ECONOMIC PROCESSES MANAGEMENT
international scientific e-journal (ISSN 2311-6293)
epm.fem.sumdu.edu.ua
№2 – 2017

Innovation and investment processes in economic systems

Cite This Article:
Omelyanenko V. A., Volodin D. V. Basics of technological systems analysis based on neural networks [Online] // *Economic Processes Management: International Scientific E-Journal*. 2017. № 2. Available: http://epm.fem.sumdu.edu.ua/download/2017_2/epm2017_2_4.pdf

Received
April 7, 2017

Accepted
May 10, 2017

Published online
June 10, 2017

UDK 629.7.05
JEL Classification: C32, O21

BASICS OF TECHNOLOGICAL SYSTEMS ANALYSIS USING NEURAL NETWORKS

Omelyanenko Vitaliy Anatolievich
PhD (Econ.), Prof. Assistant of Economic Theory Department,
Sumy State University, Ukraine
Volodin Dmitriy Vladinirovich
PhD (Eng.), Project Manager,
FARADI SRL, Italy

The article deals with the methodological basis of research of technological systems. In the framework of research methodology development the basic structural characteristics of technological systems and basic elements of internal dynamics based on external impulses were analyzed. The expediency of use for research of technological systems the model biotic neuron is substantiated and appropriate methodological approach for creating neural network based on it is proposed.

Keywords*: technological system, neural network, impulse neuron, biotic model.*

Introduction. Technology factor provides expansion of resource base through commercial effective development and improving efficiency. Technology has always developed organically and that's why breakthroughs in one field are always related to achievements in other areas. Based on this the subject of research are modern technological systems (technological packages) that bring together a whole complex of technologies and aimed at specific purpose (create a certain product). The development of technological systems (technological trajectory) is an evolutionary process that is developing in certain dependence according to internal dynamics and influence of external factors.

Analysis of recent researches and publications. In our previous studies [4; 5; 7; 8; 9] we have shown that the development strategy in high-tech sectors is aimed on providing the continuity and complementarity of complex of innovations flows and flows of wide range of necessary resources, which requires the study of problems of synthesis and analysis of

innovation systems and innovative transformations dynamics. This processes require appropriate methodical base, which as we suggest should include modern analytical tools. Some cases of such analytical tools application were considered on the nano materials application in space industry [6].

In studies [1; 2] the general concept of evolution of systems and development impulses were considered. Research [3] covers the problem of bionic neural network models creation. The problem of bionic neural network application for the systems evolution and development impulses analysis provides new opportunities for analytical tasks.

The aim of this research is reasoning of application of biotic neuron model for analysis of problems of complex technological systems development.

Main material. Modern technologies especially high technologies, can be defined as a system that requires the large-scale involvement of information and material and technical resources, leading the appearance of new products and providing of more optimal costs and benefits balance. Any technology is a dynamic integrated system that includes and operates the following elements:

1) products, operations and procedures, rules, standards and norms of technological and management processes and necessary for it:

2) information and knowledge;

3) energy, raw materials, personnel and other resources;

4) set of economic, social, environmental and other impulses and effects that influence and in some way change the environment of system and also resulting from its operation.

Accordingly we can move to broader field of analysis of technological systems as socio & economic & technological system (SETS) and that requires the change of tools.

Let's consider more detail the factor aspect because technology system develops based on external factors (impulses), which, for example, include the results of market research or development of other technologies which may affect the technology or should be analyzed within its technological package. An example of this can be increasing the efficiency of traditional industries through the using of automation and IT.

In previous studies in the analysis of technological systems [4; 5], we have determined that they integrate the entire spectrum of environments through the following aspects:

1) it structures of technological environment, creating the possibility of implementing an entire group of technology solutions;

2) it affects the natural, environment (including indirectly through new technologies);

3) it interacts with the social environment, greatly influencing on it until the creation of new structures in it. In turn the social environment largely generates requests for technological system and is changing so that the maximum extent to meet the requirements of the system;

4) it is embedded in the information environment.

By the analogy with biological approach, open systems are the systems that are supported in some state by continuous flow from outside and inputs from inside of them energy or information. Moreover, the input and output are usually lengthy in nature and occur at each point of system (subsystem, separate component). Constant exchange of matter, energy and information is a necessary condition for the existence of non-equilibrium

states opposed to closed systems that are not suitable for dynamic systems that are analyzed in this paper.

