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ACCOUNTING IMPRINT OF MACROECONOMIC MAGNITUDE: VERTICALLY INTEGRATED SECTORS OF THE GREEK ECONOMY

Abstract

The productivity indicators are based either on the microeconomic or the macroeconomic notion of sectors of production and vertically integrated sectors of production correspondingly. The first refers to the set of factors of production implemented by the enterprise, whereas the others are the utilized factors employed in other sectors added to the microeconomic sectors. In a traditional approach the microeconomic sectors of production play a dominant role in the analysis of economic development. This paper suggests a microeconomic approach of macroeconomic production factors with the realism implied by using the Computable General Equilibrium (CGE) Models, while enhances the study of areas which are difficultly examined by the aggregate production function. The proposed methodological tool is applied to the Greek economy.

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Key words:

Microeconomic and macroeconomic production functions, capital, labor, closed economy, a final or intermediate commodity, vertically integrated sectors, aggregate production function, economic growth.

1. Introduction

Traditionally the assessment of productivity indicators is based on the microeconomic definition of «sector of production». According to this definition the sector of production consist of a number of business concerns, which produce a homogeneous group of products. The corresponding amount of the factors of production employed by the sector, is the sum of the factors of production that each enterprise employs. In this way, the immediate needs of the sector accrue in primary factors of production. Using this data the traditional rates of productivity are calculated. For instance, if the food sector produces 500 tons of foodstuffs and employs 100 workers, therefore work productivity is 5 tons per each employee.

On the contrary «the vertically integrated sectors of production» is a macroeconomic notion and therefore, it is not mentioned in the immediately observable economic units. These sectors are theoretical economic units, which produce the same homogeneous group of products as the microeconomic sectors. They differ though in the immediately needed amount of factors of production, which are added to the indirectly utilized amount of factors that are employed in other sectors. For instance, from the previous example if production of 500 tons of foodstuffs requires the use of electric power, which in turn requires 10 employees to be produced, then the direct or immediate needs in the number of employees are 100 and the indirect needs are 10. Consequently each vertically integrated sector of food production produces 500 tons of food and employs directly and indirectly 110 employees. Equivalently, production is 500/110 tons per each worker.

The present paper introduces the methodological approach for the evaluation of tables of the vertically integrated sectors.

2. Microeconomic and Macroeconomic Production Functions

2.1. General

It is known that the interpretative capacity of economic models is dependent on the flexibility and validity of the analytical tools they are composed of. A classical example of such a tool comprises the aggregate production function, which is used in the overwhelming majority of models of economic growth that have been developed in the last fifty years.

The reasons of enormous demand for this particular tool are both theoretical and practical. The theoretical reasons include a capacity of gaining very vital conclusions with the least complexity of supposition. From the practical point of view the aggregate production function requires the most available statistical data for an empirical evaluation. Despite the popularity that the aggregate production function has acquired, it has also received acute criticism, as to the extent as well as the reliability of deduction, which derive from its use. In the very opposite of single sector models of the aggregate production function we find the multi-sector Computable General Equilibrium Models or CGE. The CGE, which have become quite popular in the last twenty years use instead of the aggregate production function the microeconomic functions of tens of sectors of production. Their trend is purely empirical and their theoretical selections are guided by the availability of required data. However, the increased pragmatism of CGE hypotheses is balanced by the inability of deduction of the theoretical conclusions, which arise from the models of the aggregate production function. The confluence of these models begins (from the time) when computer data analysis ends.

The microeconomic foundation of macroeconomic productions functions is examined below. This tool combines deductive properties of the production with the realism of micro foundation of CGE.

The macroeconomic production functions on the one hand broaden the capabilities of development of economic models in areas, where the aggregate production function is unable to approach due to its nature. On the other hand, they contribute to the decrease of volume and complexity of the CGE, without causing the slightest loss of the realism of their hypotheses.

