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"Periodic Table of Elements" for the Digital Economy

Elena Pilipenko

Institute of Economics and Entrepreneurship, Nizhny Novgorod State National Research University, Nizhniy Novgorod, Russia

Email address

pilipenkoev@bk.ru

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Abstract

The rapid digitalization of society makes the transformation of existing economic systems inevitable. Is it possible to predict the economic characteristics of the digital age? Natural sciences have very effective forecasting tools - in chemistry, for example, it is the periodic system of chemical elements by D.I. Mendeleev, which establishes a qualitative dependence of the properties of chemical elements on the quantitative change in the mass of their atomic nucleus and which allows to anticipate the properties of undiscovered elements. The purpose of the article is to substantiate such universal laws for the creation and development of economic systems of any level and degree of complexity. As a research method, it is proposed to consider the structure of the products manufactured in terms of the ratio of the two main production factors: Knowledge and the Substance of Nature. The ratio of the factors ("Knowledge-Substance of Nature") in product manufacture is determined by the geometric dimension of the Substance of Nature involved in the manufacture of this product. In fact, when the geometric dimension of the Substance of Nature used to manufacture a product changes, the socio-economic system also changes. With changes occurring within the size range, the economic system evolves; for a transition from one range to another, a revolution occurs that requires the breakdown of old socio-economic conditions, institutions and tools and the creation of entirely new ones. Thus, an element whose quantitative changes lead to qualitative changes in the economic system is the share of knowledge in the structure of the product, which finds a tangible expression in the geometric dimension of the Substance of Nature used to manufacture this product. Knowledge of these laws allows us to move from the "empirical" to the strictly scientific and theoretical study of economic reality, to forecasting socio-economic processes and towards building effective economic models.

Keywords

Digital Economy, Knowledge-Based Economy, Technological Wave, Economic Product, Mental Production

1. Introduction

Economics is a truly extraordinary science having its Nobel prize winners but having no "fundamental laws" or, at least, "universal character regularities".

The core of all concerns about the economic science is related to the fact that we've not yet determined the element quantitative changes in which result in the qualitative changes of the economic system.

Meanwhile, for natural sciences such regularities are clearly specified: the most illustrative example is the periodic table of the chemical elements of D.I. Mendeleev setting the qualitative dependence of the properties of the chemical elements on the quantitative changes in their nuclear atom mass.

Is it possible to define such dependence for a social science - economics?

Years-long studies carried out by the author in the field of knowledge-based economy allow answering this question positively.

2. Method and Model

Studies in the sphere of knowledge-based economy allow asserting that above-mentioned "regularities having universal character" exist and, moreover, can be defined and formulated.

The element quantitative changes in which result in the qualitative changes of the whole economic system is the share of knowledge in the structure of the produced economic product.

Economy as a kind (sphere) of social activity exists only to produce an economic product. If there is no need in the product, then there is no need in the economy. Thus, it is fair to assume that the specific features of the economy are determined by the specific features of the product produced.

Products of different social epochs and technological modes that are incomparable in particular forms and peculiarities can be compared in abstract quantities and terms, that is, in the structure of products produced within the frames of these epochs and modes. Structure of the product is nothing else but the total of the shares of production factors in the product produced.

All factors participating in the production of "economic product" can be subdivided into 2 major groups: Knowledge and Substance of Nature. Such two-factor model of social production is universal and can be applied to all social epochs and technological modes without exception. Such division is viewed as the most logical and natural following from the very essence of the production process understood as a "specifically human type of substance exchange with the nature, or, to be more precise, a process of active transformation of natural resources by people with the aim of creating necessary material conditions for their existence". [1]

Here it is necessary to give a number of explanations. The initial two-factor model of the social production was described as Human / Natural Resources (Nature), but the necessity of ensuring the maximum comparability of the products of different epochs and technological modes required amending the definition of the factors.

