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Journal of Economic Theory 159 (2015) 401–442

JOURNAL OF
**Economic
Theory**

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Approximate implementation in Markovian environments [☆]

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Received 6 March 2014; final version received 26 June 2015; accepted 9 July 2015

Available online 20 July 2015

Abstract

This paper considers dynamic implementation problems in environments with changing private information (according to Markov processes). A social choice function is approximately implementable if it is correctly implemented an arbitrary large number of times with arbitrary high probability in all (communication) equilibria. We show that if a social choice function is strictly efficient in the set of social choice functions that satisfy an undetectability condition, then it is approximately implementable.

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JEL classification: C73; D82

Keywords: Implementation; Undetectability; Efficiency; Dynamic; Mechanism design; Markov processes

[☆] The authors thank Olivier Gossner, Johannes Hörner, Rene Saran, Juuso Toikka, and Nicolas Vieille for useful remarks and comments, as well as seminar participants at Yale, Brown, Princeton, IHP, SUTD, Manchester, the 24th Game Theory festival at Stony Brook, and the 13th SAET Conference. We are grateful to anonymous referees for perceptive comments. Ludovic Renou thanks the hospitality of the Cowles Foundation, where this project was completed. Tristan Tomala acknowledges the support of the HEC foundation and the Agence Nationale de la Recherche, under grant ANR JEUDY, ANR-10-BLAN 0112.

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1. Introduction

This paper introduces the concept of *approximate implementation* for dynamic implementation problems, a concept intermediate between partial implementation (mechanism design) and full implementation. A social choice function is *approximately implementable* if it is correctly implemented an arbitrary large number of times with arbitrary high probability in all (communication) equilibria. In other words, undesirable outcomes may be implemented in some periods, but those periods are quite rare.

The motivation is two-fold. On the one hand, a well-known problem with mechanism design is the multiplicity of equilibria. This problem is likely to be particularly severe in dynamic problems where agents can sustain a wide range of equilibrium outcomes through appropriate punishments and rewards, as the plethora of folk theorems demonstrates. On the other hand, full implementation does not suffer from the problem of multiplicity of equilibria (by its very definition), but often relies on “unnatural mechanisms” such as integer games, modulo games or sequences of dictatorships. Moreover, the monotonicity conditions for full implementation are often hard to check in concrete economic applications. The aim of this project is to retain as much as possible of the desirable properties of full implementation, while avoiding the less desirable properties such as “unnatural” mechanisms or hard-to-check monotonicity conditions.

It is important to stress that we focus on the implementation of outcomes, rather than payoffs. There are two important reasons why. First, implementing outcomes implies implementing payoff profiles, but the converse is not true. For a simple example, consider an allocation problem with quasi-linear preferences and transfers, and choose an efficient allocation. For any other allocation, we can find transfers that give the same expected payoff to all agents, but the allocation is clearly not the desired one. Second, we may want to incorporate additional considerations than payoffs in deciding what is socially desirable, e.g., fairness, equity, environmental concerns, well-being of as-yet unborn generations, etc.

The main result of the paper states that if a social choice function is *undetectable efficient*, then it is approximately implementable. A social choice function is undetectable efficient if for each reporting strategy profile that is “statistically indistinguishable” from truth-telling and yet does not implement the social choice function, there exists a whistle blower, i.e., an agent who strictly prefers truth-telling (and thus the implementation of the social choice function). In other words, the social choice function is strictly efficient in the set of functions that satisfies an undetectability condition. The condition of undetectable efficiency is weaker than the condition of efficiency; it makes it possible to implement a large set of social choice functions, not previously covered by the literature.¹ It is also easy to check. In particular, it is enough to check whether for each permutation of types other than the identity permutation (i.e., truth-telling), there is an agent who is strictly worse off. As an economic application, we consider a procurement problem with privately known costs of production. We show that one can implement the allocation that maximizes the consumer surplus at each cost profile, i.e., the most efficient firm produces the good at its marginal cost.

To prove our main result, we construct a “review” mechanism, where agents are asked to report their types and are periodically tested against what the designer would expect if the agents were truthful. Whenever an agent fails the test, the designer “punishes” the agent for a number of periods and the relationship resumes as normal afterwards. In particular, the mechanism has no

¹ An exception is [Matsushima et al. \(2010\)](#), who investigate the role of undetectability in linking mechanisms.

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