Olha Shulha
ORCID: https://orcid.org/0000-0002-3230-3124
Doctor of Economics, Professor, Professor of the Department of Management
Borys Grinchenko Kyiv Metropolitan University (Kyiv, Ukraine)

TRANSFORMATION OF INTELLECTUAL CAPITAL OF THE ORGANIZATION IN THE CONDITIONS OF TRANSITION TO A CIRCULAR ECONOMY: CONCEPTUAL PRINCIPLES OF SYNERGY

https://doi.org/10.5281/zenodo.20730743

Abstract
The theoretical and methodological principles of the transformation of the intellectual capital of the organization in the conditions of the transition from a linear economic model to the paradigm of a circular economy are substantiated. Based on the systemic and synergistic approaches, the architecture of green intellectual capital is decomposed into human, structural and relational components, and their specific role at different stages of the life cycle of a waste-free product is determined. The key importance of the formation of eco-oriented competencies, in particular systems thinking and cognitive flexibility of personnel, for minimizing operational risks in conditions of instability of secondary raw material flows is outlined. A conceptual model of organizational synergy resulting from the integration of human resource eco-potential into flexible, decentralized and cross-functional management structures has been developed. Destructive barriers to the ecological transformation of personnel have been identified (organizational resistance, lack of funding, intellectual rigidity) and strategies for overcoming them have been proposed. Practical recommendations for enterprise management on reforming corporate HR strategies in the direction of implementing a system of continuous learning and assessing effectiveness based on environmental criteria to ensure long-term sustainable development have been formulated.

Keywords: *intellectual capital, Green Intellectual Capital, circular economy, sustainable development, Green Skills, systems thinking, cognitive flexibility, organizational synergy, cross-functional teams, Lifelong Learning, business processes, logistics chains.*

Introduction

The modern paradigm of global economic development is undergoing radical transformations under the influence of environmental and resource imperatives. The traditional linear model of production demonstrates its economic and environmental failure due to the depletion of natural resources and the critical growth of waste volumes. An alternative vector is the circular economy, which is focused on resource recovery, minimizing the carbon footprint and looping production chains. However, the transition to circular business models requires not only technological modernization, but also a radical restructuring of the enterprise's internal resource management system. The key driver of this transformation is the organization's intellectual capital. Environmental innovations, recycling and the concept of zero waste are based on specific knowledge, new forms of cross-functional interaction and eco-oriented personnel competencies. In this context, there is an acute scientific and practical need to study the mechanisms of intellectual capital transformation and determine the conditions under which a synergistic effect arises from the integration of human resources into circular processes.

The purpose of the study is to provide a theoretical and methodological justification of the conceptual principles of the transformation of the intellectual capital of an organization and develop a model of its synergistic interaction with the processes of the circular economy to ensure the sustainable development of the enterprise.

Materials and methods

The methodological basis of the study is a systemic approach, which allowed us to consider the intellectual capital of the enterprise and the operating cycles of the circular economy as interconnected elements of a single organizational and economic system. To achieve the set goal, a set of scientific methods was used: the method of theoretical generalization and scientific deduction - used to decompose intellectual capital into its structural components (human, organizational, relational) and determine the specific requirements of the circular economy for each of them; the comparative analysis method served to compare the profiles of personnel competencies in

the conditions of traditional linear and modern circular economic models, which made it possible to single out the definition of «green skills»; the conceptual modeling method was used as the basis for developing the author's matrix of correspondence of intellectual capital components to the stages of the life cycle of a waste-free product.

Results and Discussion

In the modern system of strategic management, intellectual capital is considered as a set of intangible resources, specific knowledge, information arrays and organizational capabilities, the use of which provides the enterprise with the formation of long-term competitive advantages and an increase in market value. The architecture of this phenomenon has a clearly differentiated three-component structure, which includes human, structural (organizational) and relational (client) capital.

Human capital is the primary element of this system and is determined as a set of individual knowledge, professional skills, experience, creative abilities and intellectual potential of the organization's employees. This component is inseparable from its direct carriers and cannot be owned by the enterprise, which necessitates the formation of specific incentives for its maintenance and effective use.