2.2. The meaning of the aggregate production function and the micro foundation in the contemporary theory of economic growth

2.2.1. The aggregate production function

The modern theory of economic development had as its starting point the prototype methodological work of Harrod (1939), which was followed a short time later by a similar contribution of Domar (1946, 1947). However, from the point of view of interest the so-called «neo-classical approach», whose very beginning are considered to be two articles by Solow (1956) and Swan (1956), possessed the dominant position in the followed decades. Both approaches mentioned above are placed by Hicks (1965) in what he named as «contemporary theories of economic growth» in juxtaposition with the «early theories of economic growth» developed by Smith, Ricardo, Marx and etc. The term «contemporary» does not necessarily mean that these theories were formulated most recently. They are contemporary with the meaning that they «use a fairly small number of particular economic variables in the construction of a formalistic approach» (Jones 1975).

A basic characteristic of these models for both approaches was the existence of an aggregate production function of the following form:

$$Y(t) = F[K(t), L(t)], \qquad (1)$$

Where Y = gross national product (GNP);
K = capital;
L = labor;
t = time.

The basic difference of both approaches is confined in the form of production function (1). Both Harrod and Domar use in their models the production function of stable proportions of Leontief (Leontief 1941), which has the form:

$$Y = \min(AK, BL), \qquad (2)$$

Where $A > 0$ and $B > 0$ are constant quantities.

In the function of stable proportions if the available capital and labor happen to have such a magnitude so as $AK = BL$, then the two factors of production are totally engaged. In the opposite case, one of the two factors remains in part inoperative. On the contrary, the neo-classical school adopts the function of the form (1), which allows the substitution of factors, it is differentiated and it has the following properties:

$F_K > 0, F_L > 0$ (marginal product of components are positive),

$F_{KK} < 0, F_{LL} < 0$ (marginal efficiency of components are descending), (3)
$F(\lambda K, \lambda L) = \lambda \cdot F(K, L)$ for every $\lambda > 0$ (homogeneity of first class),

Where F_K = first derivative of F as K;
F_L = first derivative of F as L;
F_{KK} = second derivative of F as K;
F_{LL} = second derivative of F as L.

Functions of this type are for example, the functions of Cobb-Douglas, which have the form $Y = K^a L^{1-a}$

Since the models of development are dynamic by nature, then their presence should be ensured for the duration of time both «schools» succeeded in their above objective in the following manner: The gross national product *Y(t)* may be used in two ways. One part of *Y* is consumed by the country citizens in question and therefore constitutes output for the system. The remainder, which constitutes investment *I(t)* is added to the capital *K*, in order to be used in the production process of the following period. In a closed economy the following applies:

$$Y(t) = I(t) + C(t), \tag{4}$$

Where *Y(t)* = gross national product (GNP);
I(t) = investment;
C(t) = consumption.

The next topic that should be addressed was the determination of the GNP part, which is disposed for investment. The question was dealt with the hypothesis that saving and therefore (in a closed economy) investment is equalized by a stable percentage of the GNP. Mainly the relation applies:

$$I(t) = \frac{dK}{dt} = s \cdot Y(t) - \delta K(t), \tag{5}$$

Where δ = percentage of depreciation.

Based on the production function (1) and on the aggregate function, a differential equation of the following form accrues:

$$\frac{dK}{dt} = s \cdot F[K(t), L(t)] - \delta K(t). \tag{6}$$

According to what has already been mentioned above, the difference of the two models was that while in the Harrod-Domar model the differential equation is of a linear form, in the Solow-Swan model it is non-linear. All of the neoclassical models up to the present operate in this methodological framework; that is, they comprise an aggregate production function and an aggregate function on the basis of which a differential equation is formed, which determines the operation of the whole economic system.

From a methodological point of view the differences in what appeared later are confined in the manner in which each specifies the aggregate production function and the accumulative function. As far as the accumulative function is concerned, we can distinguish the contribution by Cass and Koopman (1965). They both introduced to the neo-classical model the analysis by Ramsey (1928), by which the percentage of the marginal propensity to save is not determined externally but accrues during the process of maximization in time of the consumer's utility.

