TOPIC 1. INTRODUCTION TO METHODOLOGY OF SCIENCE

- A brief history of the development of science, the stages of the formation of scientific worldviews. Modern scientific paradigm.
- Science as a social institution. The role of the subjective factor and the mentality of society.
- Interdisciplinarity. Evolution of the scientific paradigm. Co-evolution and its significance for the formation of the modern economic paradigm.

Science Studies. In the 60s, by the initiative of the Soviet philosophers, the study of science (the science studies) was institutionalized as an interdisciplinary field that studies the system of the main aspects of how the science functions: its history, economics, psychology, management, and methodology. When embarking on the study of science, it is important to determine to which aspect of the science functioning we appeal.

Science can be studied as:

- A system of knowledge;
- Professionalized activity;
- Social institution.

The most complexly organized way of the science functioning is a social institution, which means the transformation of science into a mass occupation determining the pace and direction of social development. The increasing dependence of society on science leads to an increase in inverse dependence, which is especially noticeable in relation to financial support and material and technical base of basic science.

The genesis of science is a key point in the study of science, no matter which aspect of science is being studied. In the science studies, there are two main competing theories on the origin of science. The first theory assumes that science emerged as a result of Socrates intellectual revolution at the turn of the 5th-4th centuries BC. The second theory claims that science in the proper sense of the word originated in the Modern Times (16th-18th centuries), when the first scientific worldview, called the classical, mechanistic or Newtonian view, was being developed.

It is possible to state the emergence of science in the history of culture only if sufficient and indispensable attributes are determined (an attribute is a fundamental intrinsic property) of the scientific knowledge. Having a theoretical nature is an indispensable attribute of a scientific knowledge, i.e., a scientific discovery can become operational only if it has a theoretical basis. A striking historical example of this principle is the story of a self-taught mechanic, Ivan Kulibin. When working on the construction site of one of St. Petersburg bridges, Kulibin actually discovered one of the laws related to the theory of mechanics of materials (the theory of resistance of metals). However, having no university education, he could only formulate it in his own words, and hence, this discovery was not recognised as a scientifically important one.

The law did not leave its mark in science and was not applied in practice until an educated researcher of German origin discovered it anew; i.e., formulated and substantiated it theoretically.

Theory is a system of categories, principles, and laws. A scientist should, above all, be able to operate a system of scientific concepts and categories. For instance, how can a chemist work without knowing a relevant terminological system? Only by means of the system of relevant categories can a scientist formulate initial principles of a scientific theory. A scientific principle is a statement taken as a self-evident truth, which serves the basis of a scientific theory; in other words, a scientific principle is not proved logically, but rather accepted as it is. The exclamation of Archimedes: “Eureka!” it is a cultural symbol that fixes this first step in constructing a theory as an appropriate form of scientific discovery. Isaac Newton, one of the greatest scientific geniuses, generously imparted the way how a scientific discovery is carried out to us, by recording in his memoirs his eureka moment, i.e., the moment when he, watching the falling apple and pondering why the apple falls and the moon hangs, received a revelation about the existence of the universal law of gravitation. This truth, presented to Newton's mental gaze as self-evident, then had to be proved. Thus, the three laws of mechanics (Newton's laws of motion in classical mechanics), emerged comprising a classical theory of mechanics, the top of which is the Law of Universal Gravitation with its formula: F = ma.

A law represents a connection between phenomena, although not any kind of connection; namely, an internal, significant, objective, general, indispensable, and of a repeated effect.

Apart from being theoretical, the content of a scientific theory must be objective. Objectivity is a sufficient attribute of science. Objectivity of a scientific theory guarantees the expected result upon the application of the theory, no matter which agent makes use of the theory, although special conditions implied by the theory are to be observed. For economics, this aspect is of particular importance.

Today, no one needs a prove that social reforms while being successfully introduced in one country, are not necessarily as successful when implemented in another one. The reason is that social laws, unlike natural laws, are the result of human endeavor; thus, people act freely and, quite frequently, carelessly. Therefore, when using social laws, it is necessary to take into account the subjective factor, the core of which is the mentality of a society.

Objectivity is the essence of any law. A social law is objective by its content, but subjective by the form of its manifestation. This aspect, the impact of the subjective factor, has not been properly studied yet.

