

Entrepreneurship in the Era of the Digital Economy. Neuroeconomic Aspect

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Abstract: *Total technologization inherent in the present encourages economic units, and especially enterprises, to adapt to the requirements of the era of the digital economy. In order to achieve the main goal of activity, entrepreneurs need to make decisions, applying not only generally accepted economic knowledge, but also take into account the emotional state, values and ethical preferences of their consumers.*

The issue of synergistic application of digital capabilities and scientific achievements in brain research and their adaptation to the economic sphere in business activities is becoming relevant. The purpose of the study is the analysis of entrepreneurial activity in the era of the digital economy in the aspect of neuroeconomic development.

A high technical and intellectual level in the era of the digital economy requires entrepreneurs to be constantly up-to-date. An interdisciplinary approach is becoming more effective in training entrepreneurs, which includes not only economic and digital sciences, but also psychology and neurophysiology, which allows expanding the methodology and deepening knowledge about a person. The study of the influence of brain activity on the emotional mood and preferences of consumers has modified standard marketing approaches. The synthesis of marketing science with neurophysiology expands the opportunities of entrepreneurs to study customer preferences and improve their products.

Synthesizing the economic meaning of enterprise activity and the way to achieve this meaning led to the digitalization of business activity. Innovative solutions of enterprise activity and the use of digital technologies are the key factors in the development of contemporary enterprises.

Keywords: *Neuromarketing; digitization; innovative solutions; interdisciplinary approach; business training.*

How to cite: Lytvyn, L., Hryhoruk, A., Orlova, V., Shcherbych, V., Serhieieva, O., & Riabtsev, G. (2023). Entrepreneurship in the era of the digital economy. Neuroeconomic aspect. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, 14(4), 228-241. <https://doi.org/10.18662/brain/14.4/502>

Introduction

The current phase of economic development has characteristics that have led to the spread and entrenchment of the concept of the digital economy, which corresponds to the features of the introduction of innovative and digital methods of economic activity. Total technologization inherent in the present encourages economic units, and especially enterprises, to adapt to the requirements of the era of the digital economy. In order to achieve the main goal of activity, entrepreneurs need to permanently make decisions, applying not only the stereotyped approaches and generally accepted economic knowledge, but also take into account the social and emotional state of their consumers, value and ethical preferences of customers.

Thus, in the era of the digital economy, the next step for entrepreneurs should be not only adapting to digitalization standards, but also anticipating the emotional response of their target audience. In the conditions of digitization and globalization, which are constantly expanding, competition is constantly intensifying, and those entrepreneurs who form among their features the superpower of "brain scanning" of their consumers will win the competition.

The issue of synergistic application of digital capabilities and scientific achievements in brain research and their adaptation to the economic sphere in business activities is becoming relevant. Thus, the purpose of the study is the analysis of entrepreneurial activity in the era of the digital economy in the aspect of neuroeconomic development.

The urgency of the problems of training in entrepreneurship in the era of the digital economy

The digital economy makes significant demands on entrepreneurs, crucial among which is the need for constant development and advancement. In order to maintain the necessary technical and intellectual level in the era of the digital economy, the issue of training is of particular importance for entrepreneurs.

Studying the impact of digitalization of the economy on entrepreneurship, Youssef et al. (2021, p.1), point out that "personal attitude and behavioral content are the main determinants of entrepreneurial intention". This emphasizes the need for effective "entrepreneurial education" that integrates not only economic, but also technological courses (Higgins & Elliott, 2011, p. 345; Prots et al., 2022).

Determinants of the success of entrepreneurial activities are a high and effective volume of consumer coverage, and therefore an urgent problem in the field of business education is to increase awareness of marketing tools and technologies. An interdisciplinary approach gives an exceptionally fruitful result in research. The study of the influence of brain activity on the emotional mood and preferences of consumers has modified standard marketing approaches. The “combination of neuro and marketing implies the merging of two fields of study” that created a separate direction of neuromarketing (Morin, 2011, p. 131), which expands the opportunities of entrepreneurs to study customer preferences and improve their products (Fig. 1). Thus, the urgent need of modern training of future and effective entrepreneurs is the synthesis of multi-vector directions, such as economic, digital, managerial, and even neurobiological and psychological.