In terms of self-organization theory in complex hierarchical systems control levels are necessary for fixing of external impulses arising in macro-system and parallel systems, processing of information about these impulses, selection of internal impulses that allow the system to adapt to external influences. The emergence of new (unfamiliar) impulse generates in system additional antientropy linkages. Under the threat of internal structure destruction system self-organizing is happened, leading in particular to formation in it new hierarchical control level [1].

Giving above points are relevant to technological systems that operate in the conditions of interrelated systems and competition. Unusual impulse (e.g. new technology) can lead to significant reconfiguration of system.

So we can consider the technological system as a complex open self-organizing system that is an adaptive system in which perception and memorizing of information (gain of experience) is reflected in restructuring of system at various levels. Therefore, we face with the problem of its analysis, particularly in macrosystems case study (e.g. technological cluster in space industry), and select the appropriate modeling tools.

Development of systems always is a result of combination of influence factors and key point of development is transition to new state, which may be due to several reasons: external influences or accumulated internal contradictions [2].

In the context of this study we propose to consider the factor of "innovation impulse", ie possibility (potential) of increasing of capacity of technological system as a result of an external impulse and extent of future using of result.

In the Fig. 1 the technological system diagram, which is based, firstly on the information pulses and secondly on resource sharing, decision on which is adopted based on information impulses, is shown.

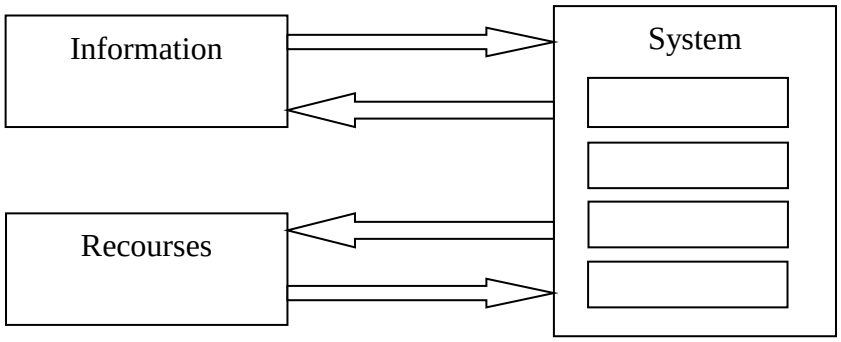

Fig. 1. **Scheme of technological system development**
(author`s development)

So to implement targeted management of such complex system as technological is possible only based on consideration of whole complex of external factors and model, composed on this basis and verified with assessment of internal conditions and characteristics of development.

In the fig. 2 three main variants of technological system dynamics depending on perception of input impulse are shown.

Taking into account defined aspects of technological systems analysis we propose to develop neural network based on bionic neuron model [3].

In proposed model bionic neuron can receive signals (impulses) can via inputs. Each neuron input is characterized by the weight coefficient *W*. Impulses by coming to the neuron input, change its status. The effect of impulse is determined by the type of entry, for which it was received, weight of entry as well as the neuron current state.

In the analysis of technological systems it is also necessary to form neuronal model according to characteristics of subsystem. Therefore for the full design of required type of neural networks basic blocks are required, which can include depending functions, formed according to technological relations in system.

