



# The effects of market structure on industry growth: Rivalrous non-excludable capital

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## Abstract

We analyze imperfect competition in dynamic environments where firms use rivalrous but non-excludable industry-specific capital that is provided exogenously. Capital depreciation depends on utilization, so firms influence the evolution of the capital equipment through more or less intensive supply in the final-goods market. Strategic incentives stem from, (i) a dynamic externality, arising due to the non-excludability of the capital stock, leading firms to compete for its use (rivalry), and, (ii) a market externality, leading to the classic Cournot-type supply competition. Comparing alternative market structures, we isolate the effect of these externalities on strategies and industry growth.

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## 1. Introduction

The role of capital deepening on economic growth is usually studied through highly aggregated growth models. In these models, typically focusing on the macroeconomy, perfect competition is the prevailing market structure. Yet, little attention has been paid to the forces and incentives behind capital deepening and growth in smaller markets, like industries.

In a significant number of industries firms sell their final products in imperfectly competitive markets. Classic Cournot-type oligopolistic incentives arise in such industries. Yet, whenever specific capital is useful for production, each firm's intertemporal capital allocation is

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an additional strategic lever, apart from its supply strategy. By accumulating capital, a firm can use its productive capacity to affect its oligopolistic competitiveness and profit margin over time.

We focus on industries with production that relies on the use of a specific type of capital, infrastructure, specific equipment, or a natural resource, which is provided exogenously. Capital in our analysis is non-excludable, it can be used at no cost by all firms, and also rivalrous, subject to a first-come first-served rule or to congestion costs. Moreover, capital in our study depreciates with utilization. Thus, higher aggregate production in the industry today implies lower capital in the future.

The key to understanding the link between market structure and industry dynamics in such an environment is to analyze the fundamental strategic incentives that arise, (i) from the interaction of firms in the market for the final good, a *market externality* among firms, and (ii) from the interaction of firms in the process that determines future capital deepening, a *dynamic externality* among firms.<sup>1</sup> To isolate the impact of each externality on aggregate industry production, and hence, industry growth, we build a parametric model that allows us to encompass four market structures, namely, (a) a single-firm monopolistic industry, (b) an industry with two monopolists selling the final product in their own separate markets but utilizing capital from the same provider, (c) a duopoly with firms selling in the same market and utilizing capital from the same provider, and (d) a duopoly with firms utilizing capital from separate providers.

The nature of the two externalities brings significant technical complexities into the dynamic problem faced by each firm in such non-cooperative games. The presence of these externalities in the dynamic game makes the strategies of competitors part of the structural maximization problem of a firm. In order that the problem of each firm be well-defined, the primitives of the model should imply that the equilibrium strategies possess convenient functional properties. So, we model the economic environment to obtain linear equilibrium strategies that make the analysis tractable. In order to accomplish this we use homogeneous or isoelastic functions to capture consumer demand and the primitives of firms. Our parametric model is essentially an extension of the example of Levhari and Mirman [8], that is designed to accommodate the market externality, as well as the dynamic externality.

In a fashion similar to Levhari and Mirman [8], a comparison of market structure (a) with (b) reveals the impact of the dynamic externality. Our results suggest the dominance of a commons problem, i.e. more firms induce higher aggregate supply and lower growth.<sup>2</sup> The comparison of (a) with (c), and of (b) with (c), reveal the impact of the market externality in addition to the dynamic externality, the core contribution of this paper.<sup>3</sup> Compared to the benchmark monopoly, we find that the aggregate supply of firms in each period is always higher. But compared to the market structure of two monopolists with common capital utilization, the impact depends on the model's primitives. We find that below a threshold level for the demand elasticity (depending only on the number of firms in the market), the aggregate supply of firms increases compared to the structure of two monopolists. When the demand elasticity is higher than that

<sup>1</sup> The terms “dynamic externality” and “market externality” were coined by Mirman [9], who pointed out the distinction of the two effects in the necessary conditions of a general framework of fishing games.

<sup>2</sup> See, for example, Mirman [9], Levhari and Mirman [8], who were the first to analyze the commons problem using non-cooperative dynamic games, and also Amir [1], Sundaram [11], Benhabib and Radner [2], Dutta and Sundaram [3,4], and Sorger [10], who apply their analysis to natural-resource games, focusing mostly on the commons problem.

<sup>3</sup> To our knowledge, the economic impact of the market externality on final good supply strategies in such a dynamic environment has not been studied before.

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