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Research paper

On the economic growth theory with Kadiyala production function

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ABSTRACT

We study the discrete time neoclassical one-sector growth model with differential savings while assuming Kadiyala production function which shows a variable elasticity of substitution symmetric with respect to capital and labor. We show that, if workers save more than shareholders, then the growth path is bounded from above and the boundary is independent from the savings rate of shareholders. Moreover, the growth path for non-developed countries is influenced only by the savings rate of shareholders while level of capital per capita of developed economies is influenced by the savings rate of workers. We also show that multistability phenomena may occur so that the model is able to explain co-existence of under-developed, developing and developed economies. We prove that fluctuations and complex dynamics may arise when the elasticity of substitution between production factors is lower than one and shareholders save more than workers.

1. Introduction

In the classic article *A Contribution to the Theory of Economic Growth* [1], the Nobel Prize-winning Robert M. Solow investigated the relationship between the structure of production functions and income distribution. Solow proposed a model describing the dynamics of the physical capital and the long-term evolution of the growth process taking into consideration the role of capital, labor and technology. In his essay he took into consideration how the long-run equilibrium or disequilibrium of the economy changes considering different types of production functions: the Harrod–Domar, the Cobb–Douglas (CD) and a third type of production function that five years later had been generalized with the two-factor Constant Elasticity of Substitution (CES) production function (see Solow et al. [2]). Solow's third case showed that, thanks to the particular production function and to the level of savings, the income per head can grow forever even without technical progress. In 1989 de La Grandville [3] considered the Solow model with a normalized CES function and showed that an higher elasticity of substitution implies an higher capital per-capita level. Moreover he conjectured that the huge growth in Japan and East Asian countries could had been due to an higher elasticity of substitution between capital and labor instead of a more efficient technical progress or an higher savings rate. Several successive papers inspect how the elasticity of substitution affects economic growth and the speed of convergence towards the balanced growth path (see among all Klump and Preissler [4] and Klump and de La Grandville [5]).

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Elasticity of substitution σ between production factors measures how quickly the marginal rate of technical substitution of labor for capital changes as we move along an isoquant. The greater the ease with which one factor can be substituted for another (for a given level of output), the greater will be the elasticity of substitution. In linear production functions inputs are perfectly substitutable for each other, isoquants are straight lines and $\sigma = +\infty$. On the contrary, in fixed-proportions production functions inputs are perfect complements, isoquants are L-shaped and $\sigma = 0$. Many papers investigating neoclassical growth model used the CD specification of the production function in which capital and labor can be substituted for each other and the elasticity of substitution is equal to one. More recently, several contributions investigated theoretically and empirically the role played by the CES production functions (see Klump and Preissler [4], Klump and de La Grandville [5], Miyagiwa and Papageorgiou [6] and Masanjala and Papageorgiou [7]) in which elasticity of substitution between inputs is constant and takes values that are either greater or lower than one. Although CES production functions widen the range of values of the elasticity of substitution from 0 to ∞, these production functions restrict σ to be constant along an isoquant whereas the elasticity of substitution between inputs should be a variable depending upon output and factor combinations (see Hicks [8], Allen [9] and Revankar [10]). Moreover, for more than two factors, different degrees of substitutability between inputs are not allowed (see the Impossibility theorem of Uzawa [11] - McFadden [12]). The class of Variable Elasticity of Substitution (VES) production functions proposed by Lu and Fletcher [13], Revankar [14] and Sato and Hoffman [15] fixed this criticisms exhibiting an elasticity of substitution between capital and labor that is affected by changes in the economy's per-capita capital level. Many studies analyzed the role of a variable elasticity of substitution within the Solow model (see Karagiannis et al. [16], Papageorgiou and Saam [17]).

As a further step on the economic growth theory Kaldor [18,19] proposed a Solow's type growth model in which the two income groups (labor and capital) might have different savings behavior. Consequently, the investigation of the influence of differential savings rates between workers and shareholders arises in literature. Böhm and Kaas [20] studied the Kaldor model assuming a generic production function satisfying the weak Inada conditions and showed that instability, fluctuations and complex dynamics may emerge. Brianzoni et al. [21–23] and Cheban et al. [24] investigated the discrete-time neoclassical growth model with constant but different saving propensities between capital and labor considering CES production function, proving that multiple equilibria and topological chaos can be generated if the elasticity of substitution between production factors is low enough. Tramontana et al. [25] used the Leontief production function and proved that cycles and fluctuation can be exhibited if shareholders save more than workers. As a further step in this field, the role of different VES production functions has been considered: Brianzoni et al. [26] studied Kaldor model with Revankar [10] production function; they found that unbounded endogenous growth is possible (differently from CES) and fluctuations may arise if shareholders save more than workers and the elasticity of substitution between production factors falls below one. Similar results can be found considering non-concave production functions (see Brianzoni et al. [27] and Michetti [28]).

Empirical studies proved that VES production functions are a better representation of the reality: works of Lovell [29], Diwan [30], Revankar [10] and Meyer and Kadiyala [31] rejected both the CD and the CES specifications in favor of the VES using U.S. data. Bairam [32] and Sato and Hoffman [15] provided same results for Japanese economy while evidences in favor of VES production function for Soviet economy and larger regions are given respectively in Bairam [33] and Karagiannis et al. [16].

VES production functions used in cited works allow to consider that elasticity of substitution between capital and labor can be affected by a change in the capital intensity within the economic system, however for these production functions $\sigma(k)$ is a monotone (either increasing or decreasing) function of the input ratio $k = \frac{K}{L}$, where K is capital and L is labor. As Kadiyala [34] noted, this property contradicts the trivial intuition that elasticity of substitution should monotonically increase (decrease) as the input ratio k tends to a critical value k_c and decrease (increase) for $k > k_c$ since the elasticity of substitution of labor for capital is the same as the elasticity of substitution of capital for labor.

This paper extends previous literature on economic growth by examining the neoclassical one-sector growth model with differential savings while assuming that technology is described by the Kadiyala [34] production function: a VES production function whom property is to present elasticity of substitution symmetric with respect to input factors, fixing monotony's critic moved to main VES functions. The aim of this work is to investigate how the elasticity of substitution between capital and labor and savings rate of capitalists (shareholders) and workers influence the speed with which economies grow, the existence of poverty traps and the occurrence of fluctuating long run behaviors.

We found that when the elasticity of substitution between labor and capital is lower than one the growth path for non-developed countries is influenced only from investments made by capitalist while for developed economies the level of capital increases only for higher values of the savings rate of workers.

As in Chakraborty [35], we found that poverty traps may result if savings and investment rates are low despite the absence of inefficient technology, mainly considered the source of "vicious circle of poverty" (see among all Capasso et al. [35] and Azariadis and Stachurski [36]).

In addition we analyze qualitative and quantitative dynamics of the model: multistability phenomena, fluctuations and complex dynamics can be observed if elasticity of substitution is lower than one, confirming results obtained with different technologies.

The paper is organized as follows. Section 2 introduces the model. Section 3 analyzes the influence of savings rates on the growth path. Section 4 investigates the dynamical behavior of the framework. Section 5 shows complex dynamics and multistability phenomena. Section 6 concludes the paper.

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