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METHODS

Ecological pricing and transformity: A solution method for systems rarely at general equilibrium

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Abstract

This paper outlines a new method for determining ecological prices/transformities in complicated ecological–economic systems where non-equilibrium prices are likely to be prevalent. That is, an eigenvalue–eigenvector mathematical solution method for solving an overdetermined, homogeneous system of simultaneous linear equations is proposed and tested. Previous mathematical approaches to the problem of ecological pricing are reviewed before proceeding with an explanation of the new solution method for the determination of ecological prices. The proposed method seeks to avoid the need to make a number of untenable assumptions used in previous methods—e.g., the assumption that there necessarily needs to be an equal number of processes and quantities in the ecological–economic system. The paper also provides practical advice and an algorithm for solving the ecological pricing problem. For example, advice on how to overcome the problem of ill-conditioned matrices which are sometimes encountered.

Keywords: Ecological prices; Transformity; Sraffa; General equilibrium; Mathematical models

1. Introduction

Price theory and underpinning theories of value form the theoretical core of every major body of economic theory. Argumentations and tensions between different schools of economic thought are often based on fundamental disagreements on price (value) theory (Cole et al., 1991).

The dominant price theory in contemporary economics is neoclassical price theory. It is essentially based on the idea of subjective preference whereby the consumer (or producer) subjectively ascribes an exchange value for each commodity. From this basis,

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an equilibrium price for a commodity is determined where the demand and supply curves intersect at a point where marginal utility and marginal cost are equalised. General equilibrium theory demonstrates that when this equilibrium point is achieved across all commodities, then social welfare (economic efficiency) is maximised (Debreu, 1958).

Despite the hegemony of neoclassical price theory, other price theories have been advanced in Economics, notably from Marxist and Neo-Ricardian perspectives. Sraffa's (1960) Neo-Ricardian methodology of price determination provided the strongest challenge to the Neo-classical approach, both in terms of its mathematical rigour and philosophical cohesion. The Sraffa (1960) model not only provides a cogent model of price determination, but it explicitly models the link between price determination and income distribution. Passenti (1976) argued that the Sraffian model falls within von Neumann's (1946) general equilibrium framework of price determination, although the Sraffa (1960) model invokes more economic detail than von Neumann's (1946) more abstract mathematical model.

The mathematical basis to the Sraffa–von Neumann model is the solution of a system of simultaneous linear equations that describe the inputs/outputs of various sectors (processes) in the economy. The solution of these equations yields an uniquely determined vector of prices for each commodity in the system. The prices are expressed in terms of multiples of a selected numeraire-commodity. The Sraffa–von Neumann model is an equilibrium model generating equilibrium prices, as the equation structure only permits equal 'interest' rates (efficiencies) for each process.

Recently, Ecological Economists such as Judson (1989), Mayumi (1999) and Patterson (1998, 2002) have begun to advocate the application of the Sraffian method to the valuation of ecological processes and services. The motivation for using the Sraffa-type method of price determination lies in the perceived shortcomings of Neoclassical subjective preference methods, as is discussed in detail by Lockwood (1997) and Stirling (1997). In particular, it has been shown that the Neo-classical approach systematically undervalues or ignores some species and ecological processes, as the approach is dependent on human valuers who have imperfect knowledge of ecological matters. Instead, the Sraffa-type method objectively measures the flow of mass and energy between species, as an indicator of the interdependencies between species. This then becomes the basis for objectively measuring the contributory value of species, in terms of how one species contributes to the value (livelihood) of other species.

Odum (1996) has developed a method very similar to ecological pricing that aims to measure the value of different forms of energy in terms of their *transformity*. That is, in terms of how efficiently one form of energy can be transformed into another form of energy—e.g., how much solar energy it takes to produce 1 joule of electricity. The ecological pricing and the transformity methods are similar because:

- Both methods imply 'prices/transformities' based on data about the transformation of energy/mass in complex systems. The only difference is that transformities only focus on energy transformations, whereas ecological pricing focuses on both energy and mass transformations.
- Both methods because of their focus on physical transformations, do not depend on subjective preference methods of valuation. This makes both methods particularly well suited to the valuation of natural ecological processes that are difficult to undertake by using methods such as contingent valuation which are based on subjective preference ideas.

Sraffian–von Neumann price determination depends on stylised mathematics, which doesn't always adequately deal with the complexities of ecological–economic systems. The Sraffian model for example: (1) assumes determinacy (equal number of processes and quantities) and equilibrium conditions; (2) as pointed out by Patterson (1998), is often inconsistent with biophysical principles such as energy and mass conservation. The von Neumann model deals with overdeterminacy (more processes than quantities), by assuming the system is self-optimising and hence eliminates inefficient processes in order to reach determinacy. The theoretical justification for these types of limiting assumptions, which are further discussed in Section 2, is often weak (Schefold, 1978, 1989; Patterson, 1998, 2002).

The purpose of this paper is therefore to put forward a more rigorous solution for the Sraffian–