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# Taking turns

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ABSTRACT

Two individuals face a regular task that requires the effort of only one. They take turns but sometimes arrange to swap obligations. These swaps account for their changing, private costs. While seemingly primitive, flexible turn-taking is surprisingly efficient, even relative to what can be achieved by mechanisms using monetary transfers. I model and experimentally evaluate a simple form of flexible turn-taking and then present a second form that is both consistent with patterns of subject behavior and approximately second-best in a benchmark case.



## 1. Introduction

Turn-taking is a fundamental social behavior and a major developmental milestone for children (Sheridan et al., 2014). It has also been observed in animal species (Harcourt et al., 2010; Voelkl et al., 2015). Turn-taking is a fair and natural arrangement in settings where one individual's effort is needed to complete a regularly occurring and mutually beneficial task. Examples include a parent waking to calm a crying baby, a monitor keeping watch in a dangerous environment, or a doctor on-call for a late-night emergency.

Under stochastic, private costs, rote turn-taking can result in inefficient assignment. A flexible turn-taking arrangement, with the possibility of swapping turns, overcomes some of this inefficiency. I formalize,[1] a simple model of flexible turn-taking as a dynamic economic mechanism referred to as *recurring rotation*. A benefit of modeling this in the framework of mechanism design is that flexible turn-taking can be compared to alternative solutions. The result of this comparison is surprising. Despite its simplicity, recurring rotation achieves impressive efficiency even relative to what may be achieved in this environment by mechanisms that use monetary transfer. For instance, with uniformly distributed costs, recurring rotation captures about three-quarters of the achievable efficiency.[2] I present recurring rotation in section 2.

Peeling back the gentle exterior of this mechanism reveals a complex set of incentives. The theoretical properties presented here are the properties of this indirect mechanism *in equilibrium*. However, given the complexity, it is natural to ask whether the empirical properties are likely to match the theoretical properties.

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[1] Specifically, I model recurring rotation as a *Perfect Public Equilibrium* (*PPE*) of a repeated, private cost version of the volunteer's dilemma game (Diekmann, 1985).

[2] The robustness of the incentives in recurring rotation, which make it appropriate for an informal interpersonal environment, implies it is part of a particular subclass of *Perfect Public Equilibrium* (*PPE*) known as *Ex-post Incentive Compatible Perfect Public Equilibrium* or *EPPPE*, and first-best is not achievable by an *EPPPE* in the environment studied here (Miller, 2012).

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In section 3, I report the results of a laboratory experiment designed test the empirical properties and to evaluate actual behavior of subjects under the recurring rotation mechanism. Interestingly, although the mechanism achieved efficiency close to the theoretical prediction, subject behavior departed systematically from predictions. These patterns of unexpected behavior appear to arise from how subjects approach the decision problem induced by the incentives of the mechanism and cannot be explained by pro-social interest or strategic concerns. This lends to the possibility that the subjects used heuristics borrowed from their experience in turn-taking arrangements with a different structure.

In section 4, I present an alternative arrangement: *obligation takeover*. Obligation takeover permits a "debt" of turns where recurring rotation allows only delay. While more complex, obligation takeover retains a familiar structure, and the asymmetries in subject behavior that appear anomalous under recurring rotation are part of equilibrium behavior in obligation takeover. Furthermore, in the benchmark case of uniformly distributed costs, obligation takeover achieves second-best efficiency for perfectly patient players. In this case, no improvement is available from any mechanism appropriate for this environment, even those using monetary transfers. This may attest to the durability of flexible turn-taking as a social arrangement and suggests further study of the how these arrangements are commonly applied in real-world applications.

To my knowledge, this paper is the first formal study of flexible turn-taking. It may be understood as both a normative and a positive exposition of these institutions. The mechanisms in this paper may be thought of as abstract models of the kinds of flexible turn-taking arrangements people actually use. The results also permit normative conclusions; flexible turn-taking can provide a large amount of efficiency without the use of money, but the incentives underlying these mechanisms are remarkably complex, despite the familiar exterior.