As a meaning, in the framework of these models, the aggregate production function has undergone quantitative rather than qualitative changes. The different treatments refer mostly to the facet of inputs, which are incorporated in the analysis. On the contrary, the output is only one, the GNP. With the point mostly of the theories of endogenous growth the right member of (1) is broadened in a way as to include the human capital *H* apart from the «material» capital *K* (Lucas 1998), or the public commodity *G* (Barro 1990). In other instances it dwindles with the removal of labor as a factor of production, as it occurs in the known «AK-model» (Romer 1986). Since the endogenous models of growth are models of general equilibrium, the increase of inputs dictates the need for a mechanism to be found so that these inputs could be produced endogenously in the model. The solution given in the majority of cases is the broadening of operations, which is summoned to achieve the one and only commodity GNP. In this manner, this commodity is simultaneously of investment and of consumption. As an investment it is at the same time material and human and as consumption it is both private and public.

2.2.2. The microfoundation of macroeconomic variables

The mathematical equations, which constitute the theoretical models, as it is natural, try to interpret with as much accuracy as possible the behavior of phenomena, which they describe. Especially, the models of economic growth try to interpret the (usually) augmentative variation of the GNP, which takes place in an economy during a period of time. If the models (that have been) mentioned focus their interest on a macroeconomic level, the behavior and motives, which they aim to interpret, are of a microeconomic nature. The GNP by nature is an aggregated magnitude. The adoption of an only production function such as (1) does not necessarily mean that the writers of these models assumed that the GNP is produced by one and only producer. On the contrary the hypothesis made is that (1) is an aggregation of the production functions of thousands of producers, each of whom aspire to maximize personal profit. Therefore (1) may result by adopting:

a) The microeconomic maximization of profit, and

b) A method of aggregation.

In particular the process and presumptions, which lead to the formation of the aggregate production function (1), are referred to in the bibliography by using the term microfoundation. In short, this process consists of the following steps:

a) Maximization of profits

In a closed economy, there are *m* identical enterprises, which produce the final product *Y*, using two endogenous factors of production *K* (capital) and *L* (Labor). The return of these factors in units of the commodity *Y*, are represented by *w* (return for each unit of labor) and *r* (return for each unit of capital). The magnitude of these returns cannot be affected by the decision of individual enterprises. The aim of each enterprise is to combine the factors of production in such a way so as to maximize its profits. The technological possibilities of production of the final product *Y* are the same for all enterprises and are described by the following neoclassical production function in which time t does not appear for reasons of convenience:

$$Y_i = F(K_i, L_i), \quad i = 1,2,...,m, \tag{7}$$

Where Y_i = final product, which is produced by a business *i;*
K_i= capital, which is used in business *i*;
L_i = labor which is used in business *i*.

Based on the above, the conditions of the first order for the maximization of profits of a business are:

$$F_K(K_i,L_i) = r; \quad F_L(K_i,L_i) = w; \quad i = 1,2,...,m, \tag{8}$$

Where F_K = the first derivative of *F* as to *K;*
F_L = the first derivative of *F* as to *L*.

b) Method of aggregation

Since enterprises are identical the following will be valid.

$$\begin{aligned} Y &= Y_1 + ... + Y_m = mY_i; \\ K &= K_1 + ... + K_m = mK_i; \\ L &= L_1 + ... + L_m = mL_i, \end{aligned} \tag{9}$$

Where *Y* = the total final product;
K = the total capital in the production of *Y;*
L = the total labor in the production of *Y.*

Based on the relations of (9) and taking into account the homogeneity of the first degree of microeconomic production functions (7) accrues that:

$$mY_i = F(mK_i, mL_i) \Rightarrow Y = F(K,L). \tag{10}$$

Therefore, from the known property of homogeneity of zero degree of relations (8) and utilizing (9), we conclude the relations:

$$\left.\begin{array}{l} F_K(mK_i, mL_i) = r \\ F_L(mK_i, mL_i) = w \end{array}\right\} \Rightarrow \quad \begin{array}{l} F_K(K,L) = r \\ F_L(K,L) = w. \end{array} \tag{11}$$

The relation (10) constitutes the aggregate production function of the gross national product Y and has all the properties of microeconomic production function (7) from which it is derived. By the same reasoning the relations (11) may be characterized as the macroeconomic conditions of the first order of the problem of maximization of the total amount of production of product Y, where Y = GNP. In general terms the above description constitutes the philosophy of use of relations (10) and (11) on a macroeconomic level and may be detected in almost all macroeconomic manuals of analysis (e. g. Blanchard and Fischer 1989). In reality, the whole process constitutes a direct transmission of relations from the microeconomic level to the macroeconomic. This treatment received the criticism of a part of economists, whose views are examined in the following section.

