Physica A 395 (2014) 269–274

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

A macro-physics model of depreciation rate in economic exchange

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ARTICLE INFO

Article history:
Received 29 January 2013
Received in revised form 2 September 2013
Available online 9 October 2013

Keywords:
Depreciation rate
Econo-physics pure barter model (EPB)
Edgeworth box
Pure barter
Theory of value

ABSTRACT

This article aims at a new approach for a known fundamental result: barter or trade increases economic value. It successfully bridges the gap between the theory of value and the exchange process attached to the transition from endowments to the equilibrium in the core and contract curve. First, we summarise the theory of value; in Section 2, we present the Edgeworth (1881) box and an axiomatic approach and in Section 3, we apply our pure exchange model. Finally (in Section 4), using our open econo-physics pure barter (EPB) model, we derive an improvement in value, which means that pure barter leads to a decline in depreciation rate.

1. Introduction

Economics is a field of knowledge dealing with 'wealth dynamics' (production, distribution and consumption) and certainly the most clearly value dependent among the social sciences. It attempts to determine what is valuable at a given time by studying the relative exchange values of goods and services. Its conceptions and models are based on value systems and views of human nature. In the economic models, the values can be quantified by being assigned monetary weightings. This emphasis on quantification gives economics the appearance of an exact natural science.

In its turn, physics is traditionally a science dealing with the quantification of the observable world, and thus is appropriate to develop a theoretical framework of economic dynamics based on suitable macro- and micro-models. The evolution of physics has been based on a progressive microscopic interpretation of reality from a previous well-established macro framework. In this work, the authors also want to depart from a macro-econo-physics perspective, trying to find a very simple model which is able to lead to a well-established economic result as an output.

This article contributes to the field of econo-physics, which has been steadily growing in the recent past, in particular by giving a new formal-physics approach to the theory of value, and thus obtain a well-known result in the economic domain. The authors introduce and discuss a model of depreciation rate within economic exchange.

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http://dx.doi.org/10.1016/j.physa.2013.09.064

Neoclassical economics gave birth to mathematical economics through the notion of economic core, a refinement of the Edgeworth [1] box, but has not forgotten that economics is also a social science. The formalisation of existence and number of equilibria is a way to approach economics as a social engineering (Debreu [2], Scarf and Debreu [3], Aumann [4], Balasko [5] and more recently Balasko [6] using differential topology methods); nevertheless, Sen's [7] approach, even though not being formal, extended also the economics domain as a social ethics domain.

First, we sum up some economic fundamentals. Our main aim will be to understand the theory of value; we start from the Edgeworth [1,8] box, in an economic model with no production, and then we create our general exchange model.

One should take into account the fact that dynamics, namely the use of diffusion processes (Wiener processes), have been in the economic literature now for quite a while. For instance in macroeconomics, researchers include Turnovsky [9]; Dowry, Pitchfork and Turnovsky [10]; Ljunqvist and Sargent [11]; and Stokey, Lucas and Prescott [12]. Recently, for economic geography, Fujita, Krugman and Venables [13] discussed the diffusion properties of economic physical goods; and more recently endogenous growth models with human capital, the diffusion of technology and human capital spillovers have become important—see Aghion and Howitt [14] and Barro and Sala-I-Martin [15]. Stoneman [16] has abridged the role of diffusion in economic systems from not only a physical but also an economic vision.

Regarding the next sections, in Section 2, we present the Edgeworth [1,8] box and our axiomatic approach; in Section 3, we present the transition from endowments (model without production) to equilibrium and simple core and contract curve.

Our model provides an intuitive approach which is common knowledge to economics, that is exchange increases up value (a fundamental theorem in economics), but in an extended framework: our basic econo-physics model. It is now quite common in finance and economics to have diffusion processes of goods and information. The idea of diffusion has been 'imported' from physics and mathematics [9–16], from concepts such as Brownian motion and Wiener processes, to evaluate option pricing (Black–Scholes) and international macroeconomics exchange rate risk pricing [9]. The main novelty is that of the processes of economic diffusion, namely barter or trade between two goods that are blended together and that can have implications on social welfare/economic valuation. What does happen in the barter exchange between two (at least) different goods? The diffusion process has physical properties which can be applied to economics. In the exchange process (the mixing diffusion econo-physics), we conclude that in a macroscopic scale (in our economic model, for a society or class or group of consumers) there is a decrease in depreciation (thus degradation). The conclusions might seem obvious, but the framework henceforth used is new and has been taken from the idea of diffusion in physics.

2. Axiomatic approach

We consider the following hypothesis for our first simple model:

1. We have non-perishable goods (A, B; A ≡ corn, B ≡ wheat).
2. We consider a time interval in which there is no increase in production (constant production, P).
3. We have two consumers (1, 2) and two goods (A, B) in the Edgeworth box [1,8], with quantities N_A and $N_{B,}$ respectively; this is what is called (2×2) model.
4. The economic system is closed (there are no exchanges with the exterior).
5. The social welfare function of this economy is given by V, the value of utility in consumption (U_t) plus the production (P):

$$V = U_t + P \tag{2.1}$$

in which U_t is utility, which is satisfaction obtained from consumption of goods.

Marginal Utility ($U' = \frac{\partial U}{\partial N_i}$, in which i stands for each good A, B) is decreasing at an increasing rate; thus, $U'<0$; $U''>0$.

P is production, a kind of 'manna' from heaven, which is a standard hypothesis in simple economic models. A social welfare function is just some function of the individual utility functions; it gives a way to rank different allocations that depends on the individual preferences, and it is an increasing function of each individual utility. The utility function is the degree of satisfaction obtained from consumption of goods.

To pursue the goal of this article, we explain the transition process from initial endowments (ω) to the final equilibrium (E^*) located in the core (optimal Pareto points in the contract line on the Edgeworth box)—see Fig. 1. The Edgeworth box is a convenient graphical tool to analyse the exchange of two goods between two people, as a way of representing various distributions of resources between two agents. It is frequently used to illustrate general equilibrium, aiding in representing the competition and efficient outcomes [8]. The width of the box measures the total amount of good A available in the economy and the height measures the total amount of good B. Agent 1's consumption choices and utility are measured from the left-hand lower corner, while agent 2's variables are measured from the upper right. Indifference curves are utility parametric curve levels which represent ordinal increasing satisfaction in consumption, thus increase in welfare. Pareto points or efficient loci are allocations with which any consumer cannot improve his welfare without reducing the welfare of the other consumer and vice versa. The Pareto point is represented by the tangency of indifference curves (utility curves) in the Edgeworth box. The contract curve is the set of all Pareto allocations, and the core is the Pareto set of points obtained from trading starting at the initial allocation, which naturally includes all viable equilibria. Thus in Fig. 1, from a given initial endowment (ω) for two goods (A, B), and two given consumers (1, 2), we have respectively a closed box in which we have initial utilities (U_1^0, U_2^0). Therefore, after a trading or barter process we have a final equilibrium E^*, which cannot be improved