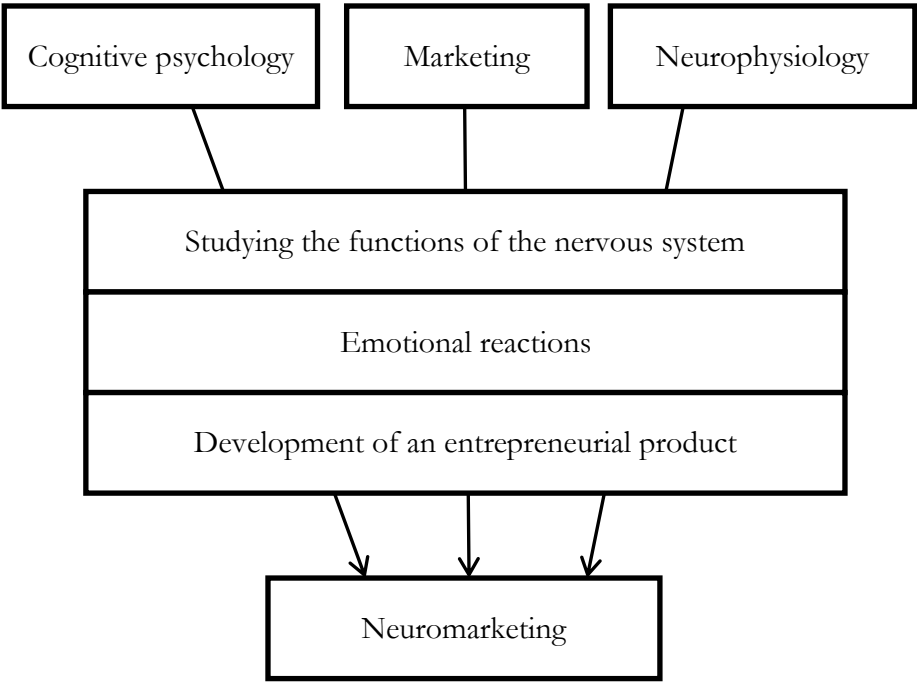


Figure 1. Synthesis of areas of knowledge in the formation of the neuromarketing concept
Source: Created by the authors based on the findings by Morin (2011)

Study by Treanor et al. (2021, p.1) presents that “early career biotechnology researchers develop entrepreneurial competences through participation in a bespoke entrepreneurship education competition” and “this

affects their longer-term entrepreneurial actions”. A short-term experimental intervention in the educational process of researchers in the field of biotechnology regarding the development of their entrepreneurial skills contributed to the achievement of significant positive long-term results. It should be noted that the introduction of the impulse of competitiveness, which is an organic characteristic for the activity of every enterprise, into the educational process of every specialty prepares the ground for the formation of a layer of specialists who are more determined to achieve economic success and are adapted to the realities of market relations.

Educational business programs in an academic environment create an opportunity for students to familiarize themselves with the general approach to conducting business activities, which encourages further interest in acquiring more specific knowledge and skills. The atmosphere in the academic environment, which promotes the unification of future specialists from various disciplines in business education programs, is the best possible condition for the formation of original and unique enterprises. So, as emphasized by Yami et al. (2021) the presence of "academic technological centers promotes innovation and entrepreneurship", not only due to the possibility of human capital development, but also due to the integration and collaboration processes that take place in them (Graham & Bonner, 2022).

A vivid example of a harmonious combination of an interdisciplinary approach to the creation of effective entrepreneurship in the conditions of the digital economy is digital academic entrepreneurship. Secundo et al. (2020) notes that academic entrepreneurship itself is characterized by a high level of digitalization, and its unique feature is the opportunity to develop various graduate startups. A comprehensive and structured review of the literature made by the author showed fragmentation in the study of the problems of academic entrepreneurship in the context of digital entrepreneurship (Fig. 2). An important aspect of academic entrepreneurship is its potential to develop and apply non-standard approaches and create new products. “Each dimension of knowledge networks improves firms' innovation performance, and that firms' knowledge integration capability has a fully mediating effect on the relationship between knowledge cognition and innovation performance, but only a partial mediating effect on the relationships among firms' network centrality, knowledge heterogeneity, and innovation performance” (Wang et al., 2018, p.222). It is the ability to combine the developments of researchers from various fields of science in the university environment that allows creating combined approaches to entrepreneurship and providing economic content to research in the field of human cognition, brain activity, neurophysiology and its impact on consumer decision-making.