2.2.3. The criticism against the aggregate production function

The use of the aggregate production function (1) was found in the epicenter of the largest conflict known in economic thought in the last fifty years. The neoclassical treatment of economic growth models had as its supporters a distinguished group of economists at the Massachusetts Institute of Technology, the primary representatives being Samuelson and Solow. Opposite them there was a group of economists equally distinguished, who constituted the «School of Cambridge» because of their connection to the Economics Department at the University of Cambridge in England. The main representatives at the Cambridge School were Kaldor, Pasinetti and Joan Robinson. Even though he did not take an active part in the conflict as a member of the Cambridge School, Piero Sraffa is also included. The purpose of the present paper is not of an in-depth analysis of opinions (which have been) formulated during the conflict. Reference is being made to those points, which refer to the topic of the present study. It must be noted however that the period of conflict of the two Schools of Thought was quite fertile in the production of ideas and techniques of economic analysis as well as in the clarification of the misunderstandings, which had dominated economic thought.

The basic objection of the School of Cambridge regarded the meaning of the variable capital *K*, which is inserted in the aggregate production function (1). The neoclassical meaning of capital used in the single sector model of growth by Solow, has two functions. First, co-operating with labor it produces the GNP, as indicated in (1). Second with the logic of microfoundation, which was analyzed above and which had as a result the relation (12), the marginal productivity F_K of capital «explains» or «determines» the percentage of profit *r*. The authors of the Cambridge School juxtaposed that in reality there doesn't exist only one homogeneous commodity «capital» but there exists a large number of heterogeneous capital commodities which participate in the production process. According to the Cambridge School it is impossible for a unit of measurement to be found, by which it is possible to sum heterogeneous capital commodities by formulating a capital index *K*, so as to satisfy the pair of neoclassical requirements, mentioned above. The basic argument is that if assumed that there exists one such unit of measurement, a vague circle is created as to what determines what. This vagueness derives from the fact that while wages *w* consist of the fees of natural units of work (man-hour) etc., the percentage of profit *r* is mentioned in the «value» of capital: namely, the value which has derived from the reduction of the heterogeneous capital commodities in the common unit of measurement. The variable *K* of (1) namely consists of a capital value index on the basis of the common unit of measurement. The value however of the total capital is a magnitude, the assessment of which requires previous knowledge of the percentage of profit *r*, which is exactly the variable that we aspire to define (Pasinetti 1977). The circularity of these arguments led Pasinetti to conclude that the neoclassical approach could hold true only in an imaginary economy in which only one commodity is produced.

To these arguments Samuelson answered «that we could sometimes foresee with precision the manner of behavior of certain quite complex models of heterogeneous capital, dealing with them as if they accrue from a very simple production function» (Samuelson 1962). What becomes evident from the quotation of the above arguments is the different philosophy by which the two schools approached the construction of economic models. The Cambridge School gave more significance to the realism of hypotheses of the model with equivalency implications of complexity and the weakness of empirical evaluation, due to deficiency at the time of essential statistical data. The neoclassical authors with their distinct preference in the construction of models, by which it would have been possible to have empirical evaluation, approached the subject differently. In the article, which constituted the starting point of contemporary models of economic growth, Solow mentioned: «The technique of developing successful theoretical forms constitutes in suggesting the unavoidable simplification hypotheses in such a way that the final results are not very sensitive» (Solow 1956).

The difference of these philosophies would have been without meaning if there were not a serious methodological question. The question is formulated as such: The existence in reality of heterogeneous capital commodities overbalance or not the results that accrue from the neoclassical models of growth, which adopt the existence of a homogenous and pliable capital commodity.

