Methodological fundamentals of quality management theory in condition of digital economy

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Abstract. Theory and practice of quality management are still under longstanding crisis which is most evidently manifested in conditions of digital economy. This article is addressing a conceptually new approach to solving the problem of quality management system development. Lack of progress in solving this problem is caused by (I) mismatch between today’s basic economic model and economic practices and, as a consequence, (II) failure to solve it within the scope of recommendations obtained in limited subject field. Referring to analysis of centuries-long experience of scientific development the authors investigate potential directions of quality management system development. The paper substantiates necessity to address the background of methodology — a science dealing with functioning and using of practical recommendations which already exist in this sphere. As a result, this subject acquires the features of interdisciplinary character — interfacing economical, general systematical and general methodological disciplines. It should be mentioned that so far problems presented herein have not been completely investigated and further more profound and detailed survey is required. Results obtained make it possible to expand potential directions of economic theory improvement and development. This paper has, to a greater extent, a prearranged character, is innovative by its nature and may be interesting for experts specialized in economy and related disciplines.

1. Introduction

The fact that modern economic science is under longstanding crisis has been pointed out by leading experts, not only national but also by foreign ones [1–4]. Probable cause thereof consists in the fact that modern economic science is solving the surface description tasks of quality management process and, therefore, constitutes rather empirical than analytical science where the main part of economists-researchers is still staying within “normal” [5], “substantive methodology” and is “a priori” limited by the framework of established scientific paradigm excluding any possibility to disclose the reasons of emerging antinomies and collisions of economic science common for real economy like “market and state management failures” or actually resolve the issues of quality management, pricing, fair salaries or resources allocation.

As a result, in case of economic theory we deal with situations typical for the process of science development in any subject field, i.e. with so-called “break of knowledge continuity” represented by its inability to adequately disclose cause-and-effect relations objectively shaped in its cognitive object,
i.e. economic system, and to explain the essence of phenomena taking place in global economic environment in condition of society digitization [6, 7].

Cause of this — established scientific community's opinion that any scientist who is shaping his knowledge about the subject of his study must obligingly use tools and methods developed within the framework of his own specific discipline.

2. Methods
In order to evaluate within the framework of economical science today's situation regarding quality management system and its development capacities we used methods of comparative analysis proceeding from researches made by domestic and foreign economists for the recent century. Methods and techniques of research existing at the stage of “normal economy” make it possible to elaborate mutually consistent knowledge satisfying the assigned tasks. This simplifies the process of investigation and allows (neglecting the legitimacy of this knowledge application) to rest on established practices peculiar for this academic field [8].

Fundamentally different situation develops in conditions of new digital infrastructure, new goals and new objects of investigation. Here, the history of science can show numerous examples when application of outdated methods is inadmissible while the only way to resolve a collision is to use conceptually new materials and methods of investigation based on a specialized theory of such methods reproduction — i.e. on “methodology”. At that, there are two essentially different approaches of construing it – subject-oriented and general-theoretical [9].

In the 1st case, “methodology” is integrated into the framework of particular subject-oriented investigation and constitutes a modification of established materials and methods of investigation supplemented at the expense of missing data borrowed from other science sub-disciplines. Here, the researcher is borrowing from other sub-disciplines not the entire scope of accumulated knowledge but only accessible knowledge and methods and selecting only those ones which could be useful in solving the problems encountered. Such approach, however, cannot eliminate “normal science” limitations in full scope.

Second approach is based on historical experience accumulated in the course of formation and development of scientific activities. As it is known, the history of science has a lot of examples demonstrating how our predecessors-natural scientists managed to completely resolve compositionally similar and coessential problems. These examples have been described in papers dedicated to history of formation of mathematics, physics, electricity industry, microelectronics, global computer networks, bioengineering and other subject-oriented sciences. Their consecutive systemization and generalization lead to creation of initial backgrounds of special scientific discipline called “general methodology” at the turn of XXth century.