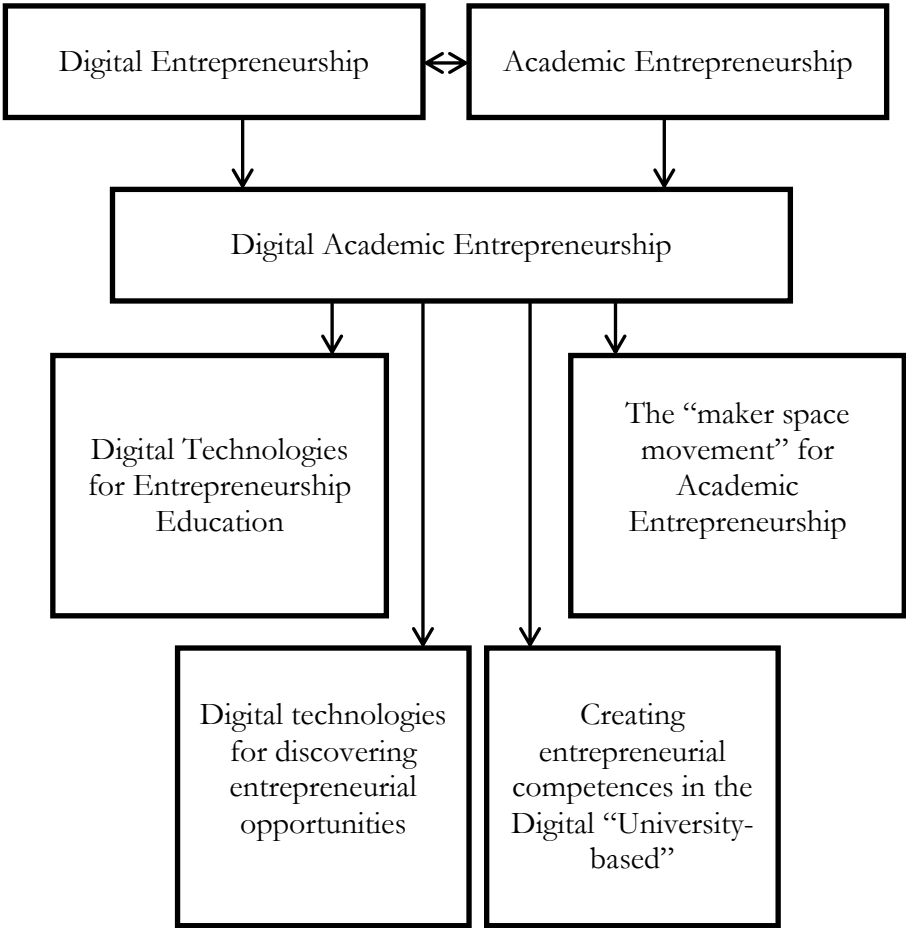


Figure 2. *Issues of digital academic entrepreneurship in the context of digital entrepreneurship*
Source: Created by the authors based on the findings by Secundo et al. (2020)

Abaci (2022, p.1) emphasizes the expediency of introducing “entrepreneurship courses in the curricula of universities”. Theoretical knowledge acquired by students, as well as practical training of students, should be accompanied by courses that will contribute to the development of their communication skills. A study by Fortunato et al. (2014) confirms a special role in communication and notes the need to use neuromarketing channels in the promotion of entrepreneurial products (Fig. 3). Considering the neurophysiological nature of these communication channels, it is at the level of brain research in the academic environment that there are the best conditions for channeling the obtained results and knowledge towards their commercialization and adaptation to business needs.