The answer of the Cambridge School was that the existence of many commodities in one model overbalances one of the most basic conclusions of the neoclassical model. More specifically one of the conclusions of the models used by Solow is that, if we have two countries in the status of steady state with different ratio of capital-labor, then in the country with the lowest ratio of capital-labor, higher interest rates and smaller wages will prevail. Namely, in the status of steady state there exists a negative correlation between capital per capita and interests. The Cambridge School maintains that this conclusion is not valid in cases where we have the existence of many heterogeneous capital commodities. This is due to the phenomenon, which is known by the term «switching of techniques». This phenomenon arises from the following condition. If for the production of commodities we allocate more than one technique, then, according to the neoclassical school of thought, in conditions where we have high interest rates, the technique, which has the relatively smallest capital intensity, will be adopted by the economy. On the contrary in low interest rates the technique with relative high capital intensity is used. According to the phenomenon of switching of techniques it is possible for the technique of capital intensity to be more profitable and to be followed in high and low interest rates. At the immediate level of interest rates we use the technique which is relatively low capital intensive. In other words, the technique of capital intensity is used with low interest rates it is displaced of//by? techniques of low capital intensity in immediate interest rates and is reused again with high interest rates. According to the Cambridge School the appearance of switching of techniques is sufficient to nullify almost all the neoclassical comparisons. (Hartcourt 1972).

The above discussion regardless of having winners or losers, demonstrates the need for development of more disaggregated models. Many years after the conflict, Nobel winner economist R. Lucas wrote in his famous article «Making a Miracle»:

«I do not believe that we could have an economic miracle theory in a clear aggregate framework in which every country produces the one and only commodity (and consequently the wealthiest nation is the one which produces more), but one such framework is useful to present the problem and to narrow theoretical possibility» (Lucas 1993). This necessity resulted in the appearance of the first macroeconomic production functions.

2.2.4. The appearance of the macroeconomic production functions

The articles which accompanied the conflict of the neoclassical school of thought and the Cambridge school for more than twenty years were an important source of «instruments», techniques and concepts that affected the later development of economic growth models. Both sides developed models that either categorically or indirectly had as their basic factor a multi variable interpretation of the aggregate production function (1) like (12), which follows:

$$Y_i = F_i(K_{1i},\dots K_{ni}, L_i),\ i = 1,\dots,n, \qquad (12)$$

Where Y_i = total final commodity i;
K_{ji} = capital commodity j in the production of commodity i;
L_i = labor employed in the sector i.

The production functions (12) were part of a model which described an economy that produced n final commodities, which are either consumed or contribute to the formation of capital K_i. The following applies:

$$Y_i = C_i + I_i, \quad i = 1,\dots,n, \qquad (13)$$

And

$$K_i(t+1) = K_i(t) + I_i(t) - \delta_i K_i(t), \quad i = 1,\dots,n. \qquad (14)$$

The relations of (12) in the models of the period of the «conflict» are specified either with the function of stable proportions of Leontief, or by the neoclassical productions functions. The preference of the Cambridge School was clearly towards the first category of functions (Burmeister& Sheshinski 1969).

On the contrary, in the book written by Samuelson and Solow, where the «Turnpike» property of the closed models of production was first introduced, the neo-classical production functions were used (Dorfman, Samuelson, Solow 1958).

The relations (12) are called macroeconomic production functions. The term «macroeconomic» is justified by the fact that they do not represent the technological condition faced by a particular small producer, according to the meaning of the term, «production function». On the contrary, it is a theoretical invention as is the aggregate production function (1). For a function to result by which the final amount of commodity i is dependent exclusively and only on the amount of primary factors of production, all the products, all the producers and all the markets of an economy should be involved. This can be most clearly seen if we remain for a second on the term final commodity. As known, a final commodity is that commodity which is used for its intended final use, namely either for consumption or for investment or export purpose. In reality a very important part of the total production of commodities is used as intermediary inflow in the production of other commodities. The commodity, produced by a producer, is characterized as final or intermediate the moment it enters the market. If the commodity is final it is determined by the user of the commodity and not by the producer. Therefore there cannot be a directly observable technological relation such as (2). The problem is created by the existence of intermediary uses. For the problem to be noticeable, in Table 1 the allocation of 14 commodity categories is introduced as used between intermediary and final uses for the Greek economy for 1990. From the data on the table it can be deducted that the total value of intermediary commodities constitutes 36% of the total tender, while for some categories of products the percentage climbs to 94%. The existence of intermediary commodities besides the above problem of complexity creates an accounting problem as well.

