Mobile Common Pool Resources – Heterogeneity of Marginal Productivity and Property Rights

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Introduction

The management of common-pool resources (CPRs) remains a key challenge for sustainable resource allocation. A particularly underexplored issue is the role of resource mobility and the heterogeneity of marginal productivity across resource patches. While previous studies have extensively examined CPR management in stationary settings, fewer have considered mobile CPRs (MCPRs), where resources migrate between different zones with asymmetric productivity levels. This study seeks to deepen the understanding of MCPR management by focusing on the allocation of property rights and the implications of productivity differences across patches.

Theoretical Benchmark

Our analysis is grounded in a discrete-time theoretical model in which a natural resource stock is distributed across a spatial domain divided into multiple patches. The stock dynamics in each patch are influenced by harvests, local growth, and resource dispersion between patches. We assume a linear growth function and analyze subgame perfect Nash equilibria using backward induction, comparing different ownership structures—single versus multiple owners per patch. Additionally, we explore the implications of cooperative and non-cooperative behavior among resource users. Analytical conditions are derived to characterize equilibrium strategies based on ecological parameters such as growth rates (α_i) and dispersion coefficients (D_{ij}), as well as the ownership structure. An efficient extraction path, which maximizes aggregate payoffs, serves as a benchmark for comparison.

Impact of Property Rights and Patch Productivity

A key area of investigation is the impact of property rights allocation, particularly in the presence of heterogeneous patch productivity, on management efficiency. One central hypothesis posits that when a high-productivity patch is managed by a single agent, the system is either more efficiently managed or exhibits no difference compared to when it is managed by two agents. This hypothesis accounts for both non-cooperative and locally cooperative interactions within the two-owner patch. The rationale is that intra-patch dilemmas among non-cooperative players in a high-productivity patch can lead to overexploitation, with spillover effects on neighboring patches due to resource mobility. However, if cooperation emerges between co-owners, the management outcome may resemble that of the single-owner case.

The theoretical analysis suggests that when marginal productivity is low in both patches ($D_{ii} \times (1 + \alpha_i) < 1$), the resource is depleted quickly regardless of ownership structure. Conversely, when marginal productivity is high in both patches ($D_{ii} \times (1 + \alpha_i) > 1$), conservation until the final period can be optimal. The most interesting case arises when marginal productivity differs between patches.

For instance, a single owner managing both a high- and a low-productivity patch may conserve the resource in the low-productivity patch, depending on dispersal parameters. In contrast, non-cooperative co-owners are more likely to extract from the low-productivity patch earlier, leading to inefficiencies in resource conservation. One of our theoretical predictions suggests that MCPRs are managed less efficiently in a given patch when a neighboring patch is co-managed by multiple agents rather than a single agent.

Hypotheses

Based on these theoretical predictions, we formulate the following hypotheses:

- **H1**: In patches with higher productivity, participants will delay extraction compared to lower-productivity patches, maximizing long-term yields.

- **H2**: Individual ownership of a patch will lead to more strategic resource conservation compared to collective ownership, where coordination failures may emerge.

Experimental Design

To test these hypotheses, we design a laboratory experiment to analyze decision-making in a dynamic MCPR setting. Participants engage in a game where they manage renewable resources across two patches (A and B), which differ in their marginal productivity. In one treatment, Patch A exhibits higher productivity than Patch B, while in another, the productivity distribution is reversed. Resource stocks evolve dynamically through a structured process involving harvesting, growth, and migration between patches. Participants make sequential harvesting decisions in groups of three, where one participant manages Patch A (single-owner condition), and two participants jointly manage Patch B (co-managed condition).

Results and Policy Implications

The experiment was conducted in June 2024, with a total of 273 subjects. There were 51 groups in treatment *Ah* (high productivity in Patch A) and 40 groups in treatment *Bh* (high productivity in Patch B). Results indicate significant differences in extraction behavior depending on patch productivity and ownership structure.

Our findings provide policy-relevant insights, particularly for designing governance mechanisms in sectors such as fisheries, forestry, and land use management.