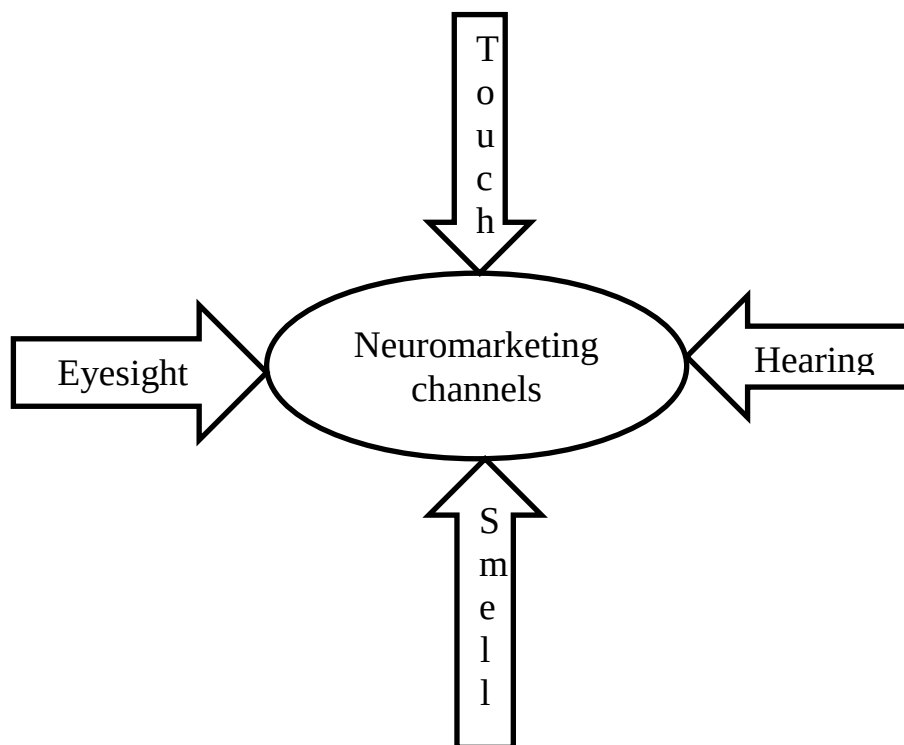


Figure 3. *Neuromarketing communication channels in entrepreneurial activity*

Source: Created by the authors based on the findings by Fortunato et al. (2014)

The need to take into account neurophysiological aspects in entrepreneurial activity in the realities of the digital economy should also be considered in the context of the theory of planned behavior. In modern conditions, the importance of a person in the economic and social environment is changing, which is associated with the unique abilities of a person, his creativity and talents (Nerubasska et al., 2020; Gerasymova et al., 2019; Sarancha et al., 2021). As noted by Nerubasska & Maksymchuk (2020, p.275), a person is a component of a complex system and is a “part of the “society” system” that, on the one hand, puts pressure on him, on the other hand, a person himself is a system capable of adapting. Therefore, as Pogodayev (2013, p. 639) notes, it is very important for entrepreneurs to be able to offer “new concepts of hybrid offers” for modern consumers. A study by Al-Mamary & Alraja (2022, p.1) in the field of the “theory of planned behavior confirmed the significant contribution of entrepreneurial intentions among young people”, and especially young people in the university sphere, to the development of digital entrepreneurship.

Thus, in order to achieve success, entrepreneurs are forced to be in a constant process of learning about the expectations, needs and behavior of their existing and potential customers, who are constantly adapting to new conditions and environments. In the realities of the era of the digital economy, an interdisciplinary approach that includes not only economic and digital sciences, but also psychology, sociology and neurophysiology, which allows expanding the methodology and deepening knowledge about a person, becomes expedient and more effective.

Innovative solutions in business activities in the era of the digital economy

The practice of ever-unfolding progress among technologies has led to their spread among all industries and spheres. The phase of development of the contemporary economy is marked by deep digitalization, which is reflected in the name "digital economy".

Although total digitalization is changing the economic environment, the main economic agents still function in it, the decisive among which are enterprises. As noted by Fernandes et al. (2022, p.1) the “entrepreneurship is a driver of innovation and economic growth”. From an economic point of view, the success factor of innovation for entrepreneurship is its financial return and increase in productivity. It is the desire to achieve the best possible result that prompts entrepreneurs to digitize the existing business model and new digital enterprises arise (Fig. 4). Thus, synthesizing the economic meaning of enterprise activity and the way to achieve this meaning, which consists in the application of innovative solutions, led to the digitalization of business activity.

