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Unilateral production restrictions in a dynamic duopoly

Hassan Benchekroun

Department of Economics, McGill University, 855 Sherbrooke Street West, Montreal, QC, Canada H3A-2T7

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Abstract

This paper examines a dynamic game of exploitation of a productive asset by a duopoly. A closed-loop Nash equilibrium of the game is constructed and used to analyze the effects of a unilateral production restriction. Surprisingly, such unilateral action may result in a decrease of the long-run asset's stock. We also exhibit production restrictions that can result *simultaneously* in an increase of the asset's stock *and* the long-run profits of the firm that is being imposed the production restriction. Moreover, a unilateral decrease of the production of one firm can induce its rival to also decrease its production.

JEL classification: C73; D43; L13

Keywords: Unilateral restriction; Dynamic game; Duopoly

1. Introduction

When several countries share access to a productive asset, agreements upon the exploitation of the asset are very hard to reach. If for example one of the countries that share access to the asset wants the level of the asset's stock to increase, it has to make the overall exploitation of all countries decrease. Convincing the other countries to limit their exploitation is often hard to achieve. If no agreement can be reached, this country can only consider unilateral production restrictions. A unilateral production restriction is a reduction in production adopted by a single country and affecting its domestic firms only. This paper studies the effects of a

E-mail address: hassan.benchekroun@mcgill.ca.

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unilateral restriction on the exploitation of a productive asset. More specifically, we determine the effect of such a policy on the stock of the asset as well as on the profits of the firms that are subject to the production restriction. We first determine the effect of a simple production restraint where the amount by which a firm is required to reduce its production is fixed. We then determine the effects of more general restrictions under which the production reduction at each moment depends on the asset's stock available at that moment.

Surprisingly, it is shown that a production restriction that reduces by a fixed amount (that does not depend neither on time nor on the level of the asset's stock) the production of the domestic firm may result in a decrease in the asset's stock at the steady state. This remains true even for more general production restrictions for which the amount by which the domestic firm is required to reduce its production varies with the asset's stock. On the other hand, we exhibit a class of production restrictions that can result *simultaneously* in an increase of the long-run asset's stock *and* in an increase of the domestic firm's profits. Moreover, it is shown that under this latter class of production restrictions a unilateral decrease of the production of one firm can induce its rival to decrease its own production, though firms' outputs are perfect substitutes. These effects are in sharp contrast with the predictions based on a static framework. In a static duopoly, when firms' outputs are strategic substitutes, reducing the production of one firm only results unambiguously in a decrease of this firm's profits (see [14]) as well as in an increase in its rival's production (see [2]).

To conduct our study we use a differential game framework (see [7]). We focus on closed-loop strategies: the strategy of a firm is a production rule that can depend both on time and on the asset's stock.[1]

The differential game framework has been very successfully used to study the exploitation of a productive asset. In a discrete time framework,[2] Levhari and Mirman [15] showed that in the case of two countries sharing access to a fish stock, the outcome of a closed-loop Nash equilibrium is over-exploitation of the resource. Benhabib and Radner [1] showed that these games may admit efficient as well as inefficient equilibria. They showed that when firms can adopt strategies that allow credible threats of punishment in case "cheating" occurs, then, the first-best equilibrium can be enforced. Dutta and Sundaram [10] showed that when two agents share access to a productive asset there exist an infinite number of closed-loop Nash equilibria, under which the equilibrium production path exhibits a very regular behavior. They derive sufficient conditions under which these equilibria result in over-exploitation of the asset. Dutta and Sundaram [11] shows that for a finite time horizon the game of joint exploitation of a productive asset in a non-cooperative behavior might not admit closed-loop Nash equilibria and when equilibria exist the asset's stock can have very complex or "non-intuitive" paths. They also showed that in the case of an infinite time horizon and when future utility is not discounted over-

[1] Open-loop strategies, where the production of a firm depends on time only, are inappropriate for studying a game of exploitation of an asset under common property (see [12] or [4]).

[2] Discrete time differential games are often referred to as difference games.