An attempt to quantify the economic system motion under the investment process incidence

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Abstract

In this paper we proposed a model deriving from physics laws, which are associated to the investments impact upon the economic system potential. Defining several physics fundamental dimensions and starting from a series of assumptions, we tried to find their possible economic meaning and interpretation. The economic growth reflected in the system potential rise under the incidence of investments, could occur on three paths (extensive, structural and intensive), depending on main factors changes: the mass of fixed capital, the resources efficiency ratio and the velocity of GDP creation. Based on the proposed model, the optimum volume and structure of investments, according both to disposable resources and targeted economic development stage, could be assessed.

Key words: system potential, physics laws, mechanics fundamental dimensions, economic growth, investments, fixed capital, technical progress, efficiency ratio, business cycle.
JEL classification: C10, E19, O11, O40

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1. Introduction

We start from the basic assumption that any measurable change of the economic system is due to an investment input. By investment we further understand the accumulation of any nature (material, knowledge, information etc.) which is inducing a change in quantity, quality or structure of any (or all) production factors. Based on the idea that, essentially, the economic growth represents a reaction of the system to the investment stimulus, we are attempting to find a model derived from physics laws which could reflect the investments impact upon the economic system motion in time and space.
Being aware of the difficulties arising from such an uncommon approach, we consider that the physics "model" is far from exhausting the potential of its utilization in economics. It is worth mentioning, in this context, the opinion of E. H. Hutten (1970) who thinks that physics has been a model for any science and that, in fact, the science, which is unique and indivisible, being created by mankind, originated in human curiosity, from the natural desire of understanding and managing the world and ourselves too.
Admitting from the beginning that the economic system has a motion along a circular orbit around a fixed point considered origin. The presumption of a circular trajectory of the economic system is obviously abstract, which has in view only a schematically representation of the perpetual reiteration of the production cycle. It also allows an analogy between this type of motion and that of the material point in physics, revealing some possible common features.

2. The main assumptions of the model

Accepting the above mentioned presumption, we also consider the following assumptions:
a) the distance from the central point around which the economic system is moving, representing the radius γ**,** is associated with the resources **efficiency ratio**, i.e. the processing degree or the efficiency of raw materials or other inputs utilization.
b) the mass of the entire economic system is concentrated into the **mass** m **of fixed capital** to which a certain efficiency ratio of raw materials, materials and energy is

corresponding. A suggestive image of this assumption is created by F. Perroux (1969) who considers investments as improving the apparatus of fixed capital which stands for the essential armature of the economy, distributing the energy into the entire aggregate.
c) the motion of the economic system occurs with a **velocity** v, represented by the gross value added created in a unit of time, or the flow rate of GDP in a cross-section unit.
Obviously, the assumptions a), b) and c) could be appreciated as questionable if we regard strictly the economic meaning of considered variables, but their acceptance under a systemic approach could lead to interesting conclusions, which we are trying to point out as clearly as possible. We are insisting upon the fact that, despite the objections, otherwise justified, that could be brought against our assumptions, what we are focusing on there is the description of investments impact upon the economic system under the circumstances of an overall view and of a certain abstraction degree. In the opinion of the physicist Max von Laue (1963) physics cannot and should not offer more. If someone who is reading the word "description" feels the lack of a causal explanation von Laue responds by the explanation of a natural process, which could be made relevant only by its relation with other processes, through known laws of the nature i.e. by the description of a complex of interdependent processes, considered as a whole.
As concerns the units of measurement that the variables γ, m and v are expressed, under an economic approach, certain observations can be made:
- the efficiency ratio is expressed by coefficients because it consists of a division between same dimensions; consequently, the ratio has an economic minimum the unity and as a mathematical minimum zero, corresponding to the origin (for instance, the efficiency ratio could be expressed by the ratio between GDP and intermediate consumption);
- the mass of fixed capital could be expressed in lei (and not in kilograms), given that money represents, ultimately, a measure of the value and it could be regarded also from a quantitative point of view (the expression "money mass" is significant in this context). To put it differently, we can imagine that, the fixed capital, from a purely physics view, is represented by the equivalent in gold of its value;
- the velocity of gross value added creation, i.e. its flow rate, could be expressed in lei on time unit, imagining that the numerator of the ratio space/time (the denominator does not raise problems, expressing the time in years for instance, although its expression in seconds is also possible, a GDP of lei 600 bn meaning lei 20 thou per second) represents, in monetary terms, the extend of the raw of the same type banknotes corresponding to its value.

