Physica A 470 (2017) 51–59

Contents lists available at ScienceDirect

Physica A

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

Role of intensive and extensive variables in a soup of firms in economy to address long run prices and aggregate data

Ali Hosseiny [a,*], Mauro Gallegati [b]

[a] *Department of Physics, Shahid Beheshti University, G.C., Evin, Tehran 19839, Iran*

[b] *Department of Economics, Università Politecnica delle Marche, Italy*

HIGHLIGHTS

- Production function has been revisited from a thermodynamic view point.
- Wage and the rate of return on capital play the role of intensive variables.
- Production, the number of labors, and capital play the role of extensive variables.
- Aggregation can not be addressed except if we know the utility preferences.
- In a toy model, given the utility, aggregate production and labor share are worked out.

ARTICLE INFO

Article history:
Received 4 June 2016
Received in revised form 16 November 2016
Available online 2 December 2016

Keywords:
Intensive variables
Extensive variables
Cost disease phenomenon
Neoclassical economy
Aggregation
Labor income

ABSTRACT

We review the production function and the hypothesis of equilibrium in the neoclassical framework. We notify that in a soup of sectors in economy, while capital and labor resemble extensive variables, wage and rate of return on capital act as intensive variables. As a result, Baumol and Bowen's statement of equal wages is inevitable from the thermodynamics point of view. We try to see how aggregation can be performed concerning the extensive variables in a soup of firms. We provide a toy model to perform aggregation for production and the labor income as extensive quantities in a neoclassical framework.

1. Introduction

The field of complex systems provides a view point to study collective behaviors, attracting attention in different areas of scientific research. It ranges from percolation of disease [1,2] to the social sciences [3–5], complex networks [6–11], biology [12–14], earth sciences [15], economics, and econophysics [16–27], etc. Emergence is one of the key features to distinguish complex systems from regular systems. In thermodynamics for example we start with the kinetic energy and momentum for simple particles of an ideal gas in the micro level. In the aggregate level however to address collective behavior we need to define new parameters such as temperature, pressure, entropy, and free energies which are emerged variables. To address interaction of different systems, in the aggregate level, these variables play a crucial role. In addressing thermal interaction for example, regardless of the micro-structure of systems, temperature indicates direction of the flow of heat and energy.

* Corresponding author.
E-mail addresses: Al_hosseiny@sbu.ac.ir (A. Hosseiny), mauro.gallegati@univpm.it (M. Gallegati).

http://dx.doi.org/10.1016/j.physa.2016.11.130

In statistical physics, there is good knowledge about important parameters for addressing collective behavior. we can divide state parameters in thermodynamics into intensive and extensive variables. Intensive variables address the equilibrium conditions. After relaxation we expect at equilibrium, intensive variables to be the same for interacting systems. Extensive variables however play different roles and define the measures that are needed to be added up in aggregation. Now, one may wonder if in the interaction of sectors in economy we have similar parameters for addressing equilibrium conditions.

In contrast to physics, in economics, recently the hypothesis of representative agent and actually the hypothesis-of-straightforward-path-from-micro-to-the-macro has been seriously challenged by heterodox schools (see for example [28–31]). Due to some problems, in economy addressing aggregate behavior is much harder than physics. One problem is that, in contrast to physics, in economics, making new experiments is almost impossible. Physicists usually have been working with table-top experiments and could repeat them frequently. But in economics conducting new experiments is almost impossible. Another difference is that physics usually deals with simple substances, while in economics micro elements are dealt with which creates serious complications. In other words the humans are trying to outguess the market and play with it. This makes things more complicated [32–34]. Another problem with the hard task of aggregation in economics is that in contrast to physics, economics is engaged with systems with fast evolution. Every day new technologies are developed and the relation between different sectors deforms. So, opposite to physics which we can think of long equilibrium, in economics it is the dynamics that we must deal with.

Economists deal with the problem of evolution by separating long and short run behaviors. Different schools however have their own assumptions [35–37]. In the neoclassical framework it is supposed that economy lives in equilibrium and the Walrasian auctioneer helps different agents to make their mind and find best strategies [38–40]. Some other schools however emphasize the impact of market failure, bounded rationality, and far from equilibrium behavior [41–43].

In this paper we consider production function and hypotheses concerning its role in addressing long run relations between different sectors of economy in the micro and aggregate level. We discuss similarities of the hypotheses in economy with the hypotheses in thermodynamics.

We should notify that many studies have challenged the hypotheses of the neoclassical framework. There is friction for finding new skills, and the mobility of labor is not easy [44,45]. In addition, the concept of capital has been debated in the Cambridge Capital Controversy [46–50] (for a review see [51]). Even the whole neoclassical synthesis has been criticized [52]. Recent works emphasize cascades, fragility of the market, and its far from equilibrium behavior [53–55]. In this paper however, ignoring all debates, we discuss within the neoclassical framework and claim that within this framework while labor, capital, and production play the role of extensive variables, wage and rate of return on capital resemble intensive variables.

We revisit Baumol and Bowen's statement on the impact of equal wages in different sectors [56]. We claim that their hypothesis is the requirement of the equality of the intensive variables at equilibrium. In other words we revisit the Baumol's cost disease phenomenon [57,58] within a thermodynamics framework. This will provide physicists a vision on why expenses for services are growing quickly in developing countries. Baumol's cost disease is a well-known fact in economy. Borrowing some known concepts in thermodynamics we aim to provide an impression on it in physics. We then observe how we can aggregate extensive variables in a soup of firms in a neoclassical framework.

This paper is organized as follows. In Section 2 we review the production function and the Cobb–Douglass model. In Section 3 we discuss the role of intensive and extensive variables in a soup of firms. We revisit Baumol's cost disease phenomenon through a thermodynamics point of view. In Section 4 we introduce a toy model and aggregate extensive variables in this toy model as a mathematical task. In this toy model we measure some extensive quantities such as production and labor income, and show by keeping the production functions in the micro level and the aggregate level unchanged, the labor share in the aggregate level is dramatically shaped.

2. A review on production function in the micro and aggregate level

Production function is a function that addresses output of a firm in terms of population of hired labors and the value of invested capital

$$Q_a = Y_a(T_a L_a, K_a). \quad (1)$$

In this equation Q_a is the quantity of good a produced in a firm in sector a. The number of labors hired in the firm is indicated by L_a, capital is indicated by K_a, and productivity is indicated by T_a. The function is supposed to have scaling properties as

$$Y_a(zT_a L_a, zK_a) = zY_a(T_a L_a, K_a). \quad (2)$$

Besides, it is supposed to have diminishing return to capital. It means that it is a convex up function of capital. Now, to choose strategy to hire more labors or invest more capital managers need to look at margins. Hiring more labor and investing more capital are reasonable if increased output compensates for the prices

$$P_a \Delta Y_a \geq \Delta L_a W, \qquad P_a \Delta Y_a \geq (R_c + \delta_a)\Delta K_a \quad (3)$$