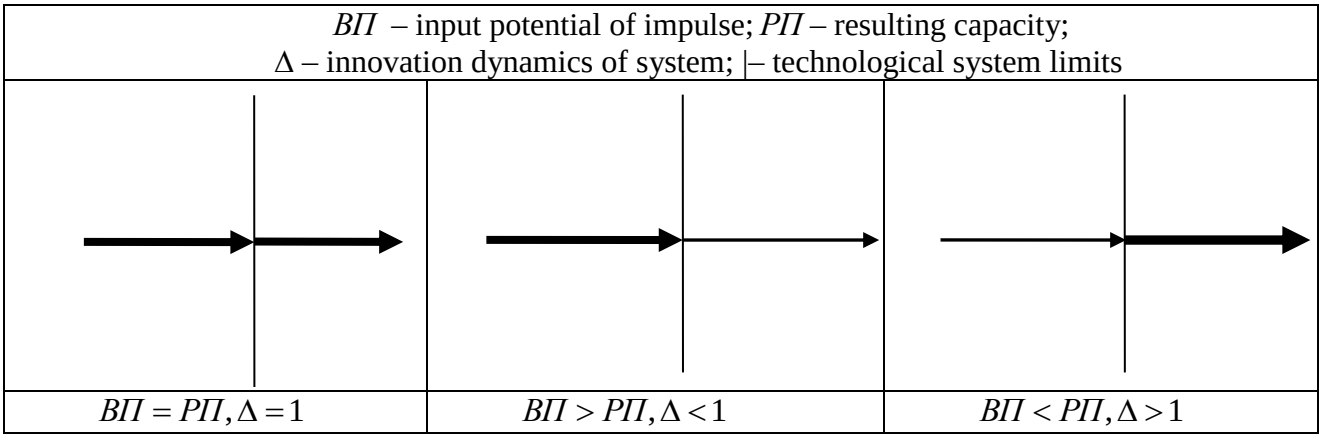

Fig. 2. **Variants of impulse impact to technological system**
(author`s development)

The current state of neuron changes with time. If there is no impulse supply on entrance, then the value of this potential goes to zero at exponential law:

$$P(t) = P(t-1)e^{-\alpha\Delta t}, \quad (1)$$

where $P(t)$ –current status of potential, $P(t\text{-}1)$ – potential value at moment t-1, α – coefficient of capacity decrement, Δt – time from the moment when potential was equal $P(t\text{-}1)$.

Potential neuron is limited by quantities P_{min} та P_{max} respectively from below and from above ($P_{\min} \le 0$; $P_{\max} > 0$). The threshold size is limited from above T_{max}, from below - $T_{\min}$. Limits of potential and threshold are taken into account when calculating the effect of impulses.

The value of this threshold over time tends to some constant value, called threshold of peace. The threshold of peace is value bigger than zero:

$$T(t) = (T(t-1) - T_0)e^{-\alpha\Delta t} + T_0 \quad (2)$$

where $T(t)$ – threshold current value; $T(t\text{-}1)$ – threshold value at moment t-1; T_0 – threshold of peace; α – coefficient of threshold decrement, Δt – time from the moment when threshold was equal $T(t\text{-}1)$.

Advantages of method are caused the ability to analyze different types of innovative impulses based on system responses of components of neuron model (stimulation entry, regulation entry, memory entry, braking entry, output (synapse)).

If to the input of neuron stimulation consistently gives impulses so that the frequency or weight of entry offset the damping potential factor, the potential will gradually increase. Braking entry reduces the potential for value, which also decreases exponentially as approach the neuron potential to lower potential limit.

Memory entry similar excitement increases capacity, but increasing capacity depends not only on the weight of entry, but also the current state of learning coefficient.

Coefficient of learning as opposed to weight value is changing dynamically in the process of neural network operation and can take values from 0 to 1. The increase in capacity is calculated as follows (3):

$$H = \mu \cdot W \cdot f(|P'|), \quad (3)$$

where μ – learning coefficient; W – weight of synapse by which the impulse came; $f(P)$ – function that has values in the range from 0 to 1.

If $\mu = 0$ the entry is considered untrained and in this case impulses to this entry does not in any way affect to the state of neuron. Maximum input trained ($\mu = 1$) works similarly to input violations with weight W, while the value μ again will change (decrease).

Overall objectives of complex objects analysis usually are solved by neural network based on formal neurons. But in our case the existing base will be insufficient to get good results in neural network formal learning. Building a heterogeneous network based on bionic neuron greatly simplifies the task. So it's better to conduct training small groups of very formal neural networks for each item analysis (component system) instead learning of one large neural network for all criteria. For solving this problem large base is not needed. Then bionic neural network based on the results obtained from formal networks can make appropriate decision.

Accordingly we can propose to develop formal neural networks of technological system components that are allocated by priority:

- basic technologies that are currently well known and are the base of production processes and are not tools of competition;
- key technologies that are owned by limited number of subjects (or just one) and ensure the possibility of key competitive advantages in the market for some time;

- test technologies that are at the initial stages of the life cycle, but because of lack of experience are not competitive instruments, but there is probability that they will move into the category of key and replace them in technology package.

Conclusion. In the article the methodological basis of research of technological systems using biotic model neuron is considered. An additional advantage of bionic model for the analysis of technological systems is the ability to create a more optimal and flexible system with the possibility of combining formal neural networks and adding new modules that expand the potential of network.

