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Digital Transformations:
Challenges and Benefits for the Economy and Society

Digital Transformations: Challenges and Benefits for the Economy and Society

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Digital Transformations: Challenges and Benefits for the Economy and Society

Monograph

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3.3. SCIENTIFIC APPROACHES TO THE FORMATION OF ORGANIZATIONAL AND ECONOMIC MECHANISMS OF FUNCTIONING OF ADDITIVE (DIGITAL) ECONOMY

Introduction. Transformational changes in the economy are taking place more intensively and becoming more radical. Today, Industries 3.0, 4.0 and 5.0 are running simultaneously. The combination of these three industrial revolutions, and as a result, the decentralization of production, the financial system, the socialization of society and the rise to a new level of artificial intelligence became the reason for the formation of a new economy – additive, which can roughly be called digital. The additive economy combines the advantages of green, digital and creative. Therefore, it is important to determine approaches to the formation of the organizational and economic mechanism of its functioning.

Analysis of recent research and publications. Many scientific works are devoted to the issue of digital transformation in the course of the latest industrial revolutions. Among the most cited are the works of such scientists as Frank A. G., Dalenogare L. S. and Ayala, N. F. (Frank et al., 2019), Ghobakhloo, M. (Ghobakhloo, 2020), Culot, G., Nassimbeni, G., Orzes, G., and Sartor, M. (Culot et al., 2020), Ibarra, D., Ganzarain, J., and Igartua, J. I. (Ibarra et al., 2018), Osterrieder, P., Budde, L., & Friedli, T. (Osterrieder et al., 2020). The concepts, foundations, key components and directions of development of the additive economy are outlined by us in (Melnyk et al., 2022).

This scientific work aims to consider the main patterns and principles on which the organizational and economic mechanism of the additive economy is based**.**

Feedback mechanisms as a basis for adaptation and transformation of socio-economic systems. The external conditions of the system's functioning, which are constantly changing, require it to have effective mechanisms for managing its state. The system must adapt to the conditions of the external environment by changing the parameters of its internal system elements (subsystems) and rebuilding the connections between them along the way. Socio-economic systems can do this with the help of feedback mechanisms (Table 1).

Table 1. The content of the feedback mechanisms of the enterprise due to the decrease in demand for its products and the decrease in its sales volumes (Melnyk, 2016)

Type (direction) of the feedback mechanism	Action content	Type of free energy expenditure (quasi-energy)
Negative	Actions aimed at preserving the volume of product sales through: a) additional marketing and advertising; b) increasing the quality of products and maintaining the volume of sales while maintaining the price level or a forced decrease in the volume of sales when the price of products is increased; c) decrease in the price of sold products with the prospects of increasing the volume of sales and maintaining the total volume of sales	a) additional costs for marketing and advertising; b) an increase in the cost of production, which, as a rule, leads to a decrease in the amount of profit received; c) a decrease in the amount of profit that can be obtained from the sale of products
Positive	Abandonment of previously produced products and transition to the production and sale of new products	Costs for modernization of production lost profit from production stoppage and non-sale of previously produced products

The cost of feedback mechanisms is the consumption of free energy (quasi-energy) of the system. In implementing *negative feedback mechanisms*, energy is spent (or not received) to maintain the state of the system at a constant level. In the case of *positive feedback mechanisms*, the system is forced to bear additional costs for its state's transformation (restructuring) (this can be verified by looking at the contents of Table 1). Both groups of feedback mechanisms – negative and positive – ensure system stability.

The negative feedback mechanism ensures the maintenance of the existing homeostasis. Several types and directions of action of negative feedback mechanisms can be distinguished.

According to the system's compensatory reaction type, two types of mechanisms can be conventionally distinguished: *increasing (intensifying)* and *decreasing (damping)*.

Increasing mechanisms are associated with the need for system activity aimed at "increasing" certain parameters of homeostasis while reducing the corresponding parameters of the external environment. In this case, the system's activity is often associated with additional activity (intensification).

Reducing mechanisms aim to reduce certain system properties due to the corresponding increase in the values of the parameters of the external environment.

Of course, both types of mechanisms are associated with energy consumption. According to the *direction of action*, the considered mechanisms can be conventionally divided into two groups: *endogenous* and *exogenous*. An endogenous group of mechanisms has an intrasystem orientation and is associated with a change in the system itself. *The exogenous group* is aimed at changing the parameters of the external environment. This may be related to environmental conditioning conditions, processing (filtering) of incoming and outgoing metabolic flows, cooperation with other systems, and migration of this system in space and time.