"Human" factor: participates in the production process by means of applying physical or intellectual labour or (more frequently) both kinds. Impossibility to compare adequately the intellectual labour to the physical one results in the necessity of reformulating the initial factor. Let's define the "Human" factor as "Knowledge". This replacement is deemed adequate and reasonable for:

1. the knowledge is a unique factor creating the possibility of interacting with the Nature and influencing it, especially with the aim of transforming it;
2. the knowledge is a unique product of the human mind. In the Nature it is impossible to "find" the Knowledge like natural resources etc. The Knowledge can be only *created, produced* by the Human Being, and only in the process of the mental production;
3. with a certain (but permissible, in our opinion) degree of abstraction it might be assumed that a human being is nothing else but the whole of the knowledge he or she bears: this is the knowledge that defines a man's concept of the world and his or her place in it, of the means of interaction with Nature and the Society, of the opportunities and limitations etc. It is no exaggeration to say that the difference between people is defined by the difference in the knowledge they bear and the concepts and ideas formed on its basis;
4. a place of the Human being in the production process and whether he or she will be involved in the physical or the intellectual labour is entirely defined by the knowledge he or she has.

"Knowledge" is a product of production (economic) activity of people in the sphere of mental production.

Properties of knowledge:

1. knowledge is a product of mental production resulting mainly from *non-paid activities,* namely from *"self-creation" and "personal self-improvement"*. Market incentives have very weak influence on knowledge production - if a person is not a creative individual, money will not work in this situation. Creation is a mental process being beyond the control of the market [2];
2. knowledge is a result of the *universal* labour. Creation of knowledge is always a result of processing scientific knowledge accumulated by the whole humanity. Important role in this process is played by "general intelligence", general culture, and knowledge based on life experience, so the necessary condition for knowledge creation is not *competition* but *collaboration and interaction.*
3. knowledge is a product being *non-marketable* in itself. Knowledge does not have *exchange value.* Knowledge in itself *is wealth and a source of wealth without producing anything that can be sold.* As a *source of wealth* it is a "productive power". When considered as *wealth* it is a source of sense and a goal in itself [3].

Identity of knowledge as an economic asset, as a product, is explained by one simple fact being beyond the control of anyone's will – *knowledge can be created only by people and only in the process of mental production.* This fact determines the methods and peculiarities of its functioning in the economic field, its characteristics as a product (non-material, universal, non-marketable character), possible mechanisms of management, performance criteria and indicators [4].

Studying the process of knowledge production from the moment of knowledge creation in a person's mind through its coding using tangible media to its materialization in products and services brings us to a conclusion about the necessity of reviewing the concepts of content and system of communications within the economic field – it is proposed to distinguish between three interrelated and interdependent spheres of economic activity within the integrated economic field: mental, information and material types of production [5-7] – figure 1.