Thus, science is a system of theoretical and objective knowledge. What arguments support the theory of science that resulted from Socrates intellectual revolution?

Socrates acted as the “midwife” of science. Socrates argued that like his mother, he is engaged in midwifery (from Ancient Greek, “maieutics”), assisting in the process of birth, although it is the truth, not a child, which is born. Socratic Dialogues aimed at helping the interlocutor to give birth to truth. Notwithstanding, Socrates himself could not appreciate that he contributed to the birth of science. All ‘pre-Socratics’ worked on the fundamental problem of the origin and structure of the cosmos. In turn, Socrates announced: ‘Philosophy has nothing to do with the problem of Arche and the structure of the cosmos; philosophy should address precisely the man’. Thus, Socrates in fact differentiated between the subject and method of philosophy and science. As a result, the science gemmated from philosophy, and the specific scientific knowledge started to develop independently, although the theoretical and methodological relationship between philosophy and science continued to evolve.

The first sign of the emergence of specific scientific knowledge after Socrates intellectual revolution was the system of geometric knowledge developed by Hippocrates of Chios at the beginning of the 4th century BC and based on the method of mathematical induction. The next step in the development of specific scientific knowledge was undertaken by Theaetetus of Athens with his theory of regular polyhedra. It is no coincidence that, initially, specific scientific knowledge was formulated in the field of mathematics, which is considered to be the language of science. Then mathematics was introduced to astronomy in the 4th century BC, when Eudoxus developed the first geometric geocentric astronomical model. Thus, a general scientific law of mathematization started to operate: once mathematics enters a field of knowledge, it starts to direct it like by a compass and steer it towards a higher theoretical level and scientific maturity. Therefore, not coincidentally, the first “genuinely scientific revolution” occurred in astronomy, when in the 16th century the geocentric model was superseded by Copernican heliocentrism.

Emergence of theoretically mature social-humanitarian knowledge, which happened 150 years later compared to natural science, is also the result of mathematization. Economics, due to the peculiarity of its subject, plays a specific role in the process of mathematization, adapting the mathematical methods for usage in social sciences while considering the vast historical tradition of mathematical methods in natural sciences. At some point, research efforts of Soviet scientists turned into a triumph: in 1975, Leonid Kantorovich was awarded a Nobel Prize for the development of mathematical methods in economics.

At this point let us consider the second concept of the genesis of science, according to which science in the proper sense of the word emerged in the 17th century, which is symbolized by the name of Newton as the author of the first scientific worldview. A scientific worldview is a theoretical representation of the world in general, formulated by the professional academic community by means of a system of categories, principles, and laws. The development of the first scientific worldview indicates that science, in general, is becoming more theoretically matured.

The two theories of science genesis are considered competing, although in fact they are not. Russian thinker, Danilevsky N.Y. proved it by suggesting a solution to the problem of the genesis of science in the second half of the 19th century in his monumental work "Russia and Europe".

While considering the development of science within the history of culture, Danilevsky writes that emergence of science should not be associated with the level of its maturity; the science represents all areas of scientific knowledge as well as a human being, by that is meant any kind of human, no matter a child or an adult. According to Danilevsky, the criterion defining the birth of science is a conscious understanding of the subject and appropriate methods of research in a specific area of knowledge. Hence, it would be logical to admit, that science started to develop as a system of specific scientific knowledge resulted from Socrates intellectual revolution, when the subject and method of science were differentiated from the subject and method of philosophy. The evolution of the system of specific scientific knowledge in Antiquity, the Middle Ages and Renaissance led to the establishment of science as a profession in the Modern Times, when science has become a type of spiritual production, as interpreted by Marx.

At the turn of the 19th -20th century, science started to shape itself as a social institution. This implies that turning into a popular occupation and embracing all areas of the empirically observed world in the research process, science started to determine the direction and speed of social development. By this time, the natural sciences have achieved a very high level of development, while social and technological knowledge has been established as specific scientific branches of knowledge. Due to the emergence of these three branches of scientific knowledge, which cover entire natural reality, the scientific community comes to the conclusion that the world is united, and it would be more effective to study any phenomenon of this world using an interdisciplinary approach. It should be noted that Friedrich Engels, in the 90s of the 19th century, predicted that the most significant discoveries should be expected at the intersection of the sciences.

