parties involved. The durable stock is exhaustible or rival in the sense that one agent's use of the stock *does* diminish its availability to other agents. Each of the agents is tempted by the immediate benefit attainable from capturing the stock. All agents who succumb to the temptation reduce their help in production of the common-pool stock and increase their efforts to convert claims on the common stock into the effective property rights. Natural (renewable) resources such as fishes and forest, and land in primitive historical societies are examples of such durable stocks or disputed wealth. In history, people developed land through cooperative efforts, while they can also seize it from others. The stock of knowledge is another more modern example.

[1] According to the Folk Theorem any outcome that is feasible and individual rational could be realized as an equilibrium outcome in infinitely repeated games, given that players are sufficiently patient. Such multiplicity of equilibria would harm the predictability of the equilibrium outcome. We also note that cooperative behavior has been investigated based on non-Markovian trigger strategies (see, e.g., Benhabib and Radner, 1992; Dockner et al., 2000, Chap. 6) even in the literature on differential games, but we do not adopt this approach here.

[2] More recently, there is another class of dynamic conflict models that include Gradstein (2004),Gonzalez (2007), and Tornell and Lane (1999). There are several important differences between their models and ours. First, in their models a flow of the output produced each period is subject to predation, while in our model a stock variable is subject to predation. Secondly and more importantly, those papers investigate the relationship between conflict and economic growth in the standard growth model based explicitly on the investment and saving decisions of a large number of agents. Hence, their models are mostly concerned with the macroeconomic consequences, such as growth effects of insecure property rights. In contrast, our model is a straightforward dynamic extension of Grossman, Hershleifer and Skaperdas. Our approach allows for dynamic interaction among a small number of agents thereby allowing for a comparison of the results. The aim of this paper is to highlight the strategic role of appropriation among those few agents in the intertemporal context.