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Interactive dynamics between natural and man-made assets: The impact of external shocks ☆

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ABSTRACT

This paper studies a two-sector economy in which one of the sectors (the "commodity sector") depends in part on the exploitation of a renewable natural resource and examines the issue in an economy-wide context where both natural resources and a man-made asset change endogenously over time. We show that under an open access resource regime: i) a resource-rich, capital-poor economy may experience a "natural resource curse" phase and under certain conditions, may even follow a non-sustainable path leading to complete natural resource depletion; ii) a labor inflow results in a *higher* steady-state per capita income, with unchanged natural resources, though it makes the economy more prone to reach a path that converges to resource collapse; iii) the introduction of a small import tariff or export tax results in larger steady-state natural resources and commodity output and renders the economy less vulnerable to resource collapse. We also contrast the open access case with the other polar case of perfect property rights, showing that in this case the economy experiences neither a resource curse nor a resource collapse.

1. Introduction

Many developing countries obtain a large share of their income from the exploitation of common-property renewable natural resources, including fisheries, forests, grazing grounds, and water resources (Larson and Nash, 2010). The degradation of natural resources has typically been associated with activities such as agriculture, fisheries, logging, and several others (López, 2010). Natural resource degradation has also been associated with the process of extraction of exhaustible resources. For instance, it is estimated that nearly one third of all active mines and exploration sites are located within areas of ecosystems of high conservation value (Miranda et al., 2003); mining and oil extraction has led to the depletion of water supplies, water contamination, deforestation, and more. Lack of property rights to natural resources generates negative externalities, resulting in excessive use of labor and other variable factors as compared with the social optimum, and thus in a higher rate of natural resources depletion and a smaller long-run or steady-state natural resource stock, and in some cases in its total depletion.

López (1998b) estimates the losses from non-cooperative behavior on common-property lands and lack of internalization of the external costs of biomass use in land allocation decisions in Côte d'Ivoire to be as high as 14 percent of the total village income. He finds that the degree of internalization of the negative externalities is less than 30 percent and declines with community size. López (1997a) obtains similar estimates for the income loss in Ghana. These and other studies make it clear that the problem of imperfect property rights is of crucial importance for many countries (Barbier, 2005).

A large number of studies have examined communities that had been stable for long periods but then started a process of impoverishment that worsened over time (López, 1998a; Pearce, 2005). These communities typically experienced important changes over time – such as an increase in community size, in market size for their output (and increase in its price), or in labor mobility – but failed to develop adequate institutions to deal with them. This resulted in a decline in the degree of internalization of the negative externalities and led to increased pressure on renewable resources. Often located in tropical areas, land quality in such communities has typically been poor, with natural resource depletion impeding regeneration of soil fertility. This has led to further decline in soil quality by hampering nutrients deeper in the soil to rise to the surface. The ensuing deforestation has, in extreme cases, led to the disappearance of entire communities. For instance, deforestation in low-lying areas in the Philippines has led in recent years to the movement of some four million people from low-lying to high-lying areas (Washington Post, February 23, 2009,

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pp. 1–2). The classic case of natural resource depletion is that of fisheries. The depletion of fisheries has affected a large number of countries over time and early studies of natural resource depletion focused on this issue (e.g., Gordon, 1954; Scott, 1955).[1]

This paper examines the welfare consequences of commodity production under lack of property rights for natural resources. In general, most renewable natural resources of great economic importance are inherently open access. The fact that the resource-dependent sector is typically composed of many small producers makes it almost impossible to regulate. Also, as Partha Dasgupta has often emphasized, the fact that most natural resources such as animals, insects, rivers, ground water, fish resources and the atmosphere are often mobile renders it almost impossible to establish or enforce property rights (Dasgupta, 2005).[2] This justifies our maintained assumption of open access resource exploitation throughout most of the text. However, for the sake of completeness, we do compare some of our results for the open access case with a benchmark case of perfect property rights.

The present study considers the impact of important shocks that often affect developing countries, including reduction in trade barriers and labor migration. Unlike most previous studies that are based on static equilibrium analysis, allowing only for endogenous changes of the renewable natural resources, we focus on the dynamics of the economy's adjustment, explicitly allowing endogenous changes not only in natural resources but also in man-made assets ("capital"). We consider a multi-sector economy where one of the productive sectors, the primary commodity-producing sector, is directly dependent on renewable natural resources. The economy uses three assets, labor, capital and the renewable natural resource. The first two are allocated competitively across the various sectors while the natural resource stock is exclusively used in the commodity-producing sector. The economy can save and invest such savings in expanding the stock of man-made capital. We highlight the interactive dynamics of two assets, natural capital and man-made capital, as a key factor determining the nature of economic development.