Application of this approach for individual components of system allows to solve complex problems, based on a small number data for network training.

References

1. Alekseev, N. (1999). Evoljuciia sistem upravleniia predpriiatiem [Evolution of Enterprise Management Systems]. *Problemy teorii i praktiki upravleniia - Problems of Management Theory and Practice, 2*, 35–41. [in Russian]

2. Anisimova, A. V. (2009). Metodologicheskij podhod k upravleniju promyshlennymi predprijatiiami na osnove ispolzovaniia impulsov razvitiia [Methodological approach to the management of industrial enterprises based on the use of development impulses]. *Bulletin of Donetsk National University. Economy and Law*, 1, 179–183 [in Ukrainian]

3. Elkin, S. S., Elkin, S. V., Klyshinsky, E. S. (2015). Bionicheskij podhod pri sozdanii kompleksa modelej nejronov [The Bionic Approach for the Creation of a Complex of Neuron Models]. *Publications on Bionic Neural Networks*. Retrieved from http://agpl.ru/bionic-neural-nets/publ-bionic-nets.html [in Russian]

4. Omelyanenko, V. (2015). Preconditions analysis of using of technological package concept for development strategy of space metallurgy. *Metallurgical and Mining Industry, 8*, 508–511.

5. Omelyanenko, V. (2016). Basics of general approach for technological systems analysis. 4th International Conference «Advanced Information Systems and Technologies, AIST 2016» (25–27 May 2016, Sumy), Ukraine.

6. Omelyanenko, V. (2016). Tasks and tools of nanoinformatics in nano materials application in space industry. *Nanomaterials: Application & Properties (NAP)*, 01NNPT01-1–01NNPT01-3.

7. Omelyanenko, V. (2017). Basics of Optimization Strategy for Integrating Space Industry Technology Package into Global Value Chains. *Economics and Business, 30 (1)*, 113–125.

8. Omelyanenko, V. A. (2015). Scientific and methodic bases of high technologies international transfer potential analyzing in metallurgy. *Metallurgical and Mining Industry, 3*, 66–69.

9. Omelyanenko, V. A. (2016). Innovation priorities optimization in the context of national technological security ensuring. *Marketing and management of innovations, 4*, 226–234.

ECONOMIC PROCESSES MANAGEMENT
international scientific e-journal (ISSN 2311-6293)
epm.fem.sumdu.edu.ua
№2 – 2017

ОСНОВИ АНАЛІЗУ РОЗВИТКУ ТЕХНОЛОГІЧНИХ СИСТЕМ НА ОСНОВІ НЕЙРОННИХ МЕРЕЖ

Омельяненко Віталій Анатолійович
кандидат економічних наук, асистент кафедри економічної теорії,
Сумський державний університет, Україна
Володін Дмитро Володимирович
PhD, менеджер проектів,
FARADI SRL, Італія

У статті розглянуті методологічні основи дослідження технологічних систем. В рамках розробки методології дослідження визначено основні структурні характеристики технологічних систем та базові елементи внутрішньої динаміки на основі зовнішніх імпульсів. Обґрунтована доцільність використання для цілей дослідження технологічних систем моделі біотичного нейрона та запропоновано відповідний методичний підхід до створення нейромережі на її основі.

***Ключові слова**: технологічна система, нейронна мережа, імпульс, модель біотичного нейрона.*

ОСНОВЫ АНАЛИЗА РАЗВИТИЯ ТЕХНОЛОГИЧЕСКИХ СИСТЕМ НА ОСНОВЕ НЕЙРОННЫХ СЕТЕЙ

Омельяненко Виталий Анатольевич
кандидат экономических наук, ассистент кафедры экономической теории
Сумский государственный университет, Украина
Володин Дмитрий Владимирович
PhD, менеджер проектов,
FARADI SRL, Италия

В статье рассмотрены методологические основы исследования технологических систем. В рамках разработки методологии исследования определены основные структурные характеристики технологических систем и базовые элементы внутренней динамики на основе внешних импульсов. Обоснована целесообразность использования для целей исследования технологических систем модели биотического нейрона и предложено соответствующий методический подход к созданию нейросети на ее основе.

***Ключевые слова**: технологическая система, нейронная сеть, импульс, модель биотического нейрона.*