3. Defining the model fundamental dimensions

In the circular motion of a material point to which the economic system movement is associated, the following fundamental dimensions are defined, with the related equations:

(1) **moment of inertia**: $\mathrm{I} = m \cdot \gamma^2$

(2) **angular velocity**: $\omega = \frac{\nu}{\gamma}$

(3) **kinetic moment** (impulse moment): $J = \omega \cdot \mathrm{I} = \gamma \cdot m \cdot \nu$

(4) **moment of force**: $\eta = \gamma \cdot F$, where: $F = m \cdot a$

(5) **kinetic energy**: $E = \frac{\omega^2 \cdot \mathrm{I}}{2} = \frac{m \cdot \nu^2}{2}$

Note: In the equations (1) – (5) the dimensions *v, J,* γ , ω , *m, F, a* have to be considered as vectors. The symbol *a* represents tangential acceleration.

Trying to find an economic interpretation of the above dimensions and considering the assumptions presented before, we could notice some remarks:
- **the moment of inertia** expresses the inertia of the economic system: the bigger the fixed capital mass existent at a time is and the higher the level of efficiency rate is, the grater the effort required for changing the system speed is and the more the difficulties to beat the inertia are. Showing that, in principle, any future effect of passed and present technical discoveries could be foreseeable, N.P. Fedorenko underlines that according to these principles, the socio-economic dynamics is characterized by a clear inertia; in this context, he considered that inertia means the impossibility of arbitrary changing, subjectively and on the short run the economic and technological structure of a society: so, development trends from the past are gradually evolving, continuing to show themselves also in the future;
- **the angular velocity**, representing the angle measured by the radius vector in a unit of time and describing the speed of rotation, is much more difficult to explain in economic terms; the ratio between speed and radius, being expressed by radians per second, could be presented also as $\omega = \frac{2\pi}{\mathrm{T}}$, where T stands for the time of an overall rotation. The angular velocity represents a qualitative element par excellence, T indicating the intensity of production process inside of the economic system: the higher the velocity, mainly due to the increase of the GDP flow rate, the bigger the decrease of the rotation period, i.e. the number of rotations in a time unit. It is worth mentioning that, from an economic point of view, the rotation period could be associated with the production cycle.

- **the kinetic moment** (impulse moment), by the coverage of the evolution basic factors, could represent the potential of the economic system, being the essential element of our model. Whether the kinetic moment is expressed as $\omega \cdot \mathrm{I}$ or $\gamma \cdot m \cdot v$, it represents the capability of the economic system, the level of development that had been reached, including also a qualitative component (ω and/or v).

4. The main objective of the economic growth: rising the system potential

The rise of the potential could be considered as the major objective of the economic growth to be achieved. It is worth mentioning that in the literature many authors are thinking that the economic growth essentially represents a process of increasing the productive capabilities of a nation[1]. Even we have another opinion regarding the definition of the economic growth we believe that, under the circumstances of the proposed model, the rise of the economic system potential constitute a measure, adequately enough, from the point of view of the economic growth measurement.

- **the moment of force** representing the multiplication of force with a certain efficiency ratio could express the potentiality of investments impact upon the economic system (the force is determined by the fixed capital mass and the acceleration, this last one representing the derivative of velocity with respect to time i.e. the growth of GDP in a time unit). Imagining a leverage, further from fulcrum (the origin in our case) the force is applied, less effort is required to achieve a certain effect; respectively, the higher the efficiency ratio where the force is applied, the more rises the effectiveness and the GDP growth in a time unit;
- **the kinetic energy** is expressed by the work made by the economic system, which the bigger it is, the higher is the velocity of GDP creation or the mass of fixed capital (one considered that the dimension of the total energy is determined only by the kinetic energy, i.e. neglecting the system friction during its motion).

The impact of investments upon the economic system motion is obviously extremely complex, their effects on considered factors being simultaneous. In order to separate the main paths to achieve the targeted objective i.e., the growth of the economic system potential, we will make use of the statistical method of growth decomposition on factors. It is worth mentioning that we will deal only with the equation (3), which defines the kinetic moment; the conclusions regarding the incidence of investments on the other dimensions described could be deduced starting from our previous considerations.

So, the total growth of the kinetic moment Δ_J is decomposing in: the growth of economic system potential due to the moment of inertia (Δ_J^{I}) and due to the rise of the

[1] In this respect, in the opinion of G.B. Stafford (1981), the economic growth is defined as increasing the potential production on the long run, this potential being determined by the volume of disposable inputs and by the current processing technology which is transforming these inputs into production.

angular velocity (Δ_J^{ω}); the moment of inertia (Δ_J^{I}) is also decomposing in the growth of the inertia due to the rise of the mass (Δ_J^{m}) and due to the rise of the radius (Δ_J^{γ}):

(6) $$\Delta_J = \Delta_J^{\mathrm{I}} + \Delta_J^{\omega} = \Delta_J^{m} + \Delta_J^{\gamma} + \Delta_J^{\omega}$$

In the equation (6) the sign „+" is revealing the additive nature of growth composition, because of the existence also of the non-discomposed growth, which could be assigned to the factors according to usual methods.