Structural or organizational capital, unlike human capital, is fully owned by the business entity and remains within the organization after the termination of employment relations with specific employees. It is formalized in the form of patents, licenses, trademarks, databases, software, operating procedures, institutional experience and internal organizational culture. Structural capital performs the function of a coordination environment that transforms the individual knowledge of personnel into systemic assets of the enterprise.

Relational capital reflects the integration ties of the organization with entities of the external environment. It includes business reputation, long-term relationships with customers, distribution channels, contracts with suppliers, as well as network alliances with research and government institutions. The balanced interaction of all three components forms a synergistic architecture of intellectual

capital, which directly affects the adaptive capabilities of the enterprise in the context of macroeconomic transformations.

The concept of a circular economy is based on the principles of cyclical resource reproduction and serves as a fundamental basis for achieving sustainable development goals at both the micro- and macroeconomic levels (Bilousko T., 2024). The strategic essence of this paradigm is the transition from traditional linear flows to closed regenerative systems, which ensures increased competitiveness of national production in the international arena. The specificity of circular-type operational cycles requires a significant change in technological processes, in particular the introduction of eco-design, waste recycling, remanufacturing (product recovery) and cyclical use of biomass, which is especially relevant for the agricultural and processing sectors of the economy (Bilousko T., Bilousko R., 2024). The implementation of closed cycles leads to the emergence of strict requirements for the flexibility of the enterprise's internal and external business processes. Unlike linear production, where supply and sales are deterministic, circular operating systems operate in conditions of high scarcity and instability of incoming flows of secondary raw materials. This necessitates the transformation of logistics chains and the implementation of reverse logistics processes for the collection and disposal of used products.

Adaptation of an enterprise to the requirements of European integration in the field of greening production requires management to reformat operating capacities at a high speed (Yatsenko O., Shvydanenko O., Shvydanenko G., 2022). Flexibility of business processes under such conditions is achieved by digitalizing product life cycle monitoring and creating dynamic production modules capable of quickly changing the parameters of raw material processing depending on its current characteristics and incoming volumes.

The application of the methodology of the synergistic approach allows us to study the processes of integration of the enterprise's human resources and environmental innovations not as a linear summation of individual factors, but as a complex nonlinear interaction that causes the emergence of a systemic effect. In the conditions of ecological modernization of production, human resources undergo qualitative changes, transforming into a system of

eco-oriented competencies that include the ability to systematically analyze environmental risks, mastery of waste-free production technologies and energy efficiency management skills. The interaction between the human factor and innovative technologies of an ecological direction has a two-way synergistic nature. On the one hand, the presence of a high level of cognitive lability and specific environmental knowledge among personnel is a precursor for the successful development and implementation of environmental innovations. On the other hand, the integration of the latest environmental technologies into the production process stimulates the development of organizational culture and intellectual capital of the enterprise as a whole. The synergistic effect in this context manifests itself in the form of an outpacing increase in economic efficiency and a decrease in environmental destruction, which is impossible under the condition of isolated development of personnel or technological subsystems. The mechanism of emergence of such synergy is based on the principles of self-organization of cross-functional teams, where the exchange of implicit knowledge between specialists of different profiles ensures the minimization of transaction costs and accelerates the diffusion of environmental innovations within the circular cycles of the organization. At the same time, the transition from a linear economic model to closed production cycles requires a fundamental reformatting of the personnel competence profile and the replacement of traditional functional skills with eco-oriented qualification characteristics. Within this process, systems thinking becomes key, which allows employees to perceive the production process not as an isolated sequence of operations, but as an integrated ecosystem with several feedback loops. In waste management and recycling, systems thinking provides the ability of personnel to predict the secondary use of materials at the stage of primary product design, thereby minimizing the formation of irreversible losses of raw materials. Along with systems thinking, a critical factor is the cognitive flexibility of personnel, which is determined as the ability to quickly switch between different cognitive strategies and adapt behavioral patterns to changing operating conditions of the operating environment. Since secondary raw material flows are characterized by a high level of heterogeneity, instability of chemical and physical

parameters and irregularity of supply, employees must demonstrate readiness for rapid modification of technological modes of processing and sorting. Thus, the integration of systems thinking and cognitive flexibility into the structure of human capital allows transforming the operational risks of circular production into sustainable technological advantages.