A stationary system can maintain a state of dynamic equilibrium only by using the free energy it receives. However, what will happen if the dynamic balance is nevertheless irreversibly disturbed, that is, the system's parameters go beyond the "point of no return" to the level of homeostasis that existed? There can be two reasons:

a) changes in the system itself (the system weakens/becomes stronger);

b) changes in the external environment (it becomes less favourable/more favourable for maintaining homeostasis).

These factors are difficult to see for the system itself because they lead to the same consequence, which can be formalized as "the mismatch of the system's resources with the conditions of the external environment." In other words, the system cannot maintain a state of dynamic equilibrium (homeostasis) under the existing external environment conditions. In this case, two different situations may arise.

1. *Free energy turns out to be insufficient* to "extinguish" the influence of the external environment (the environment is "perceived" by the system as "excessively rigid").

2. *Excess energy accumulates in the system*, which it "does not have time" to spend on its needs or dissipate into the external environment (the environment is "perceived" as "too favourable").

In the case of *the positive feedback mechanism*, the system rebuilds its organizational structure while also changing the level of homeostasis.

According to *the types of changes* in the level of homeostasis, transformation systems can be conditionally classified into three groups:

1) those that increase the level of homeostasis;
2) those that reduce the level of homeostasis;
3) those that simulate a change in the level of homeostasis.

The latter are connected not so much with a real change in the real level of homeostasis, as with ensuring its external manifestations. This is usually related to implementing any protective functions of the system.

According to the nature of the reversibility of the changes occurring, homeostasis transformations can be differentiated into two groups: reversible and irreversible.

Reverse transformations involve the possibility of returning to the previous level of homeostasis without qualitative changes in the system.

Irreversible transformations are associated with the impossibility of returning to the former qualitative state of the system when the possibility of returning to the former homeostasis level is theoretically excluded. Yes, the transformations of a caterpillar into a pupa and then a pupa into a butterfly are irreversible.

In the economy, similar transformations are associated with restructuring enterprises and industries. Returning to the old state is no longer possible due to the loss of many connections within and outside the system.

According to the nature of the post-transformation changes in the system, the transformation mechanisms can be differentiated into two groups:

(1) mechanisms that *do not change* the characteristic features of the system (*adaptive* mechanisms);

(2) mechanisms that *change* the characteristic features of the system, after which the former system ceases to exist, turning into its successor (or successors) with the help of *bifurcation* mechanisms.

Positive feedback is *self-reinforcing*. The stronger they act, the greater the impulse from the system to gain.

Classes of transformation mechanisms. The scientific work (Melnyk, 2016) presents two main classes of transformational mechanisms: which can be conditionally called *adaptive* and *bifurcation*.

Adaptation mechanisms assume such a nature of changes in the system that allows it to adapt to the influences of the external environment without losing its fundamental distinguishing features. With the adaptation mechanism, despite all the changes, the system continues to preserve its integrity, that is, to remain itself: a biological organism – the same biological organism, a family – a family, a firm – a firm, a military unit – a military unit, a state – a state.

Bifurcation mechanisms assume such a nature of changes in the system which the system *loses its fundamental distinguishing features, passing into a new quality* while preserving the hereditary connection with the former state.

These transformational mechanisms are dialectically interconnected. The adaptation mechanism implements the function of adapting the system to changes in the external environment through the selection of states of the system itself. According to the principle of I, the system is being restructured at the system level. Prigogine: the minimum of entropy production at the maximum of system entropy (Hazen, 2000).

Bifurcation changes have a very important, from the point of view of the acceleration of development processes, property: they dramatically increase the characteristics of the variability of the system under two very important prerequisites:

- first, after bifurcation (i.e., branching), the system breaks up into many possible structures (states), within which it can further develop (hence the name of this class of mechanisms);
- secondly, the stochasticity and uncertainty of each of these states increase sharply; it is impossible in principle to predict in advance which of these structures will be realized (will be selected), because it depends on the inevitably present random changes - fluctuations of the system.

Compared to the adaptation mechanism, the bifurcation mechanism has a whole series of distinctive properties that allow enormous acceleration of development processes. These properties include:

- colossal increase in the variability of states (that is, possible options for changes) and the spread of possible values of system parameters;
- the uncertainty of the future, which is explained by the high degree of randomness and the probability of fluctuations (spontaneous changes) of the system;
- irreversibility of development; due to the jump-like nature of the changes, the probability of returning to the reverse state is practically zero (!); development, acquires directionality and irreversibility.