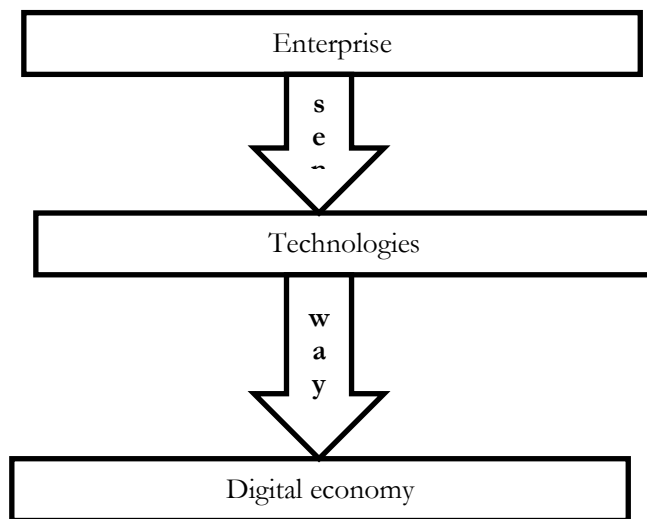


Figure 4. The economic meaning of digitization and the rise of the digital economy
Source: Authors' own conception

Enterprise innovative solutions draw not only from digital technologies, but also from new models of ecosystems, collective intelligence, integrated intelligence and entrepreneurial initiatives (Elia et al., 2020; Kibik et al., 2020). An innovative solution can also be considered the ability to optimally use the success factors of the enterprise, which affects various aspects of its activity. It should be noted that in the era of the digital economy, the phenomenon of using the paradigm of digital solutions is growing. So, the tendency to modify the original economic and material approach, forming a new picture of business activity, can be traced.

Among the key innovative structures that exist at enterprises, it is necessary to distinguish the directions of their application. The activity of the enterprise consists in the production process, application of materials and technologies, investment and financial process, sales and marketing process. Anwar et al. (2020) considers strategic management, which takes into account behavioral strategies, an important area of enterprise activity that contributes to the realization of development. Thus, depending on the application of innovative solutions, various technologies and methods of innovation implementation are used. At the same time, a fragmented approach can bring only partial results, and therefore a complex system of actions is necessary to achieve the best effect. Using mixed methods that integrate all areas of enterprise activity and systematically use digital innovations, it is possible to create synthesized programs that will affect its complete transformation (Fig. 5).

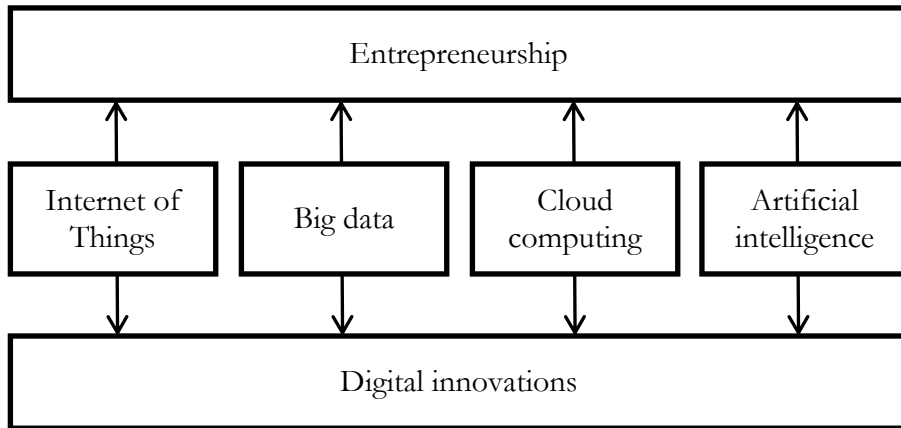


Figure 5. *Digital innovations in business activities*

Source: Created by the authors based on the findings by Si et al. (2022)

Zaheer et al. (2019) note that transformational redefinition requires businesses to take into account the changing processes and clusters in the digital world. At the same time, “recent advances in information technology are enabling new markets and revolutionizing many existing markets”, Azevedo & Weyl (2016, p.1056). Thanks to the development of markets, there is a multiplier effect of increased efficiency, which has a positive effect on public interests. “Virtual entrepreneurial firms” technologically connected to cyber-intermediary platforms not only change the way business works, but also create online social capital based on shared values and electronic association, Chandna & Salimath (2020, p.1). Thus, in the era of the digital economy, there is a modification of the competition of firms, in the behavior of which the concepts of cooperation and community membership are formed under the influence of technology.