5. Paths of growing the economic system potential

As a consequence, the economic growth reflected in the system potential rise under the incidence of investments, which in fact causes the defeat of its conservation law, could occur on three paths, depending on the nature of main factors changes: extensive (due to *m*), structural (due to γ **)** and intensive (due to ω).

I. EXTENSIVE ($m_1 > m_0$; γ = constant; ω = constant)

If γ remains constant and *m* rises, due to the law of the kinetic moment conservation, a decrease of *v* and implicitly of ω should occur. In this case, the role of investments is to defeat the law of the kinetic moment conservation and, consequently, to maintain constant the angular velocity ω and the velocity *v*, the efficiency ratio remaining the same. The investments, oriented to the increase of the mass *m* of the fixed capital, make the period of business cycle maintaining constant, which leads to a rise of the kinetic moment, otherwise their impact upon the economic system potential being null. So, the growth of the economic system potential in this case is due exclusively to the rise of the fixed capital mass, as follows:

(7) $$\Delta_J^{m} = \omega \cdot \gamma^2 \cdot (m_1 - m_0)$$

Consequently, this path of growing the economic system potential could be considered **extensive**.

II. **STRUCTURAL** ($\gamma_1 > \gamma_0$; m = constant; ω = constant)

If *m* remains constant and γ rises, due to the law of the kinetic moment conservation, a decrease of *v* and implicitly of ω should occur, as in the previous case. The investment role is also here to defeat the law of the kinetic moment conservation and to maintain the angular velocity constant, but is registering a rise in velocity, proportional with the

radius change. The higher the efficiency ratio is, the longer becomes the business cycle. In this case, just the investments are the adjustment tool of this duration, by putting into operation the fixed capital of an equal mass with that removed from service, but having higher performances and quality from the point of view of the raw materials processing. So, the growth of the system potential could be achieved in this case by promoting investments in fixed capital bearing of technical progress, as follows:

(8) $\Delta_J^{\gamma} = \omega \cdot m \cdot (\gamma_1^2 - \gamma_0^2)$

Consequently, this path of growing the economic system potential through investments which are changing the structure of fixed capital could be considered **structural**.
These two cases discussed, where the growth of the economic system potential is caused by the inertia rise (due to the increase of the fixed capital mass, respectively of the efficiency ratio) shows that, in time, the required investment effort is increasingly higher as compared with the effects acquired, given the system inertia rise to the extent of its extensive and even structural development. Referring to this, Postolache T. (1981) showed that the inertial force of the economic mechanism tends to the reproduction – on the same technical base and structure – of the production apparatus, because on the short run is the most advantageous. This inertial force, Postolache added, is hitting the new requirements and conditions which appeared meanwhile in the economy, generated from the most varied origin.

III. **INTENSIVE** ($\omega_1 > \omega_0$; m = constant; γ = constant)

If m and γ remain constant, following the same law of kinetic moment conservation, v and ω should also maintaining constant. As in the previous cases, the investment role is to defeat the law of kinetic moment conservation, but, in this case, by the rise of the angular velocity and, consequently of the velocity. So, the higher the intensiveness inside the system is, the lesser is the business cycle period, a rise in velocity of GDP creation being registered. The investments are oriented to the improvement of quality and performances of the fixed capital, being able, with the same mass and without changing the efficiency ratio, to give rise of GDP flow rate, reducing the business cycle period or, which is the same thing, increasing the number of rotations in a time unit. So, the growth of the economic system potential could be achieved with the help of investments, which are contributing to the production process intensification, as follows:

(9) $\Delta_J^{\omega} = \mathrm{I} \cdot (\omega_1 - \omega_0)$

Consequently, this path of growing the economic system potential through investments, which are accelerating the rotation velocity and increasing the processes intensity, could be considered **intensive**.

A special notice should be made regarding the contradictory status of the efficiency ratio γ**,** which is bringing effects both on the quantitative factor ($I = m \cdot \gamma^2$) and the qualitative one **(**$\omega = v / \gamma$**)**. An increase of efficiency ratio implies, on the one hand, a rise in the moment of inertia and on the other hand, a decline in the angular velocity, which could be compensated, like in the case II, by the structural path of investments impact. This also reveals that the connection between quantitative and respectively qualitative factors of growing the economic system potential is completed through the structural ones.

In reality, as we have previously mentioned, the economic potential growth in a given period results through the joint action of all three factors. Based on the proposed model, the contribution of each factor to the economic potential growth can be separated – for the past – and the optimum volume and structure of investments according to the disposable resources and to the targeted economic development stage can be assessed – for the future.

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