In light of this, the bifurcation mechanism creates almost ideal conditions for development. It contributes to the maximum acceleration of development rates. The state of "catastrophe" in which the system sometimes appears allows one to "forget" (or almost "forget") one's past.

Transformational processes in the system are associated with a change in the level of its homeostasis. This happens both during adaptive and bifurcation transformations of the system.

At bifurcations, the system passes through three possible states: stable-stationary (from which it exits); excited-turbulent (through which it passes); refractory, that is, a state of relaxation (into which it enters, finding a new level of homeostasis).

Features of the excited-turbulent state. The excited-turbulent state of the system described above is characterized by the fact that it leaves the stationary state and changes the values of its parameters in a jerky manner. This condition has a number of features. Among the main ones, the following can be distinguished:

- crisis; the system undergoes a sharp "break" in its parameters, a catastrophic disruption of connections between system elements; experiences a difficult condition due to a violation of usual cause-and-effect relationships and linear algorithms of behaviour (for example, "the more / less, the better");
- versatility; there is a multivariate continuation of the states of the system itself or successor systems (replacement of products produced at a production enterprise; elections of a new parliament or replacement of the cabinet of ministers in the country; change of projects carried out on a competitive basis in a scientific institution; etc.); the instability of the crisis state of the system in combination with the multiplicity of potentially possible (virtual) continuation options leads to the possibility of a sudden change in the trajectory of the system's development;
- irreversibility; the reasons for the irreversible development of the system are created; the system is not able to fully return to the old state (the company dismantled the old technological line, as the demand for old products fell; the new composition of the parliament begins radical changes in the economy, dismantling the former institutions (the money spent on new projects can no longer be returned for implementation old; it is difficult for former team players to return to the new team).

Phase transition (phase transformation, phase transformation) in a broad sense – the transition of a system from a stationary state with one homeostasis to a stationary state with another homeostasis (other homeostasis – in bifurcation transformations); in a narrow sense – a jump-like change in the properties of the system with a continuous change in external factors.

The critical state is the limit state of equilibrium of the system, in which adjacent phases become identical in their properties. After the system transitions to a critical state, a phase transition occurs.

Critical point – the value of a parameter (or parameters) of the system after reaching the critical state of the system occurs.

A bifurcation point is a critical point after which bifurcation transformations of the system begin. From a mathematical point of view, a bifurcation point can be considered a point (parameter value) through which two or more branches of the equation's solution describing the system's possible states pass.

Reasons for the linear behaviour of the system. Preservation of the stationary state of the system (stable level of homeostasis), which is usually observed during adaptive changes, creates conditions for the linear nature of the dependence of system parameters on changes in environmental factors. In this, the system's behaviour is characterized by the reversibility of the state, the continuity of the most important parameters, the predictability of changes in the system, the immutability of cause-and-effect relationships over time. Accordingly, all these properties are embedded in the principles of system behaviour, which can be conditionally called linear.

The main principle of management, built on linear thinking and the priority of using negative feedback mechanisms, consists in weakening (neutralizing) the action of unfavourable (for the existing level of homeostasis) factors ("the less, the better...") and strengthening the action of favourable factors ("the more, the better...").

Causes of nonlinear behaviour of the system. In bifurcation-type transformational processes, the prerequisites for the linear behaviour of the system, aimed at activating the manifestation of favourable factors and counteracting the influence of unfavourable ones, are exhausted. As a matter of fact, under such conditions, the grounds for such differentiation of factors

of the external environment (i.e., into favourable and unfavourable ones) are generally being eroded.

If the former level of homeostasis disappears, there is no need to maintain it. The task of applying feedback mechanisms is fundamentally changing. There is a need (and one can say, an opportunity) to influence not the factors of the external environment (strengthening or weakening their effect) but the state of the system itself, rebuilding it in such a way that it best corresponds to the values of the external environment.

Thus, non-linear behaviour is necessary for transforming any socio-economic system towards a new level of homeostasis.

The fundamental difference between linear and non-linear logic is that the first is focused on maintaining the existing level of homeostasis (with priority use of negative feedback mechanisms). Non-linear logic and its corresponding non-linear behaviour pursues a different goal – the search for a new level of homeostasis that best corresponds to the conditions of the external environment (with the priority of positive feedback mechanisms).