This work is related to several areas of the mechanism design literature. In the area of robust mechanism design with transfers, Drexl and Kleiner (2015) and Shao and Zhou (2013) consider robust allocation of a valuable good in a one-shot environment with transfers, and construct optimal mechanisms. Athey and Miller (2007) consider a repeated trade setting and demonstrate that first-best efficiency can be achieved by robust mechanisms under relaxed budget balance conditions. Miller (2012) focuses on robust mechanisms for collusion of two firms in repeated settings with transfers. Like these papers, the mechanisms described here do not require a planner to enforce information structure. However, unlike in these, I explicitly analyze mechanisms where players do not use money transfers.

A procedure for constructing the set of payoffs achievable by robust mechanisms without money transfers in repeated environments is discussed in Miller (2012, p. 792) and is based on the tangent hyperplane method developed in Fudenberg et al. (1994). However, this exercise provides little insight into the potential structure of such mechanisms. A primary contribution of this paper is to show that substantial efficiency can be achieved by robust and familiar turn-taking mechanisms.

Several papers also characterize or explicitly construct mechanisms using only continuation transfers in repeated settings without money transfers, but without focusing on robust mechanisms. Athey and Bagwell (2001) consider a repeated Bertrand environment with discrete cost-types and demonstrate that first-best profits can be achieved by impatient firms without money transfers through the use of promises about future market-share. The conclusion of their paper discusses the potential extension to interpersonal relationships that are the focus of this paper. In contrast to Athey and Bagwell (2001) however, I focus on a characterizing simple, *robust* mechanisms, in an environment with a continuous type-space.

Several papers consider collusion in repeated auctions. Aoyagi (2003) considers repeated auctions with a type-space on the unit interval, and constructs highly efficient collusion mechanisms. However, these mechanisms require a coordinating institution. Blume and Heidhues (2008) and Skrzypacz and Hopenhayn (2004) also consider repeated auction environments, but where communication and monitoring are restricted.[3] Although the specifics of the environment are quite different, the mechanism for bid-rotation developed in Skrzypacz and Hopenhayn (2004) is similar to the *obligation takeover* mechanism. Although these papers provide a great deal of insight into the details of using continuation transfers to incentivize mechanisms, the specifics of the environments are quite different from those considered here.[4]

Mobius (2001) considers a model where two players can offer each-other "favors". A favor is an opportunity for one player to offer a fixed benefit of $b$ to another while incurring a fixed cost $c$. The ability for one player to offer the favor is privately known and arrives at random times. Lau (2011) extends the favor trading environment to random cost and benefits but with one-sided private information and comes closest in the favor-trading literature to the kind of private information in the present environment. In addition to these theoretic papers, Roy (2012) discusses an experimental implementation of the Mobius (2001) environment.

Though the type of private information is different from that considered here, the mechanism (Mobius, 2001) develops, the "chips" mechanism, is similar to the obligation takeover mechanism in terms of integer accounting of obligations. Hauser and Hopenhayn (2008) consider alternative versions with improved efficiency in the favor trading environment, and Abdulkadiroglu and Bagwell (2012) derive optimal chips mechanisms. Chips mechanisms are further studied by Olszewski and Safronov (2016) who demonstrate the efficiency of a class of these mechanisms in a more generalized environment. The results on the optimality of obligation takeover in this paper can be seen as extending this line of research on the efficiency chips-like mechanisms to instances where there is two-sided private information about costs and ex-post incentive compatibility is required.

[3] Blume and Heidhues (2006) study a scenario in which the information environment is limited to an extent that players must rely on private strategies (rather than the public strategies studied here and elsewhere in the repeated auction literature) to achieve improvements over competitive bidding.

[4] Similar to these papers in its use of auctions, Guo et al. (2009) develops a mechanism for repeated allocation without transfers using auctions of a fiat currency in a binary valuation environment.