The links between trade and the environment have received great attention in the literature.[3] A common argument is that international trade may exacerbate environmental externalities and result in welfare losses in (developing) countries where imperfect property rights prevent the internalization of such externalities. Early studies focused on the long-run equilibrium effects of trade, using static models that assume a constant stock of both natural resources and man-made capital, thus neglecting any dynamic adjustment to changes in the trade regime (Chichilnisky, 1994). More recent literature has continued to focus on long-run equilibrium but has explicitly recognized that the underlying natural resource stocks do change over time (Brander and Taylor, 1998; Copeland and Taylor, 1994; Jinji, 2006; Smulders et al., 2004).

We are not aware of any study that considers the dynamic adjustment to external shocks and allows for dynamic adjustments of both natural and man-made assets. This is a significant problem, because changes in investment in man-made assets are likely to be an important component of the response to external shocks and because the evolution of the natural resource may be heavily dependent on the changes in man-made assets. In addition, the fact that shocks occur frequently and that the economy rarely has time to reach its long-run equilibrium but rather tends to adjust to the various shocks when in a disequilibrium situation, renders the analysis under disequilibrium highly relevant. In fact, as the analysis in this paper reveals, incorporating the dynamic interaction of natural and man-made assets leads to potential outcomes that are not obtainable with the above-mentioned models, including some rather unexpected results.

This paper also links to the vast literature on the so-called "resource curse" which emphasizes the fact that many resource-rich low income countries tend to experience low or even negative growth rates (Sachs and Warner, 1995, 2001). As shown by Barbier (2005) and, more recently, by the comprehensive survey by Frankel (2010), this literature explains the resource curse by using a variety of super-imposed special assumptions regarding governance, political conditions, social conflicts, Dutch disease and many others. We show that the resource curse is inherent to the out-of-steady state dynamics of a resource-rich economy, and it cannot be satisfactorily explained by models that focus only on long-run equilibrium or in the neighborhood of the steady state. Our analysis of the out-of-steady state dynamics allows us to uncover a mechanism that causes resource curse for a poor and resource-rich economy arising naturally from the fundamental neoclassical growth model without requiring any other super-imposed assumptions.

This paper is a first effort to fill these important gaps in the literature. We examine out-of-steady-state adjustments to changes in policy as well as their impact on the steady state, explicitly recognizing the interactive dynamics between man-made and natural assets. An analysis that emphasizes conditions outside the long-run equilibrium in a context of two state variables (physical capital and natural resources) can be exceedingly complex. In order to keep the problem tractable, we provide a basic dynamic model with the minimum level of complexity needed to yield important insights on the behavior of the economy when subjected to a variety of shocks.

The remainder of the paper is organized as follows. Part II presents the benchmark model, Part III looks at the transition path of a resource-rich, capital-poor economy, and Part IV examines the impact of trade and factor movement policies. Part V concludes.

2. The model

The economy consists of two sectors, a resource-dependent commodity sector and the rest of the economy (encompassing mainly services and manufacturing), which we henceforth call "the manufacturing sector", that does not depend on the natural resource as an input. Each sector uses labor (l) and capital (k). The commodity sector also uses a renewable natural resource input, n, in addition to capital and labor. The production functions are:

$$y_s = Ak_s^{\alpha} l_s^{1-\alpha} \tag{1}$$

$$y_c = nDk_c^{\beta} l_c^{1-\beta} \tag{2}$$

where y_s and y_c are the output levels of the manufacturing and commodity goods, respectively ($0 < \alpha < 1$, $0 < \beta < 1$) and A and D are fixed parameters reflecting total factor productivity (*TFP*) in each industry. The natural resource enters the production of the commodity (Eq. (2)) in the way it is conventionally done in the literature (Copeland and Taylor, 1994; Gordon, 1954; Schaefer, 1957).

We assume that the manufacturing sector is more capital intensive than the rural commodity sector, i.e., we assume that $\alpha > \beta$. This assumption is likely to be valid for most poor countries where resource extraction is comprised mainly of semi-subsistence activities.

[1] An example of such depletion is Peruvian anchovies whose world price increased dramatically in the late 1970s and early 1980s. This raised the incentive to invest in fishing boats. Moreover, the government of Peru subsidized investment in these boats when imposing a tax would have been optimal. The higher prices as well as the subsidies led to a dramatic increase in the fishing fleet. The result was that the stock of anchovies disappeared for several years, leading to a decline in the use of these boats and thus in fishing. This enabled the anchovy stock to replenish over time.

[2] Two studies in Sub-Saharan Africa have empirically shown that even in cases where resources are not mobile (such as forests and woodlands) and are used by a restricted number of producers, the management of these resources appears to reflect the internalization of only a negligible fraction of their true economic value (López, 1997, 1998b). Common property in these cases is indistinguishable from open access from the point of view of resource management.

[3] For a good review and analysis of trade's environmental impact, see Copeland and Gulati (2006).