Nonlinear logic is the basis of designing the system's future state under the conditions of bifurcation transformations. At the same time, the designed state of the system (a project of innovative content or form) must contain the following components:

a) of the current state – mainly determine the form and even the key (most important) elements that are the memory carriers of the system;

b) of the future state – mainly determining the goal (main function) that this state should provide.

The designed state should contain fragments of the system's old and future (desired) states. In this, the future state should be represented primarily by the goal (content) of development and the old state by the form.

In particular, the success in the modern rapid electrification of road transport is explained precisely by the fact that the mentioned principle was maintained: it was possible to put new content into the old forms familiar to the mass consumer, including both the car itself and the infrastructure used by it (close to the usual networks of gas stations). The conversion of cars to hydrogen fuel is taking a similar path.

In the social system, man is the main designer of his new state. Non-linear thinking acts as a basic tool. It is designed to build a kind of bridge between the present and future states of the system. The main function of non-linear thinking is designed to contribute to forming such a direction of system change, which would maximally contribute to increasing its efficiency. For this to be implemented, it is first necessary to use the "energy of the tendency" of the development of the system as much as possible – it begins to accumulate features and features of the state that meet the minimum criterion entropy (minimum energy dissipation).

Organizational and economic mechanism of enterprise functioning based on the principles of additive economy. The main (basic) element of the additive economy is the person. Human capital in the additive economy determines the competitiveness of socio-economic systems. At the same time, in the additive economy for an enterprise, human capital includes not only the enterprise's personnel but also its client base, suppliers, interested parties, etc. The quality and quantity of human capital are determined not only by the economic value of knowledge, skills, and abilities but also by the quality of the external environment and the effectiveness of economic institutions – rules, regulations, restrictions, and stimulants. Competition between countries, regions, local communities, and companies does not take place for financial or natural resources but for knowledge or human capital – an asset capable of generating new added value.

At the enterprise level today, a new tool is needed to measure its creative human capital. In the conditions of the additive economy, the enterprise needs to understand that transformational changes and, accordingly, changes in homeostasis begin with a review of its relationship to human capital. Moreover, the competitiveness, even the viability of the enterprise in the new economy depends on the created conditions for the development of human capital. Successful enterprises

independently create the necessary conditions for the retraining of human capital. Today, human capital training takes place not only in the physical dimension but also in the virtual space, taking into account the growing relevance of online education, courses, seminars, trainings, etc. All this allows for the development of an industry that can transform and unite in clusters with leading universities in their fields of activity and, thus, regain a leading role in attracting, forming and developing human capital.

The organizational and economic mechanism of the functioning of the enterprise based on the principles of the additive economy should include all the main tools of Industries 3.0, 4.0 and 5.0 (Fig. 1). The given toolkit should provide comfortable conditions for the creative work of human capital based on the best motivational practices. At the output, the organizational and economic mechanism should produce new added value based on innovation, which produces creative human capital.