A study by Modgil et al. (2022, p.1) shows that “Covid-19 has challenged many businesses to orient themselves towards digital solutions for their survival”. The reaction of enterprises to an unexpected change in the economic and social environment, which turned from a medical crisis into an economic crisis, was the search for survival opportunities, which was reflected in even deeper digitalization. Businesses have developed digital payment methods, contactless delivery of orders has appeared, and various virtual services have spread. As Ratten (2022) notes, under the influence of the COVID-19 pandemic and the factors that caused the economic crisis, enterprises underwent a transformation that prompted them to use new types of digital tools, including “public digital platforms”. In the conditions of crisis states of the economy, it is the state that is the economic agent that

can direct the diverse interests of other economic agents in the direction of the optimal way out of the crisis situation, Heyets et al. (2019). At the same time, it is necessary to take into account the “sustainability (social, economic, environmental)” criteria of enterprises in order to achieve sustainable development, Latysheva et al. (2020, p.328).

Thus, the current stage of economic development is closely related to digitalization, which is reflected in the activities of enterprises. In a broad sense, entrepreneurship, by its very nature, is a driving force for the emergence of new innovations due to the desire of entrepreneurs to achieve the best financial result and commercialize technologies. Innovative solutions apply to all spheres of enterprise activity, and the use of digital technologies is a key factor in the development of modern enterprises.

Conclusions

Total technologization inherent in the present encourages economic units, and especially enterprises, to adapt to the requirements of the era of the digital economy. The issue of synergistic application of digital capabilities and scientific achievements in brain research and their adaptation to the economic sphere in business activities is becoming relevant. This study, unlike others, pays special attention to the problems of education and the role of applying knowledge of neurophysiology in entrepreneurial activity in the realities of digitalization of the economy.

The need to maintain a high technical and intellectual level in the era of the digital economy requires entrepreneurs to be constantly up-to-date and in the learning process. At the same time, the success of entrepreneurship is positively influenced by effective university education, which forms entrepreneurial intentions in students and creates conditions for the commercialization of their ideas. The atmosphere in the academic environment, which promotes the unification of future specialists from various disciplines in business education programs, is the best possible condition for the formation of original and unique enterprises.

In contemporary conditions, an interdisciplinary approach, which includes not only economic and digital sciences, but also psychology, sociology, and neurophysiology, is becoming more active in the training of entrepreneurs, which allows expanding the methodology and deepening knowledge about a person.

Determinants of the success of entrepreneurial activities are a high and effective volume of consumer coverage, and therefore an urgent problem in the field of business education is to increase awareness of marketing tools and technologies. An exceptionally fruitful result in research

gives a new approach in human cognition. The study of the influence of brain activity on the emotional mood and preferences of consumers has modified standard marketing approaches. The synthesis of marketing science with neurophysiology has created a separate direction of neuromarketing, which expands the opportunities of entrepreneurs to study customer preferences and improve their products.

The phase of development of the modern economy is marked by deep digitalization, which is reflected in the name "digital economy". Although total digitalization is changing the economic environment, enterprises remain the decisive units in it. From an economic point of view, the success factor of innovation for entrepreneurship is its financial return and increase in productivity. It is the desire to achieve the best possible result that prompts entrepreneurs to digitize the current business model and new digital enterprises arise. Synthesizing the economic meaning of enterprise activity and the way to achieve this meaning, which consists in the application of innovative solutions, led to the digitalization of business activity. Innovative solutions apply to all spheres of enterprise activity, and the use of digital technologies is a key factor in the development of modern enterprises.

