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How could the non-sustainable Easter Island have been sustained?☆

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ABSTRACT

The collapsing scenario of Easter Island has been analyzed by Brander and Taylor (1998) as a predator–prey model in a Malthusian world, in which the household is only concerned with its instantaneous utility. This paper develops an endogenous growth model with a renewable resource and analyzes the possibly non-sustainable growth as a steady state, in spite of the household being deeply concerned with all its future lifetime utility. Our analysis shows that the ignorance of future lifetimes in present decision-making is indeed crucial to economic non-sustainability. We then examine whether a deforestation tax set by the government could have reduced the resource exploration rate and thereby held back the economic collapse. We also demonstrate using phase-diagrams how such a tax can switch the economic dynamics from non-sustainability to sustainability.

1. Introduction

In history, many human societies have either collapsed or vanished; examples include the Maya cities in Central America, Angkor Wat in Asia and Easter Island in the Pacific Ocean, all of which have left behind monumental ruins. The scales of such ruins testify to the wealth and power of the dwellers in these societies. The story of Easter Island as described by Brander and Taylor (1998) and Diamond (2005) is perhaps the most vivid example, and we shall only briefly describe it as we introduce the motivation underlying our modeling.

1.1. The Brander & Taylor model of Easter Island

Easter Island is a small Pacific island covering an area of 66 square miles. The nearest land is 2300 miles away on the coast of Chile. The most visible evidence of a previous culture on Easter Island is its giant stone statues and the stone platforms on which they are placed. Since the carving, transportation, and erection of such statues would have required tremendous labor input and a lot of trees (to roll and move the statues), it is suggested that Easter Island would have been a complex populous society living in an environment rich enough so that meeting subsistence requirements would have been relatively easy, leaving ample time to devote

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to other activities. However, the population was estimated to be only about 3000 when encountered by European visitors in 1722, and the island had been found to be treeless. The question is: why would a once mighty society with an abundance of forests end up collapsing?

Brander and Taylor (1998) were the first to propose a formal model explaining the process of such a collapse. They set up a predator–prey model with man as the predator and the forest as the prey, and analyzed the population-resource dynamics under different parametric specifications. The Easter Island story is a typical example of non-sustainable growth, and the model of Brander and Taylor is a classic one with Malthusian population checks. The purpose of this paper is to propose a variant model that is more compatible with the sustainability problem we face today. We explain the detailed differences below.

1.2. Special features of our model

The first feature we embody in our model is the role of *future lifetimes*. As pointed out in the Brundtland Report (WCED, 1987), Ekin (1994) and Chichilnisky, Heal, and Vercelli (1998), the concern for the well-being of future lifetimes, particularly in so far as this is affected by their access to natural resources and environmental goods, is the key to the discussion of sustainability. In the typical Malthusian model à la Brander and Taylor (1998) and the literature that follows, agents are often assumed to have a temporal utility of their own consumption, and they do not care about their future lifetimes. This setting of short-sighted agents will arguably more easily lead to the possible collapse of the economy, because sustainability by definition refers to the perpetuation of economic activities for all infinite future time. As such, the more intriguing case, as in the discussion in most of the contemporary literature on economic sustainability, is to assume that agents are deeply concerned with all their future time.

The problem of non-sustainability in this short-sighted agent context is more interesting because one has to explain why the short-sighted decision may not be enough to prevent the disaster that will befall their future lifetimes. Put differently, as Martinez-Alier and O'Connor (1999) pointed out, in the discussion on sustainability, the ignorance of future lifetimes may be the cause of the economic collapse. We believe that meaningful economic policies can be proposed only when we explicitly embody the conflicts between a single time period and all lifetimes in our model.

The second feature we consider modifying in our model is the definition of sustainability. The definition of collapse in Brander and Taylor (1998) is related to the reduction in population size and the depletion of forest resources. The typical definition in the modern sustainability literature often refers to the constraint whereby the instantaneous utility should not compromise the utility of future lifetimes; see, e.g., Chichilnisky (1996), Pearce (1998), and Chichilnisky et al. (1998). If we are to consider the conflict between the single period and all future lifetimes, we should explicitly include the role of physical capital in our model since physical capital reflects a tradeoff of natural resources between preservation and utilization. However, physical capital accumulation is typically not included in a Malthusian model of population dynamics (Chu, 1998).

The third feature we would like to study in our model is related to several fundamental questions concerning the dynamics of an *unsustainable equilibrium*. Suppose agents have perfect foresight and are deeply concerned with all their future lifetimes. Then, at each time point t, we can calculate the discounted present value of their future utility. Let this present value be v_t. Following our discussion of the second feature above, a non-sustainable state suggests a decreasing pattern of v_t with respect to t. Growth theory should provide answers to the following four questions: 1) Will this v_t converge to a collapsing state when t goes to infinity? 2) If it does converge to a collapsing state v, why would the agents *choose* an optimal consumption and saving path that converges to this non-sustainable state? 3) What rectification policy can the government adopt to prevent this from happening? 4) Along the lines of Laitner (1990), what is the phase-diagram if a policy changes a steady state from a non-sustainable state to a sustainable one?

As we suggested in the second and third features above, a path of economic growth may be unsustainable when the agents choose a very high resource depletion rate. We want to analyze when this is more likely to happen and whether this *laissez faire* state can be suppressed by a government policy. When we analyze this problem, what we have in mind is actually an *endogenous growth* model, which is typically different from the growth models that were used to study the Malthusian scenario for Easter Island. In a Malthusian model, the steady-state growth rate is zero and thus this structure can only deal with the *level* change in economic variables. Nevertheless, our endogenous growth model exhibits a non-zero steady-state growth rate in which agents' behavior is based on their optimal choice. In view of this, we can present the *rate* change of economic variables. We believe that this endogenous growth setup is a framework that is more consistent with the sustainability problem that we face today.

1.3. Previous literature

Several papers have tried to modify the Brander and Taylor (1998) paper along different directions. Reuveny and Decker (2000) incorporate the possibility of technological progress and population management into the Brander and Taylor model, and show that the fate of collapse might have been averted. However, this paper does not have physical capital accumulation, neither are there present agents' concerns of all their future lifetimes. Dalton, Coats, and Asrabadi (2005) assume that the agents' use of resources may be slower when they foresee resource depletion as a future trend. They show that when this institutional mechanism is added to the Brander–Taylor model, the feast-and-famine cycle in Easter Island may be dampened.

Erickson and Gowdy (2000) consider the accumulation of some kind of physical capital other than natural resources, and allow for their substitutability in production. However, their model still does not have endogenous growth. Finally, Pezzey and Anderies (2003) add a constraint to the minimum subsistence level of resource consumption and some institutional adaptations. They analyze the changes in equilibrium and overshoot in response to such adaptations. Again, they do not address the features we mentioned in the previous subsection.