If W_i symbolizes the return of capital commodity *I*, *W0* the wages and P_i the rate of commodity *I*, then in conditions of competitive equilibrium the following should be valid:

$$P_i Y_i = W_i K_{1i} + ... + W_n K_{ni} + W_0 L_i, \quad i = 1,...,n, \qquad (15)$$

The relation (15) constitutes the zero profit condition that results as known during the maximization of profit in the production of commodity *i*. In other words, in a closed economy (15) prescribes the equalization of value of the final commodity *i* and the added value $(VA)_i$, which is created in its production. It is noted that:

$$(VA)_i = W_i K_{1i} + ... + W_n K_{ni} + W_0 L_i, \quad i = 1,...,n. \qquad (16)$$

If we take a simple example of a closed economy without a public sector and examine the national accounting identities, which describe it, we can conclude immediately that the relation (15) is not valid in any sector of that economy.

Examining indeed the simple format of inflow and discharge (Table 2) which corresponds to the economy of the above example, we notice the following.

In the above table lengthwise is depicted the equalization between other uses and uses of commodity *i*.

$$P_i Q_i = P_i Q_{i1} + ... + P_i Q_{in} + P_i Y_i, \quad i = 1,...,n, \qquad (17)$$

Where Q_{ij} = the intermediary inflow bought by sector *j* from sector *i*.

Equivalently, lengthwise in the columns, is shown the equalization between the income of each sector and payments for production expenditure as well as payments of primary factors (capital commodities and labor) which it used:

$$P_i Q_i = P_i Q_{i1} + ... + P_i Q_{in} + (VA)_i, \quad i = 1,...,n. \qquad (18)$$

Table 1.

Participation of intermediate expenditure in total uses of the Greek economy (In 1990 purchase prices)
(Amount is in thousands of Greek Drachmas)

Product / Sector	Intermediate consumption	Final uses	Total uses	Participation of consumption in total uses
(1)	(2)	(3)	(4) = (3) + (2)	(5) = 100 × (2) / (4)
Agriculture, Forestry, Fishery	1.440.779	630.105	2.070.884	69.6%
Mining	467.714	51.927	519.641	90.0%
Processing	5.059.774	7.275.991	12.335.765	41.0%
Electricity – Water supply	292.737	190.029	482.766	60.0%
Manufacturing	209.903	2.031.139	2.241.042	9.4%
Automotive repairs	101.222	235.617	336.839	30.1%
Hotels, Restaurants	40.166	1.263.434	1.303.600	3.1%
Transport, Communication	450.650	639.951	1.090.601	41.3%
Banking	438.461	27.648	466.109	94.1%
Insurance	51.761	56.956	108.717	47.6%
Public Sector	0	1.239.503	1.239.503	0.0%
Health	9.287	603.928	613.215	1.5%
Education	26.227	708.305	734.532	3.6%
Other Services	1.001.508	1.667.317	2.678.825	37.4%
Economy total	9.590.189	16.631.850	26.222.039	36.6%

Source: ΕΣΥΕ, Management of National Accounts.

Table 2.

Table of inflow and discharge in a closed economy, without a public sector

				Intermediate uses	Final uses	Total value of production
	Product	1	....	N	P.Y	PQ
Intermediate uses	1 ... n	P_1Q_{11} ... P_nQ_{n1}	...	P_1Q_{1n} ... P_nQ_{nn}	P_1Y_1 ... P_nY_n	P_1Q_1 ... P_nQ_n
Added value	VA	$(VA)_1$	...	$(VA)_N$	GNP	
Total value of production	PQ	P_1Q_1	...	P_nQ_n		

From the relations (17) and (18) we conclude that:

$$P_iY_i = (NA)_i + \sum_{k=1}^{k=n} P_kQ_{ki} - \sum_{z=1}^{z=n} P_iQ_{iz}, \quad i = 1,...,n, \tag{19}$$

Examining (19) we can conclude that in order to verify the actual data of the economy mentioned in (15) the following should be valid:

$$\sum_{k=1}^{k=n} P_kQ_{ki} - \sum_{z=1}^{z=n} P_iQ_{iz} = 0, \quad i = 1,2,...,n. \tag{20}$$