While classical mechanics (as a discipline studying the processes of motion) began to lose monopoly in construing the world view, the process of scientific transformation displayed considerable rise of disciplines in which objects of study were associated with processes of transformation and evolution (biology, chemistry, geology). As a result, the style of scientific thinking acquired the idea of evolution and cognitive object itself ceased to be regarded as a finished and stable structure. It acquired the form of process admitting modifications and evolution.

Natural history shows that physical science at the end of XIXth century achieved objectives (in micro and macro areas) according to which habitual world view was based on assumption of priority of unmodified, “in abstracto” existing space imparted with absolute time. All objects which subsequently acquired the possibility of further interrelation whose parameters were defined in accordance with Newton's laws moved to this space thereafter. Thus, natural science for the time being kept complying with experimental findings [10, 11].

At the same time, a number of experiments undertaken on the interface of this space already gained results which cannot be interpreted in the context of mechanistic, atomistic and molecular outlook. First of all Maxwell's theoretical works are meant. His equations describing the electromagnetic fields interaction were in contradiction with generally accepted laws of classical mechanics and thus
discredited conventional image of the Universe based on a number of descriptive hypotheses. A legal question arose whether it was admissible to apply it in changed environment.

Maxwell's works materially affected and changed the world view of Wilhelm Ostwald, Nobel Prize winner in chemistry and one of the greatest scientists of that epoch, causing him to realize that it is impossible to explain some of experimental findings obtained in emerging branches of knowledge within dominating scientific paradigm. His acquaintance with special and, henceforth, with A. Einstein's general relativity theory, results of his own scientific research gave Ostwald and idea of findings interpretation from the position of thermodynamics laws considered in regard of energy and transformation thereof [12].

Based on investigations conducted, Ostwald formulated the hypothesis that energy is a sole reality and all that which is going on in the world means energy state variation. Next step made by Ostwald in this direction – attempt to form a unified energy-related world view. He elaborated the laws of conservation and transformation of energy which constitute the basis of social energetics. For instance, he considered energy as a basis of money exchange and identified energy saving as an example of rational ethics.

The idea of “energetic” theory was picked up and further developed by his contemporary — A. A. Bogdanov, Russian scientist. According to A. A. Bogdanov, main Ostwald's merit consists in elaborating the integrated approach to outworld study. A. A. Bogdanov, proceeding from Ostwald's “energetic” theory, is building up his own theory of world organization: “activity-resistance” constituting the “energies” of counteraction [13].

One more important idea accepted by A. A. Bogdanov in Ostwald's energetizm — consideration of energy as a source of modifications which are representing difference of interacting structures potentials. Namely this aspect of A. Bogdanov's work shows how deeply he understood specific aspects of paradigm shift in reference to Newtonian description of the world disclosed by A. Einstein in his general relativity theory. Space in which matter is placed does not exist a priori being itself a result of matter interaction.

Thermo dynamical principles, in full compliance with tectology principles elaborated by A. A. Bogdanov, beginning from the middle of XXth century represented themselves by substantial outbreak of organizational orientation theories. Result of this outbreak – emerging of general scientific disciplines and methodological approaches cluster. Currently, intensive development of all this set of theories (generated in the course of Ostwald's fundamental “energetic” idea segmentation) is consistently going on in compliance with tectological “law of divergence”. Furthermore, at some stage of their development in accordance with Bogdanov's law of “additional links organization” these theories predictably inter-penetrated and integrated. This resulted in scientific worldview emerging.

In virtue of A. Bogdanov's theory, we would like to point out two basic aspects of paradigm shift: firstly, the world has become probabilistic; secondly, “model” has definitely replaced “truth”.