References

- Abaci N. I. (2022). Relationship between entrepreneurship perception and communication skill: A structural equation model. *The International Journal of Management Education*, 20(3), 100725, <https://doi.org/10.1016/j.ijme.2022.100725>.
- Al-Mamary, Y. H. S., Alraja, M. M. (2022). Understanding entrepreneurship intention and behavior in the light of TPB model from the digital entrepreneurship perspective. *International Journal of Information Management Data Insights*, 2(2), 100106, <https://doi.org/10.1016/j.jjime.2022.100106>.
- Anwar, J., Bibi, A. and Ahmad, N. (2022). Behavioral strategy: mapping the trends, sources and intellectual evolution. *Journal of Strategy and Management*, 15(1), 140-168, <https://doi.org/10.1108/JSMA-01-2021-0002>
- Azevedo, E.M., Weyl, E.G. (2016). Matching markets in the digital age. *Science*, 352 (6289), 1056-1057, [DOI: 10.1126/science.aaf7781](https://doi.org/10.1126/science.aaf7781)
- Chandna, V., Salimath, M.S. (2020). When technology shapes community in the cultural and craft industries: Understanding virtual entrepreneurship in online ecosystems. *Technovation*, 92, 102042, <https://doi.org/10.1016/j.technovation.2018.06.005>
- Elia, G., Margherita, A., Passiante, G. (2020). Digital entrepreneurship ecosystem: How digital technologies and collective intelligence are reshaping the

- entrepreneurial process. *Technological Forecasting and Social Change*, 150, 119791, <https://doi.org/10.1016/j.techfore.2019.119791>.
- Fernandes, C., Ferreira, J. J., Veiga, P. M., Kraus, S., Dabić, M. (2022). Digital entrepreneurship platforms: Mapping the field and looking towards a holistic approach. *Technology in Society*, 70, 101979, <https://doi.org/10.1016/j.techsoc.2022.101979>.
- Fortunato, V. C. R., Giraldi, J. M. E., de Oliveira, J. H. C. (2014). A Review of Studies on Neuromarketing: Practical Results, Techniques, Contributions and Limitations. *Journal of Management Research*, 6(2), 201-220. <https://doi.org/10.5296/jmr.v6i2.5446>
- Gerasymova, I., Maksymchuk, B., Bilozerova, M., Chernetska, Yu., Matviichuk, T., Solovyov, V., & Maksymchuk, I. (2019). Forming professional mobility in future agricultural specialists: the sociohistorical context. *Revista Romaneasca pentru Educatie Multidimensionala*, 11 (4), 345-361. <http://lumenpublishing.com/journals/index.php/rrem/article/view/1604/pdf>
- Graham, B., Bonner, K. (2022). One size fits all? Using machine learning to study heterogeneity and dominance in the determinants of early-stage entrepreneurship. *Journal of Business Research*, 152, 42-59, <https://doi.org/10.1016/j.jbusres.2022.07.043>.
- Heyets, V., Voynarenko, M., Kholodenko, A., Stepanok, N. (2019). Modeling state regulation of the labour market. *SHS Web of Conferences* 65, 04014 p. 308–319. <http://ceur-ws.org/Vol-2422/paper25.pdf>
- Higgins, D., Elliott, C. (2011). Learning to make sense: What works in entrepreneurial education? *Journal of European Industrial Training*, 35 (4), 345-367, <https://doi.org/10.1108/03090591111128324>
- Kibik, O., Taran-Lala, O., Saienko, V., Metil, T., Umanets, T., & Maksymchuk, I. (2022). Strategic vectors for enterprise development in the context of the digitalization of the economy. *Postmodern Openings*, 13(2), 384-395. <https://doi.org/10.18662/po/13.2/460>
- Latysheva, O., Rovenska, V., Smyrnova, I., Nitsenko, V., Balezentis, T., & Streimikiene, D. (2020). Management of the sustainable development of machine-building enterprises: A sustainable development space approach. *Journal of Enterprise Information Management*, 34(1), 328-342. doi:10.1108/JEIM-12-2019-0419
- Modgil, S., Dwivedi, Y. K., Rana, N. P., Gupta, S., Kamble, S. (2022). Has Covid-19 accelerated opportunities for digital entrepreneurship? An Indian perspective. *Technological Forecasting and Social Change*, 175, 121415, <https://doi.org/10.1016/j.techfore.2021.121415>.
- Morin, C. (2011). Neuromarketing: The new science of consumer behavior. *Society*, 48(2):131–135. DOI: 10.1007/ s12115–010–9408–1