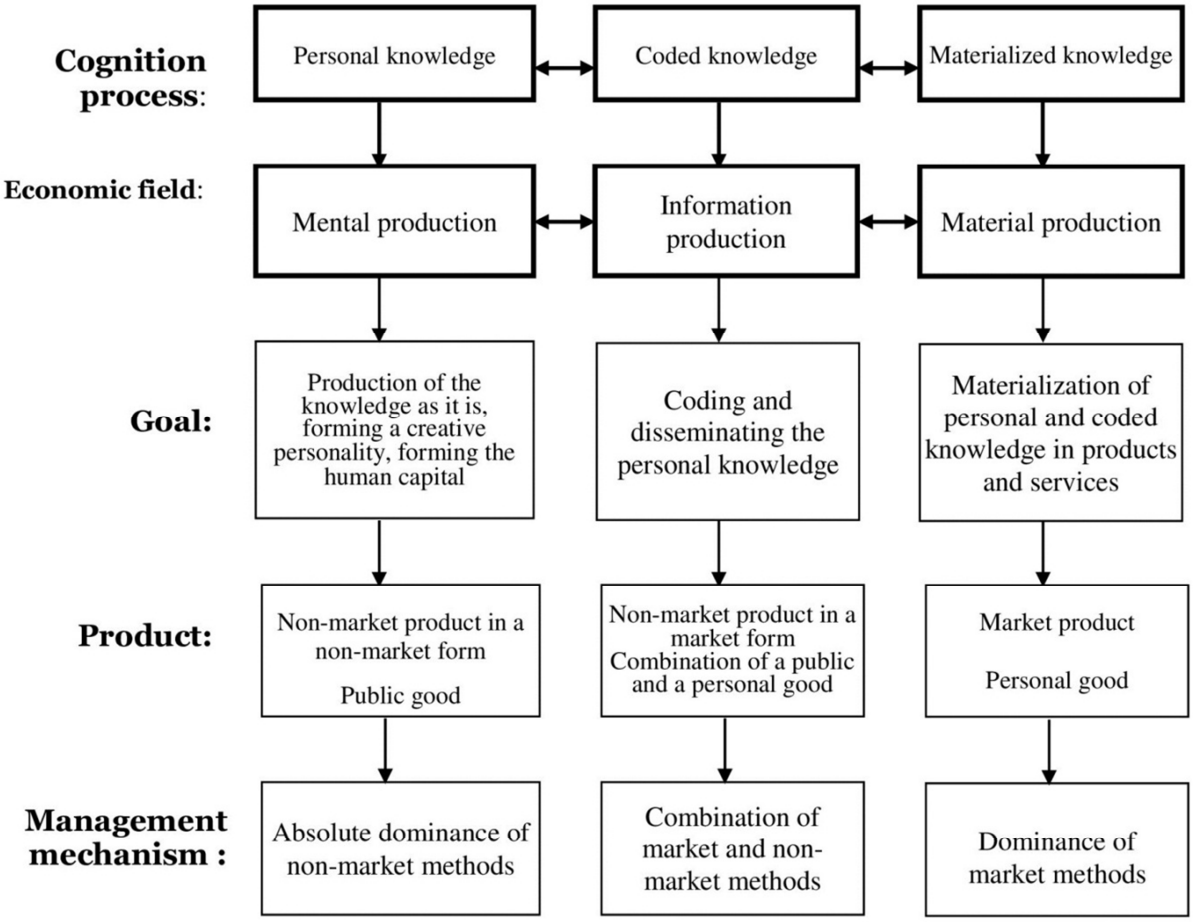

Figure 1. *System of categories of the knowledge-based economy.*

Principal differences between these three types of production are related to the differences between the *products* produced:

- in *mental production* - it is a *non-material non-formalized product:* ideas, theories, images, moral values, social relations, a person as a creative individual;

-in *information production - it is a non-material formalized product:* information technologies, information on tangible media (books, disks etc.)

- in *material production* - it is a *material formalized product:* all variety of man-made objects of the material world.

Mental production is a factor which, not being taken into account in the economic studies, brings about incorrect results in general. The fact that the economic theory ignores the existence, peculiar features and the leading role of mental production makes all the "basic models" incomplete, and the results of the studies – non-universal.

Generally material production is *always secondary* as related to mental production, because it only implements the ideas and images already *created* within the frames of mental production. Thus, the reasons for the situation taking place in material production should always be searched in the level of development and other characteristics of mental production. Failure to take account of this fact underlies the "inexplicable" phenomena and crises in economy, as well as the lack of the "single formula" for the organization of material production in the societies possessing different types of mental production.

Thus, when limiting the sphere of studies with material production, the modern economic theory limits its prospects in studying and defining the actual reasons of economic phenomena, because it focuses efforts on studying *consequences* without studying the *reasons.*

"Natural resources (Nature)" factor: the studies have demonstrated that the term "Natural resources" characterizes exhaustively the cognominal production factor in the technological modes (hereinafter referred to as TM) 1-4, and requires amending when we speak about the 6th and, partially, the 5th technological modes. Nanotechnologies forming the core of the 6th TM predetermine the dimensional level of all elements of the production process - it's a nanolevel, i.e., in fact, the level of separate atoms and molecules. It is more correctly to define "Natural resources" on the nanolevel as the "Substance of Nature". *On the nanolevel non-natural resources are formed from the "substance of nature" and undergo further treatment in the course of the production process,* just as the natural resources were undergoing treatment within the frames of the previous technological modes (from the 1st to the 4th). Thus the factor of the "Substance of Nature" is universal for all economic epochs and technological modes.

As a result the model "Human- Natural Resources" is transformed to "Knowledge – Substance of Nature" – figure 2.