A striking example of the relevance of science's transition to an interdisciplinary strategy at the turn of the 19th and 20th centuries are the scientific and pedagogical activities of V. I. Vernadsky, who started his career as a geologist, and after a couple of decades became known as a biochemist. The effectiveness of applying an interdisciplinary approach to science becomes undeniable when first cybernetics and then synergetics appear.

Having reached its maturity in the modern era, scientific knowledge became a paradigmatic force. Paradigm as a scientific category (translated as an example) was introduced by Thomas Kuhn in his work 'The Structure of Scientific Revolutions'. He used this term to define a scientific revolution. According to Kuhn, the essence of the scientific revolution is the shift of a scientific paradigm. A scientific paradigm is an optimal algorithm developed by a professional scientific community to describe the activity of a social agent under specific historical conditions.

The mechanistic paradigm developed in the 16th-18th centuries refers not only to natural processes, but also to society and humans. In other words, both society and humans are viewed as a kind of mechanism, which clearly states the very title of the work of French enlightener of the 18th century “l’Homme Machine” (“Man a Machine”) by La Mettrie. Being a doctor by his first education, La Mettrie, in accordance with the mechanistic paradigm, considered bloodletting as a universal method of treatment. The mechanistic paradigm corresponded to the stage of classical science in the Modern Times, in the 16th-17th centuries. The 19th century became a transition period in the history of science: it was a time of developing revolutionary theories (in geology and biology) and making scientific breakthroughs in various areas of knowledge. As a result, the pinnacle event of this scientific process was the discovery of electron, i.e., the divisibility of the atom.

At the turn of the 19th and 20th centuries, as a result of the scientific revolution, the mechanistic paradigm was replaced by the relativistic paradigm developed under the framework of Einstein’s worldview. The essence of this non-classical paradigm is that everything is relative. Relative to what? The starting point of the analysis is the subject, and certain scientific models and technologies are built in relation to his specific goals and interests.

At the turn of the 1960s-1970s, another shift in scientific paradigm occurs: there starts the development of a new post-non-classical scientific worldview of global evolutionism. By this time, interdisciplinarity in science reaches maturity, which is manifested in the emergence of cybernetics as an interdisciplinary area.

Cybernetics is an interdisciplinary area that develops a mathematical theory of the informational functioning of complex dynamic systems of any nature based on the feedback principle. It means that in natural, social, and technological systems there exist common laws of functioning. Norbert Wiener is considered as the father of cybernetics. In his works ‘Í am a Mathematician’ and ‘Cybernetics’, published in Russian, Wiener explains the genesis and mathematical theory as information process of any nature. Specifically, a mathematical theory of cybernetics gave rise to modern IT: from Electronic Calculating Machines to PCs. At the same time, it makes sense to emphasize that classical and non-classical scientific worldviews have their own authors: Newton and Einstein, who admitted that their scientific achievements resulted from collective efforts. As Newton said, “If I have seen farther than others, it is because I was standing on the shoulders of giants”. Einstein has put it more grotesquely: “Genius is a dwarf standing on the shoulders of giants, his predecessors’. Unlike a classical or non-classical scientific worldview, the post-non-classical one has no embodied author due to the fact that by that time the popularity of the scientific occupation and interdisciplinary approach had already matured.

At the turn of the 1960s-1970s, scientific groups effectively started its research within the Club of Rome. The creation of this international informal organization was initiated by the Italian entrepreneur A. Peccei, who, thanks to his education and outlook, saw a threat in increasing technological human activity if this process was not to be accompanied by the development of human qualities, including moral ones. Upon the request of the Club of Rome, scientific groups developed a methodology for solving environmental problems; in particular, it was during the work of the group when such technologies as the technologies of closed industrial cycles, waste-free production, and others were proposed. The key methodological achievements of the Club of Rome included the development of global computer modelling of natural and social processes. The collective work of the scientific groups of the Club of Rome prepared the transition to post-non-classical science, contributing to the emergence of the worldview of global evolutionism.

The essence of the global evolutionism paradigm is the principle of coevolution, according to which the evolution of culture and the evolution of nature represent one single process. The paradigm is based on a specific problem-solving methodology, relying on the analysis of the dynamics of society and nature as one organism, which means that any further progress is impossible without an interdisciplinary approach. The underlying meaning of the principle of coevolution is biophilia, i.e. in appreciation the value of all forms of life.