Something like that is not valid except in special cases and generally we have:

$$P_iY_i \neq (VA)_i, \quad i = 1,2,...,n. \tag{21}$$

The above arguments may explain the fact that equations (20) and (21) do not until now have empirical evaluation[1]. They indicate also that in order to result in relation, such as macroeconomic production functions (12) for which the relations (15) will be simultaneously valid, we must redefine the sectors of production as well as re-evaluate the quantity of capital and labor, «used» by the «new sectors». The quotation marks in the previous sentence were added, because the meanings contained are not concerned with actual conditions of an economy, but with technical constructions. The process of redefining the sectors of production in an economy and the subsequent re-evaluation of quantity of primary factors of production is called vertical integration of the sectors of production. The meaning of vertical integration of sectors of production has been identified in the bibliography with the name Pasinetti, who introduced it in one of his articles in the periodical «Metroeconomica» of 1973. However similar methods of vertical integration were used by Samuelson and Solow in their known book of 1958 with the title: Linear Programming and Economic Analysis.

Conclusions

This paper suggests the microeconomic establishment of macroeconomic production functions. This tool combines the abstractive properties of the cumulative production function with the realism of the CGE microeconomic foundation.

On the one hand, the microeconomic production functions are enhancing the development possibilities of economic patterns in areas where the cumulative production function –ex definition- is not able to approach. On the other hand, they are contributing to the reduction of both the volume and perplexity of CGE without causing any losses in the realism of their suppositions

[1] The macroeconomic production functions (13) should not be confused with the «sectoral» production functions $(VA) = \varphi_i(K_i, L_i)$ for which we encounter econometric evaluations.

Bibliography

1. Barro R. (1990). Government Spending in a Simple Model of Economic Growth. Journal of Political Economy. pp. 103–125.
2. Blanchard O. and Fischer S (1989). Lectures in Macroeconomics. Cambridge MA, MIT Press.
3. Burmeister E. and Sheshinski (1969). A non-Substitution Theorem in a Model with Fixed Capital. Southern Economic Journal. pp. 273–276.
4. Cass D. (1965). Optimum Growth in an Aggregative Model of Capital Accumulation. Review of Economic Studies. pp. 233–240.
5. Domar E. D. (1946). Capital Expansion, Rate of Growth and Employment. Econometrica. pp. 137–147.
6. Domar E. D. (1947). Expansion and Employment. American Economic Review. pp. 34–55.
7. Dorfman R., Samuelson P. A, Solow R. M. (1958). Linear Programming and Economic Analysis. New York, McGraw-Hill.
8. Harcourt G. (1972). Some Cambridge Controversies in the theory of Capital. Cambridge University Press.
9. Harrod R. F. (1939). An Essay in Dynamic Theory. Economic Journal. pp. 14–33.
10. Hics J. R. (1965). Capital and Growth. Oxford University Press.
11. Jones G. H. (1975). An Introduction to Modern Theories of Economic Growth. London Chapman & Hall.
12. Koopmans T. C. (1965). On the Concept of Optimal Economic Growth. In *the Econometric Approach to Development Planning,* Amsterdam, North Holland Publishing Company.
13. Leontief. W. (1941). The structure of American Economy: 1919–1939. Cambridge M. A., Harvard University Press.
14. Lucas R. (1988). On the Mechanics of Economic Development. Journal of Monetary Economics. pp. 3–42.
15. Lucas R. (1993). Making a miracle. Econometrica. pp. 251–272
16. Pasinetti L. (1973). The Notion of Vertical Integration in Economic Analysis. Metroeconomica. 1–29.
17. Pasinetti L. (1977). Lectures on the theory of Production. New York, Columbia University Press.

18. Ramsey F. (1928). A mathematical Theory of Saving. Economic Journal 38. pp. 543–559.

19. Rommer P. (1986). Increasing returns and Long Run Growth. Journal of Political Economy. 1002–1037.

20. Samuelson P. (1962). Parable and Realism in Capital theory. The Surrogate Production Function. Review of Economic Studies. pp. 193–206.

21. Solow R. M. (1956). A Contribution to the Theory of Economic Growth. Quarterly Journal of Economics. pp. 65–94.

22. Swan T. W. (1956). Economic Growth and Capital Accumulation. The Economic Record. pp. 334–361.

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