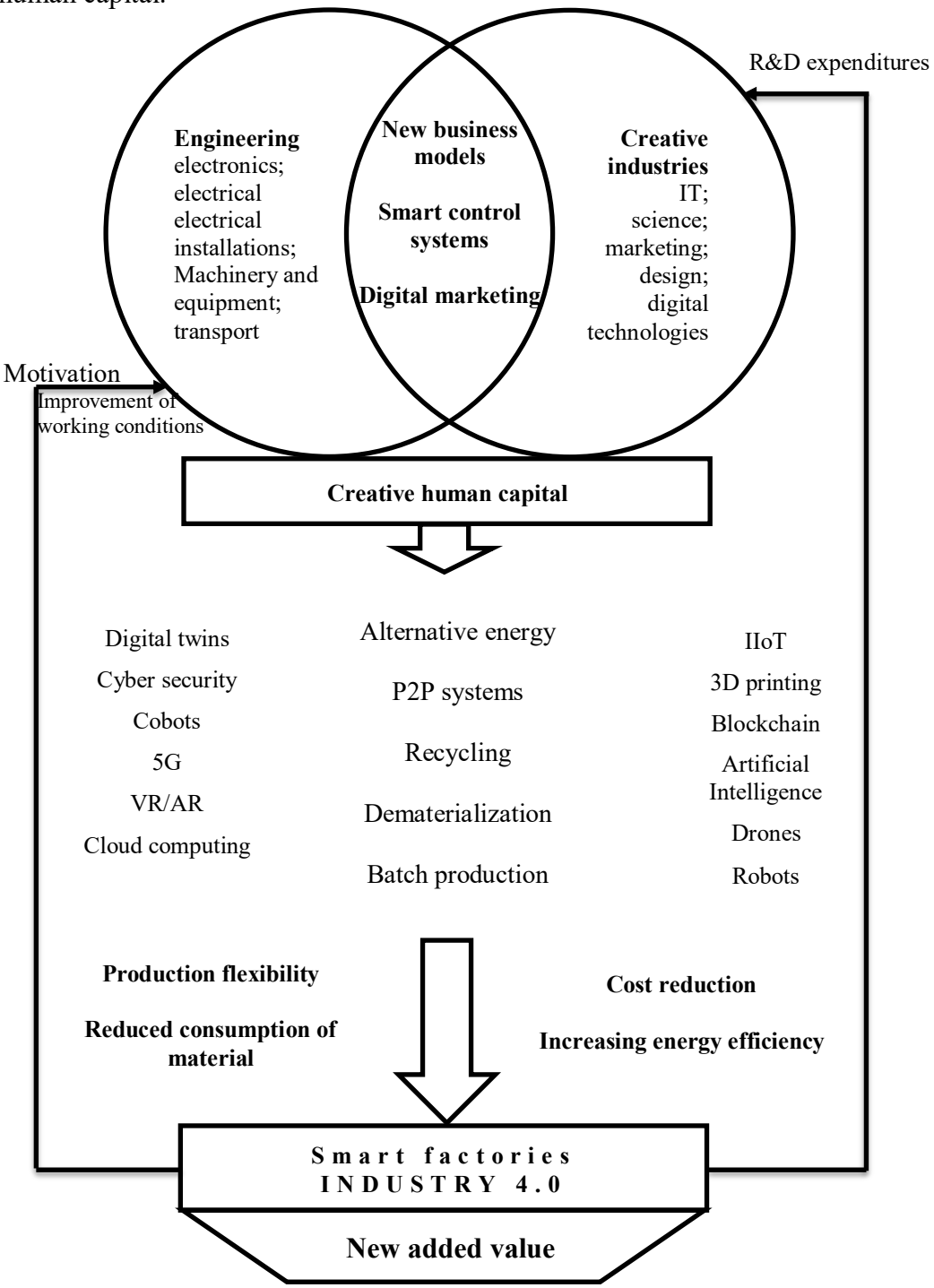

Fig. 1. A model of the organizational and economic mechanism of the transformation of enterprises to the conditions of the additive economy (Sineviciene et al., 2020)

On the other hand, enterprises can reduce the quality of human capital through destructive activities, causing damage to the environment and, therefore, human capital. For human capital, enterprises are both a source of income necessary for life and reproduction and environmental pollution. That is, human capital is formed thanks to the means that people receive from enterprises, but at the same time, part of human capital is lost due to pollution of water, air, land and other elements of the environment. Here the optimisation task arises: minimising the impact on the environment while preserving and increasing human capital.

In our opinion, human capital, intelligence, and creativity (creativity) is the main generator of ideas and the source of value creation at the basis of the competitiveness of enterprises. The competitiveness of industrial subsystems in the digital economy is interdependent (Fig. 1). For example, creative human capital's competitiveness depends on the conditions created by enterprises and the innovation ecosystem and vice versa. Launching platform development with the possibility of communication between innovators, business representatives, authorities, and investors is necessary.

Today, the points of value creation lie at the intersection of engineering and creative industries (IT, design, digital technologies, advertising, marketing) – industries that produce products with the highest added value (Fig. 1). The synergy of these advanced industries can lead Ukraine to a qualitatively new round of development.

Conclusions. Technical and technological breakthrough innovations of Industry 3.0, 4.0 and 5.0 should become the basis for the additivity of modern enterprises. At the same time, the combination of engineering and creative industries will make it possible to form and implement new business strategies and business models. When combined with smart management systems, artificial intelligence and digital marketing, it is possible to achieve significant results in modern enterprises' digital transformation. In our opinion, the main creative industries that will directly or indirectly contribute to increasing the competitiveness of digital enterprises are information technologies, science, marketing, design and digital technologies. Today's presence of new vectors of development based on breakthrough innovations requires restructuring (transformation) and the training (retraining) system of human capital. He becomes creative or cognitively creative in the conditions of modern industrial revolutions. It is this capital that becomes the basis of the additive economy.

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