- Nerubasska, A., Maksymchuk, B. (2020). The demarkation of creativity, talent and genius in humans: a systemic aspect. *Postmodern Openings*, 11 (2), 240-255. <https://www.lumenpublishing.com/journals/index.php/po/article/view/2625>
- Nerubasska, A., Palshkov, K., & Maksymchuk, B. (2020). A systemic philosophical analysis of the contemporary society and the human: New potential. *Postmodern Openings*, 11(4), 275-292. <https://doi.org/10.18662/po/11.4/235>
- Pogodayev, S. E. (2013). Marketing of works as a source of the new hybrid offerings in widened marketing of goods, works and services. *Journal of Business and Industrial Marketing*, 28(8), 638-648. doi:10.1108/JBIM-04-2012-0069
- Prots, R., Yakovliv, V., Medynskyi, S., Kharchenko, R., Hryb, T., Klymenchenko, T., Ihnatenko, S., Buzhyna, I., & Maksymchuk, B. (2021). Psychophysical training of young people for homeland defence using means of physical culture and sports. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, 12(3), 149-171. <https://doi.org/10.18662/brain/12.3/225>
- Ratten, V. (2022). Digital platforms and transformational entrepreneurship during the COVID-19 crisis. *International Journal of Information Management*, 102534, <https://doi.org/10.1016/j.ijinfomgt.2022.102534>.
- Sarancha, I., Maksymchuk, B., Gordiichuk, G., Berbets, T., Berbets, V., Chepurna, L., Golub, V., Chernichenko, L., Behas, L., Roienko, S., Bezliudna, N., Rasskazova, O., & Maksymchuk, I. (2021). Neuroscientific principles in labour adaptation of people with musculoskeletal disorders. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, 12(4), 206-223. <https://doi.org/10.18662/brain/12.4/245>
- Secundo, G., Rippa, P., Cerchione, R. (2020). Digital academic entrepreneurship: A structured literature review and avenue for a research agenda. *Technological Forecasting and Social Change*, 157, 120118, <https://doi.org/10.1016/j.techfore.2020.120118>.
- Si, S., Hall, J., Suddaby, R., Ahlstrom, D., Wei, J. (2022). Technology, entrepreneurship, innovation and social change in digital economics, *Technovation*, 102484, <https://doi.org/10.1016/j.technovation.2022.102484>.
- Treanor, L., Noke, H., Marlow, S., Mosey, S. (2021). Developing entrepreneurial competences in biotechnology early career researchers to support long-term entrepreneurial career outcomes. *Technological Forecasting and Social Change*, 164, 120031, <https://doi.org/10.1016/j.techfore.2020.120031>.
- Wang, M., Chen, P., Fang, S. (2018). A critical view of knowledge networks and innovation performance: The mediation role of firms' knowledge integration capability. *Journal of Business Research*, 88, 222-233, <https://doi.org/10.1016/j.jbusres.2018.03.034>.

- Yami, S., M'Chirgui, Z., Spano, C., Gontier Barykina, O. (2021). Reinventing science and technology entrepreneurship education: The role of human and social capitals. *Technological Forecasting and Social Change*, 164, <https://doi.org/10.1016/j.techfore.2020.120044>.
- Youssef, A. B., Boubaker, S., Dedaj, B., Carabregu-Vokshi, M. (2021). Digitalization of the economy and entrepreneurship intention. *Technological Forecasting and Social Change*, 164, 120043, <https://doi.org/10.1016/j.techfore.2020.120043>.
- Zaheer, H., Breyer, Y., Dumay, J. (2019). Digital entrepreneurship: An interdisciplinary structured literature review and research agenda. *Technological Forecasting and Social Change*, 148, 119735, <https://doi.org/10.1016/j.techfore.2019.119735>.