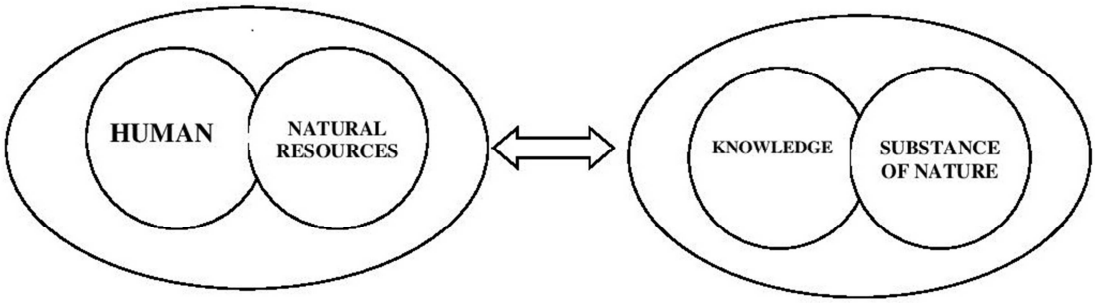

Figure 2. *Two-factor model of social production.*

"Substance of Nature" is a 100% material and, hence, marketable product. Ways, methods, laws of production, exchange, distribution and consumption of material products, "goods", have been under study for several hundreds years, they are all well-known and unchangeable. "Knowledge" is a 100% nonmaterial and, hence, non-marketable product. Ways, methods, laws of production, exchange, distribution and consumption of this kind of product are studied by the economy as a science much less; still some data has already been collected. In fact, under such conditions, the problem of determining a social and economic model and an institutional matrix of any technological mode reduces to the organization of interaction between marketable (material) and non-marketable (non-material) production within the frames of this mode.

3. Result

As demonstrated by the studies, the correlation of the factors ("Knowledge – Substance of Nature") in producing the product *is defined by the geometrical dimension of the Substance of Nature participating in the production of this product.*

Structure of the social product in relation to technological modes is described in table 1:

Table 1. *"Periodic system of elements" for economics.*

Geometrical dimension of the substance of nature participating in the production of the product	**Structure of the economic product, by factors,%**		**Correlation to the:**	
	Substance of nature	**Knowledge**	**Technological mode (TM)**	**Stage of development of the economy**
1	**2**	**3**	**4**	**5**
Macro-level *(1 mm and more)*	*75 (100-75)*	*25 (0-25)*	1, 2 TM	*Pre-industrial economy*
Meso-level *(10s of mcm -1mm)*	*50 (75-50)*	*50 (25-50)*	3, 4 TM	*Industrial economy*
Micro-level *(1mcm-10s of mcm)*	*25 (50-25)*	*75 (50-75)*	5 TM	*Post-industrial economy*
Nano-level *(1 nm– 1 mcm)*	*5 (25-5)*	*95 (75-100)*	6 TM	*Knowledge-based economy= Digital economy*

Graphically the data given in the table 1 are presented in the Figure 3

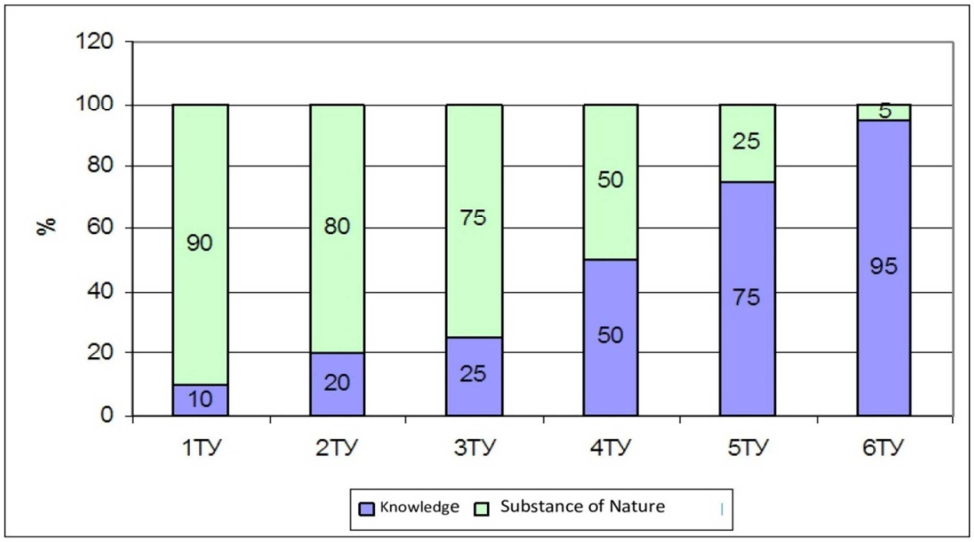

Figure 3. *Structure of the social product in relation to technological modes, as percentage of total.*

Defining the dependence (in fact, *a function* as demonstrated by the studies) of the economic system from the geometrical dimension of the Substance of Nature treated is not usual, but very reasonable and logical. Let's remember that the production of any other product requires the presence of objects and instruments of labour, and the means of connecting them in one production process – technology.