The effectiveness of innovative transformations within the circular economy is directly correlated with the level of environmental awareness of employees, which determines the internal motivational basis for adhering to the principles of sustainable development. Environmental awareness is not limited to formal knowledge of environmental standards, but encompasses a deep understanding of the cause-and-effect relationships between the operational activities of the enterprise and the state of the environment. A high level of environmental awareness transforms external regulatory requirements into internal professional imperatives of personnel, which significantly reduces the need for strict administrative control. At the same time, a critical barrier to the implementation of waste-free technologies is the psychological resistance of personnel, caused by the inertia of thinking and fear of optimizing familiar work processes. The formation of psychological readiness for changing operational paradigms requires targeted management activities to overcome rigidity and increase the level of personnel involvement in environmental initiatives. Psychological readiness is achieved through the creation of a transparent system of internal communications, where each employee is clearly aware of his or her personal role in implementing the circular strategy and sees a direct relationship between the environmental performance of the organization and its long-term stability.

The dynamic development of recycling technologies, bioeconomy and alternative energy causes rapid moral obsolescence of existing knowledge of personnel, which actualizes the need to implement continuous learning models. The traditional discrete system of advanced training is unable to provide the flexibility of human capital necessary for the constant generation and support of circular innovations. Continuous learning should become an integrated element of everyday operational activities, transforming the enterprise into a learning organization.

The implementation of continuous learning models involves the diversification of educational tools, including the use of digital platforms for microlearning, tools for mutual knowledge transfer and regular cross-functional workshops. Educational content within the framework of sustainable development should be promptly updated in accordance with the emergence of new technological solutions, changes in environmental legislation and trends in the global secondary raw materials market. Systematic support of continuous learning models allows maintaining high innovative activity of personnel, ensuring a continuous flow of rationalization proposals and successful commercialization of environmental developments of the organization.

The transition to circular business models requires a deep evolution of the structural capital of the organization, which begins with a radical transformation of organizational culture. Classic linear hierarchies, focused on vertical subordination and functional isolation of divisions, demonstrate low efficiency during the development of eco-products. The creation of products suitable for further regeneration, remanufacturing or complete biodegradation is a complex interdisciplinary task. This makes it objectively necessary to transition to decentralized, cross-functional teams.

Within such flexible structures, specialists in eco-design, materials science, production technology, reverse logistics and marketing are integrated. Decentralization of management provides these teams with high autonomy in decision-making, which significantly reduces the duration of the innovation cycle. Transformation of organizational culture in the direction of supporting initiative, open exchange of tacit knowledge and tolerance for justified risk allows overcoming internal resistance to change. As a result, environmental values become an integral part of everyday operational activities, ensuring high adaptability of the enterprise to the dynamic requirements of sustainable development.

However, the institutionalization of circular innovations requires a systematic modification of the formalized component of the enterprise's structural capital. Traditional operational regulations and knowledge bases, aimed exclusively at minimizing direct financial costs and maximizing output, are replaced by new management standards. These standards are adapted to the requirements of

achieving a zero carbon footprint and complete environmental neutrality of production. The organization's internal knowledge bases are transformed by accumulating and systematizing data on the life cycle of materials, alternative energy sources, low-carbon production technologies and specifications of secondary raw materials. The modification of technological processes is accompanied by the introduction of strict energy and resource conservation regulations, real-time greenhouse gas emission monitoring systems, as well as internal waste audit standards. Updating this regulatory and methodological framework allows us to transfer the concept of sustainable development from the plane of declarative intentions to the plane of clear, mandatory operational instructions, which minimizes the human factor in ensuring the environmental safety of production.

