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ANALYSIS

Is neoclassical microeconomics formally valid? An approach based on an analogy with equilibrium thermodynamics

Tânia Sousa *, Tiago Domingos

Environment and Energy Section, DEM, Instituto Superior Técnico, Avenida Rovisco Pais, 1, 1049-001 Lisboa, Portugal

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Abstract

The relation between Thermodynamics and Economics is a paramount issue in Ecological Economics. Two different levels can be distinguished when discussing it: formal and substantive. At the formal level, a mathematical framework is used to describe both thermodynamic and economic systems. At the substantive level, thermodynamic laws are applied to economic processes.

In Ecological Economics, there is a widespread claim that neoclassical economics has the same mathematical formulation as classical mechanics and is therefore fundamentally flawed because: 1) utility does not obey a conservation law as energy does; 2) an equilibrium theory cannot be used to study irreversible processes. Here, we show that neoclassical economics is based on a wrong formulation of classical mechanics, being in fact formally analogous to equilibrium thermodynamics. The similarity between both formalisms, namely that they are both cases of constrained optimisation, is easily perceived when thermodynamics is looked upon using the Tisza–Callen axiomatisation. In this paper, we take the formal analogy between equilibrium thermodynamics and economic systems far enough to answer the formal criticisms, proving that the formalism of neoclassical economics has irreversibility embedded in it.

However, the formal similarity between equilibrium thermodynamics and neoclassical microeconomics does not mean that economic models are in accordance with mass, energy and entropy balance equations. In fact, neoclassical theory suffers from flaws in the substantive integration with thermodynamic laws as has already been fully demonstrated by valuable work done by ecological economists in this field.

Keywords: Thermodynamics; Entropy; Neoclassical economics; Analogy and irreversibility

1. Introduction

The relation between Thermodynamics and Economics is a paramount issue in Ecological Economics. Two different levels can be distinguished when discussing it: formal and substantive.

* Corresponding author. Tel.: +351 218419290; fax: +351 218417365.
E-mail address: taniasousa@ist.utl.pt (T. Sousa).

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At the formal level, a mathematical framework is used to describe both thermodynamic and economic systems. This allows for insights that were gained in one field of knowledge to be transposed to another. However, this has to be done with great care identifying whether the conditions that have to be met in the original field are also met in the field where the analogy is taken.

At the substantive level, thermodynamic laws are applied to economic processes. The integration between economics and thermodynamics at the substantive level is of crucial importance because economic processes obey thermodynamic laws and therefore a sound economic theory must be coherent with thermodynamics. This integration highlights the dependence between the economic system and the biophysical framework contributing to the analysis of the sustainability of economic systems.

This distinction between formal analogy and substantive integration is not a new issue, e.g., Martinez-Alier (1997) says that 'the mathematical description of economic phenomena in the language of physics is different from applying the concepts of physics'. Also, Baumgärtner (2004b) discussing the different ways in which thermodynamics can be incorporated in economic analysis, considers the isomorphism of formal structure and the thermodynamic constraints on economic action among others, which are respectively, the formal analogy and the substantive integration discussed in this paper.

The belief that neoclassical economics is based on a formal analogy to classical mechanics is common among ecological economists. For example, Amir (1995) argues that 'most physical analogies in economic theory are borrowed from mechanics', Martinez-Alier (1997) argues that 'economic science has used the mathematics of mechanics since the first neoclassical economists' and Costanza et al. (1997) say that 'the market model has been formalized using the same mathematics as used by Newton for mechanical systems'. Outside ecological economics, this thesis has been most extensively argued by Mirowski (1999), who considers that neoclassical economics is an attempt to emulate classical mechanics.

Based on this supposed analogy to classical mechanics, the main formal criticisms of neoclassical economics are: utility does not obey a conservation law as energy does; an equilibrium theory cannot be used to study irreversible processes.

Here, we argue that neoclassical economics is not formally identical to classical mechanics and that the correct identification of the formalism that underlies the construction of neoclassical economics is vital in the evaluation of its internal coherence. We show that economics is formally identical to thermodynamics because they are both problems of static constrained optimisation. The similarity between both formalisms has already been explored in the literature since the 40' (Davis, 1941; Lisman, 1949; Samuelson, 1960a,b) and more recently (Saslow, 1999; Berry et al., 2000; Candeal et al., 2001a,b; Tsirlin and Amel'kin, 2001; Tsirlin et al., 2001; Amel'kin et al., 2002; Smith and Foley, 2004).

The formal analogies of Saslow (1999), Berry et al. (2000) and Amel'kin et al. (2002) are driven from superficial similarities between the entities of economy and thermodynamics instead of being derived from fundamental principles. Therefore, these analogies are not helpful in answering the criticisms raised by ecological economists concerning the formal coherence of economic theory.

Candeal et al. (2001a,b) prove that the mathematical representations of entropy and utility are analogous. Candeal et al. (2001a) and Cooper (1967) investigate the mathematical foundations of the entropy representation where the entropy is built as an order preserving function that satisfies a continuity property. Candeal et al. (2001b) establish a formal relation between the entropy function and the utility function for the axioms that establish the existence of both ordering functions. Although, these authors do not develop their analysis any further, the formal analogy obtained at the function level is important and it lies behind the optimisation analogy pursued here.

The claim that neoclassical economics is formally identical to classical mechanics has also led many Ecological Economists to the substantive assertion that neoclassical economics is fundamentally flawed because it ignores thermodynamics. This argument lacks coherence because the existence of a formal analogy does not imply the existence of a substantive integration and vice-versa. This statement about the non-equivalence between the formal analogy and the substantive integration is easily argued, in this case, because the formal analogy uses the entities that are part of economic theory, i.e., utility, while the substantive integration uses the