It is clear that both the instruments of labour and the means of applying them (technology) are entirely defined by the specific properties of the objects of labour that undergo treatment – their parameters and size, that is, the geometrical dimension.

It is impossible to produce a micro circuit or computer semi-conductor elements which dimensions equal to one micrometer using a CNC machine treating materials designed for the dimensions not excessing several dozens of micrometers. The contrary is true as well – cast iron or steel work parts that need to be treated using metal-cutting machines can't be treated using nanotechnology instruments.

In fact, according to the table, changing the geometrical dimension of the substance of nature used by the society to produce the economic product changes the social and economic system.

The more radically the dimension is changed, the more radical are the changes in the economic system. When the changes are made within the frames of the dimension range (column 1 of the table), we face the *evolution* of the economic system, when there is a transfer from one range to the other there is a *revolution* requiring the destruction of the old and the creation of the totally new social and economic conditions, institutes and instruments.

Actually, nano- and biotechnologies do not "develop" from the technologies of metal and machine treatment and do not "fit" in them, but entirely substitute them requiring the adequate changes in the social and economic system forming conditions for their implementation.

Thus, production of coal fuel or slate from the natural substance – graphite – does not require neither educational system (even primary) nor fundamental science. That's why the economic system of the society bearing knowledge allowing to use graphite only in the form of coal or slate does not establish such expensive and complex systems as education and science.

But to produce nanotubes from the same substance (taking into account that the technology of production requires producing fullerenes, laser evaporation (ablation), arc-jet synthesis, catalytic pyrolysis of carbohydrates, separation of metal nanoparticles) it is necessary to have the well-developed educational system (to the level of higher education for everyone) and research as an industrial sector.

Thus, economy as a sphere of social activities is responsible for the organization of the system of social relations necessary for treating the Substance of Nature on the level technologically available for the society. It goes without saying that this is the Knowledge being at the disposal of the society and the man that makes the Substance of Nature "technologically available" [8].

4. Conclusion

Correlation of two production factors – "Knowledge" and "Substance of Nature" determines all the major social and economic parameters:

- social order;
- economic model;
- institutional matrix etc.

Further studying of regularities and particular features of interaction of "Knowledge" and "Substance of Nature" allows coming over to the "economic constructivism" that is of special importance today under the conditions of parallel existence and differently directed development of products and productions of different technological modes.

Economy as a sphere of social activities is responsible for the organization of the system of social relations necessary for treating the Substance of Nature on the level technologically available for the society.

All changes in the character of interaction between humans, society and nature are always, in the first instance, a result of both evolutionary and revolutionary changes in the mental, intellectual nature of human beings, their progress in the process of understanding the world (nature) from beliefs to theoretical scientific knowledge. Conclusion about the evolution of knowledge as the main reason for all changes in the society evidently points out the main protagonist being the reason and the result of these changes at the same time – a human being. [9, 10]

Thus, any influence on knowledge as *an economic asset* with traditional economic tasks – increasing efficiency and returns etc. – is the influence *on mental, intellectual, moral sphere of human activities*, that is a totally new task for the economy [11].

This fact determines the novelty and complexity of the knowledge-based economy development and brings about the necessity of reviewing and revaluation of nearly all existing social and economic mechanisms in the context of their *utility or disutility* for the process of forming a *creative individual* as a *sole knowledge producer*. At the same time it brings hope that finally a person will become not a means but a target of the social and economic development and "the measure of all things" [12].

Further studying of regularities and particular features of interaction of "Knowledge" and "Substance of Nature" allows coming over to the "economic constructivism" that is of special importance today under the conditions of parallel existence and differently directed development of products and productions of different technological modes [13].

Understanding of these regularities allows moving from "empiric" to strictly scientific, theoretical studies of economic reality, forecasting of social and economic processes and building effective economic models that will, in its turn, allow to save time and resources and increase efficiency.

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