The functioning of the enterprise within regenerative cycles makes its isolated development impossible, which actualizes the need for expansion and qualitative transformation of relational capital. Traditional market transactions based on short-term contracts and price competition are replaced by long-term strategic partnerships. An extensive ecosystem of stakeholders is being formed, which unites suppliers, end consumers, research institutes, logistics providers and recycling companies. Interaction with suppliers is reoriented to the purchase of exclusively certified, environmentally friendly or secondary raw materials, which requires joint development of quality standards. Consumer relations are being transformed through the introduction of new business models, such as «product as a service», where the ownership of the product remains with the manufacturer, and the client pays only for its functionality, which guarantees the return of the product after wear. A critically important vector for the development of relational capital is integration with waste market operators and recycling enterprises, which ensures the looping of resource flows. The stability of these network connections minimizes transaction costs, reduces the risks of raw material shortages and generates a collective synergistic effect, increasing the resilience of the entire ecosystem to external economic fluctuations. The mechanism of the emergence of a synergistic effect within the conceptual model is based on the principle of complementarity of the cognitive abilities of personnel

and the architectural parameters of the organization's internal environment. Eco-oriented human capital by itself, containing specific knowledge in the field of decarbonization and recycling, is unable to ensure high innovation dynamics if it operates within rigid bureaucratic hierarchies. Synergistic gains in performance are actualized only when the intellectual potential of personnel is integrated into a flexible, adaptive organizational structure. The process of generating synergy unfolds through three consecutive stages. At the first stage, a flexible structure ensures the elimination of inter-functional barriers, creating conditions for the unhindered exchange of implicit knowledge between holders of eco-competences from different departments. At the second stage, the effect of cognitive resonance occurs, in which the cognitive flexibility of personnel is enhanced by the operational lability of decentralized working groups, which allows several alternative hypotheses regarding resource utilization or recovery to be tested in parallel. In the third stage, the launch of positive feedback loops transforms successful local solutions into systemic patents and regulations that update the company's structural capital. The organizational synergy of such interaction is manifested in an exponential reduction in the time to develop an eco-product and a reduction in the capital intensity of remanufacturing processes.

To ensure the continuity of regenerative processes, a clear architectural link between the components of intellectual capital and the stages of the zero-waste product life cycle is necessary. At the eco-design stage, the leading role is played by the combination of human capital in terms of the systems thinking of developers and structural capital in the form of databases on the life cycle of alternative materials. The dominant presence of these components allows setting the parameters of the future disassembly and recycling of the product even before its physical creation begins. At the stage of direct production, the focus shifts to the plane of structural capital (automated carbon footprint control systems, energy-efficient regulations) and specific skills of technical personnel in managing zero-waste lines. The stage of product use by the client critically depends on the relational capital of the enterprise. New consumption models, in particular leasing and «product as a service», require stable communication channels with consumers and service centers

to monitor the condition of the product during operation. At the final stage – recovery (recycling, remanufacturing) – relational capital becomes key in terms of integration with reverse logistics operators and specialized processing enterprises. This partnership is supported by the human capital of experts who are able to assess the residual resource of returned parts and raw materials. The process of evolution of human resources in the direction of sustainable development faces three destructive barriers. The first is organizational resistance caused by the inertia of middle management, which tends to adhere to the usual linear KPIs and sees circular transformations as a threat to current operational stability. The second barrier is associated with the lack of targeted funding for long-term training programs, since the costs of developing Green Skills are often viewed by management as current expenses, rather than as strategic investments. The third, most profound barrier is intellectual rigidity — the mental inability of personnel to abandon the linear thinking algorithm and accept the concept of cyclical business models.

The strategy for minimizing organizational resistance involves the introduction of a balanced system of environmental indicators into the general matrix for assessing the effectiveness of managers, which makes sustainable development financially attractive for managers. The limitation of budget funding is offset by attracting state grants for environmental modernization, optimizing costs through the use of corporate digital microlearning platforms, as well as concluding partnership agreements with higher education institutions for targeted training of specialists. Overcoming intellectual rigidity is achieved through gamification of the educational process, regular cross-functional hackathons, and involving employees in the direct design of circular chains, which transforms them from passive performers into co-authors of innovations.

For the successful implementation of the conceptual model of synergy, the management of business entities is recommended to carry out a comprehensive reform of corporate HR strategies along the following key vectors:

1. Modification of job profiles and personnel selection criteria. It is necessary to integrate eco-oriented competencies into the qualification requirements for vacant positions at all levels. When

hiring new specialists, it is advisable to use test tasks to assess systems thinking and cognitive flexibility in conditions of uncertainty of resource flows.

2. Reconstruction of the corporate training system. It is necessary to move from discrete trainings to building a continuous system of environmental education. It is necessary to create an internal knowledge base with the best global practices of the circular economy and ensure regular advanced training of engineering, technical and managerial personnel in the field of low-carbon technologies.

