The genuine savings criterion
and the value of population

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Summary. In any dynamic model of the economy with changing population, the latter should properly be one of the state variables of the system. It enters both in the maximand, at least under total utilitarianism, and into the production function in one way or another. If population growth is exponential and constant returns prevail, then a simple transformation to per capita variables can be used to eliminate one state variable, but this ceases to be true if growth is not exponential, as it obviously is not and cannot be. If the growth of population is exogenous, then introducing it into the system does not affect the optimal policy. However, if one asks whether the system is sustainable, in the sense of at least maintaining total welfare (integral of discounted utilities), then the criterion is that the value of the rates of change of the state variables is non-negative, so that the shadow price of population becomes relevant. In this paper, we derive explicit formulas in a simple model, showing that the rate of growth of per capita capital is not the correct formula but must have another term added to it. We also study the question under an alternative criterion of long-run average utilitarianism.

Keywords and Phrases: Optimal control, Population, Genuine savings, Accounting prices.

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The idea of systematic planning for the future (whether by individual economic agents or by the collectivity) was implicit in economic theory since the latter nineteenth century. It had been given more explicit though still not very usable form in the 1930s with the work of Lindahl (1929, 1939) and Hicks (1939). But dynamic planning became a practical possibility with the nearly contemporaneous work of two mathematicians, Bellman on dynamic programming (1957) and Pontryagin and associates on optimal control theory (1962). The two approaches are equivalent; each has technical advantages and disadvantages of its own. However, in many ways, the formulations of optimal control theory are closer to standard economic thinking, and it has been the preferred approach, particularly in theoretical work.

Optimal control theory started being applied by economists fairly soon after being published in book form. One of the earliest applications was the work of Kenneth J. Arrow and Mordecai Kurz (1970). It discussed the criteria for optimal public investment policy using the tools of optimal control theory to clarify much of the existing literature and to introduce new concepts. The present paper continues the intellectual impetus of the Arrow–Kurz book and brings some new considerations to bear.

1 Introduction

We deal with a set of ideas with regard to control of the economy. Much of the stimulus has come from an increasing attention to the role of the environment and ecological factors in general. The importance of these factors is given recognition by arguing that there are many forms of capital supplied by nature beyond the reproducible capital usually emphasized in growth models.

Two traditions are drawn on, though our conclusions go beyond those in the literature. One is the study of the criteria for evaluating policies when population is varying. The other is the question, whether and what extent a given policy is causing a gain in aggregate welfare, what has come to be called measurement of genuine savings. These have been two fundamental approaches in the study of sustainability. We argue that the only consistent approach is to recognize population as another form of capital (state variable); this does not exclude a priori its having a negative value, as many have argued. This will hold even if we do not consider population policy and regard the evolution of population as exogenous to the economic and policy variables. The main aim of the paper is to derive the accounting price for population (costate variable).