Therefore, in virtue of performed investigations, forwarded hypotheses and accepted postulates, beginning from 2nd half of XXth century, visualization of mechanism of purposeful formation of missing investigation objects ontological representation from the viewpoint of practical activity isomorphism has gradually shaped. Approach enabling the possibility to use power of entire continuum of knowledge and methods generated by science during all its life cycle for particular purpose of particular subject-oriented discipline improvement has been formed. As a result, a standalone scientific discipline called “methodology” emerged.

3. Results and discussion
It should be mentioned that subject of methodology as a scientific discipline fundamentally differs from subject of any other science. Methodological activity itself is becoming an independent, standalone phenomenon having its own type of knowledge and its own set of investigation methods. It is possible to point out six groups of characteristics making it different from conventional sciences:

1. Main objective of methodology — grasp entire spectrum of human's activities. Main products thereof — structures, projects, norms, methodological prescriptions.
2. Methodological activity is always oriented on design support services provision. It is directing it towards the specified goals.

3. Methodology is creating the compositions of polytypical knowledge combining and linking natural science, technical, historical, practical and methodological knowledge. It is creating and using the knowledge about knowledge.

4. Essence of methodological approach – to link and to integrate knowledge about activity and knowledge about the object of this activity. Resulting knowledge is multidimensional. Integrating dissimilar knowledge it appears to be unified and integral.

5. A methodologist involved in object re-designing assumes that his perceptions are characterizing the object from different perspectives. That is why; object conceptualization employed by him may comply only with strictly limited set of selected knowledge.

6. In methodology, integrating of various knowledge is performed according to schematics of activity itself, not by schematics of the object. As a result, perception of complex activity encapsulating various spheres becomes the tool which enables blending of perceptions about the object of this activity which is based on logic of application of various knowledge in co-operated team work. Therefore, “general methodology” is a specific discipline oriented on knowledge development which makes it a top-priority issue in condition of globalization.

One of the goals — establishment of “theory of activity”; purpose — disclose essence of formation of new types of knowledge on the basis of system-structural language (so-called “methodological mathematics”). Within this theory we worked out a common approach to overcome antinomies, collisions and paradoxes as elements of the life cycle imminently occurring in the course of any science development.

The proposed approach proceeds from firmly established scientific perception of uniformity of inanimate nature, life and society processes which correlates with quality management system. Aiming to describe this approach, modern science formed a set of systematic theories aiming to ensure completeness of viewpoints used to represent it. All of them, using the concept of isomorphic analogy, confirmed the possibility to unify methodological solutions in various subject-oriented disciplines including quality management system.

We are considering the postulate that analogy is similarity of items, events, processes by particular features and properties, at that, all aforesaid items and processes have been initially different. Proceeding from this statement, ratiocination by analogy is a logical output of confirming similarity between these items. According to J.C. Maxwell, affirming of analogy between two systems of ideas is leading to more profound and complete knowledge of both of them rather than knowledge that we obtain when we consider them individually. Namely considerations by analogy are giving birth to hypotheses constituting the basis for arrangement of item, event or process under consideration. As a result a “model-based approach” is emerging. Its purpose is to ensure recurrence of experimental conditions and to exclude impacts of hard-to-account factors.

Model of the object — another object (realistic, symbolic, ideal). It differs from reference object, however, retains the entire set of essential properties which were existing at the stage of model creation. For this purpose it could fully replace the initial material. Formally said could be represented by the following scheme. There are systems A and B for which “ai” and “bi” elements have been assigned. Both elements are interlinked by the system of relations “ri” and “fi”. In each system there are relations allowing establishing the new dependencies between system elements, at that, a part of them could be defined initially. Referring to these systems is it possible to define isomorphism, i.e. complementarity of the proposed elements. For this purpose it is required to set a condition which enables locating of any “ai” element in compliance with “bi” element in the adjacent system. Besides, it is required to establish one-to-one link between “ri” relations from A and “fi” relations from B. Subsequently, A and B dependencies acquire one-to-one links; the result of implementation thereof – a situation when (having and understanding of interaction inside one of polymorphic systems) we have a possibility to obtain information about relations in the other system. At that, no additional investigations are required.
From this we can conclude that drawing an analogy with isomorphism application may be defined as a case when relations from well-examined model are projected to the prototype. This approach is widely used in scientific sphere. In order to use it is required to satisfy the below requirements:

1. Uniformity of relations which are correlating between each other and between other systems elements under investigation.
2. Unilateral equidirectional functionality of relations under consideration.
3. Communicativeness of correlators with relations in systems compared.