3. Transformation of the motivation and incentive system. It is recommended to develop and implement a system of environmental KPIs, linking the variable part of the salary and bonuses of employees with indicators of reducing specific energy consumption, reducing the volume of production waste or successful development of secondary raw materials. Non-material motivation should include public recognition of employees' environmental initiatives and support for internal eco-volunteerism.

4. Formation of an innovative environment and flexible interaction. Management should initiate the creation of permanent cross-functional teams to develop closed cycles of material use. These groups should be delegated authority for operational changes in technological parameters of production, stimulating an open exchange of ideas and horizontal transfer of knowledge within the organization.

Conclusions

Successful implementation of regenerative operating cycles is impossible without a fundamental restructuring of the intellectual capital architecture of the enterprise. Traditional approaches to managing intangible assets, focused exclusively on minimizing direct financial costs within the linear model, should be replaced by the concept of "green intellectual capital", which integrates environmental imperatives into the human, structural and relational components of the organization. The key factor in the qualitative transformation of human capital is the formation of eco-oriented competencies. Within circular business models, systems thinking and cognitive flexibility of personnel are of particular importance, which

provide the ability to design closed cycles of material use and promptly adapt technological processes to the high heterogeneity and instability of secondary raw material flows.

A conceptual model of organizational synergy is substantiated, which arises as a result of the nonlinear interaction of eco-oriented human capital and a flexible, decentralized management structure. It has been established that the elimination of interfunctional barriers and the creation of cross-functional teams is a precursor for the effective exchange of implicit environmental knowledge, which allows exponentially reducing the time for developing eco-products and optimizing reverse logistics processes. Key barriers to the evolution of human resources (organizational resistance, lack of funding, intellectual rigidity) have been identified and comprehensive strategies for their minimization have been proposed through the implementation of a system of environmental KPIs, the use of digital platforms for continuous learning and gamification of innovative activities. Promising areas of future scientific exploration are: creating a system of metrics and integral indicators to measure the level of formation of green intellectual capital and its direct impact on the financial and economic indicators of the enterprise; adapting the proposed conceptual model of synergy to the specifics of specific sectors of the economy (in particular, agricultural production, metallurgy, construction or IT) taking into account their inherent technological features of resource cycling; research into the role of artificial intelligence, blockchain, and big data technologies as tools for automating knowledge transfer and monitoring carbon footprint within an organization's structural capital.

References:

1. *Bilousko T. (2024) Circular economy in the context of achieving sustainable development goals. Economy and society. No. 65. https://doi.org/10.32782/2524-0072/2024-65-52*
2. *Bilousko T., Bilousko R. (2024) Development of bioeconomy as a prerequisite for increasing the competitiveness of the national economy in international markets. Bulletin of Khmelnytskyi National University. Series: Economic Sciences. No. 328(2). P. 131-139. URL: https://doi.org/10.31891/2307-5740-2024-328-20.*
3. *Horbal N. I., Lomaga Y. R. (2022) Circular economy – the basis of sustainable development of enterprises. Bulletin of the National*

University «Lviv Polytechnic». Series: Problems of Economy and Management. No. 1(9). P. 9-22. URL: http://doi.org/10.23939/semi2022.01.009

4. *Zamlynskyi V. A., Osyk S. V., Zamlynskyi Ya. V. (2023) Circular Economy in the Context of Ukraine's Competitiveness Prospects. Economic Bulletin of the Black Sea Region. No. 4. P. 28-43. URL: https://www.ebbsl.com.ua/index.php/visnuk/article/view/51/44*
5. *Strapchuk S.I. (2022) Sustainable Development of Agricultural Enterprises on the Principles of Circular Economy: Monograph. Kharkiv: DBTU; Lviv: Publishing House "Novyi Svit – 2000". 380 p.*
6. *Yatsenko O. M., Shvydanenko O. A., Shvydanenko G. O. (2022) Circular economy as a basis for ensuring sustainable development of the country in the context of European integration. Economy and Region. No. 4(87). P. 150-167. URL: https://doi.org/10.26906/EiR.2022.4(87).2794*