Detection of natural occurrence of isomorphism relation considerably expanded methodological tools arsenal. In particular, a possibility has come up to use modeling on the basis of the so-called “substitution layers”. And this made it possible to undertake investigation of, inter alia, quality management system based on aforesaid postulates; it is possible to affirm that difference between systems consists only in their appearance and complexity. It’s generally accepted that particular class of systems constitutes the object of investigation of any science. Here, “system” is understood as a set of elements and relations between them with marginally broad interpretation of “relation” term.

Let us consider $S$ system in capacity of ordered couple: $S = (A, R)$, where $A$ — various elements, $R$ — various links between them. Let us classify couples $A, R$ using the below criteria:

1. By characteristic of individual types of elements;
2. By characteristic of individual types of relations between them.

Classification with the use of first criterion is actively used in science for the purpose of dividing it into disciplines and specialties where each of them is covering a particular sphere of knowledge and skills. This sphere is characterized by types of elements, at that, type of relations between them is not considered. Elements of different types require different tools for data acquisition. This classification has a level of proto-science, i.e. it is based on empirical knowledge. This is mentioned also in today’s consideration of modern science in general and quality management in particular. In condition of global digitization this system is already outdated and requiring updating.

Second criterion is introducing a fundamentally new classification. In this classification a specified type of relations or links is established depending on the class of objects. At that, type of elements which are formed by those links is normally not excluded out of consideration. Such classification becomes possible in the course of investigation beginning from the stage of data systemization, i.e. at the stage of transition to data acquisition at the level of confirmations and conclusions.

Most large classes of systems which are classified by the second criterion — consideration of various orders of knowledge in reference to phenomena under study. With reference to methodological differences specific for individual indicators, all system classes are subdivided into smaller classes. At that, each of these classes includes systems which are equal by their particular essential characteristics and by relations existing between them. This equivalence is called isomorphism; classes identified in this way are called isomorphic.

Systems belonging to the same isomorphic class are equivalent only by features attributive to some of their links characteristics. This is why; they may be composed of various elements. Therefore, if you are interested only in relations existing inside this system we can replace existing isomorphic class by its prototype depending on our objectives provided that in this way it will be more useful for further acquisition and processing of information. For this purpose, more frequently used are systems in which sets of elements have common nature. This allows describing their relations in any standard format. The only condition in this case is using a unified criterion for this selection in respect of entire isomorphic classes. Representatives of classes under consideration which are meeting these requirements belong to common systems. Such system is more often abstract. It is considered as a class of systems which are isomorphic while studying essential characteristics of the relations [11].

Besides, employment of fundamental provisions of activity theory allowed substantiating expediency of transition to classification of objects under investigation by the features of relation types [14, 15]. Such approach provides researchers with a range of new possibilities. For example, if we assume that systems integrated in a particular class of structures is similar only in some characteristics of their relations they may be considered on different elements. Thus, we can replace a particular class
of isomorphic systems by its prototype. This gives a possibility to describe them in maximally friendly standardized format using a unified selection criterion applied for different isomorphic classes. Those representatives which are capable to satisfy the forwarded requirements are represented as abstract system. It constitutes a class of systems which are isomorphic in regard of various essential characteristics of the link which fact is considerably simplifying the process of their study and is leading us to important conclusions.

Thus, investigation of abstract system functioning process enabled us to determine presence of ambivalence in its models. One side of which is the interconnectedness of properties in the object, the other side is the unity of elements in the model. Emerging of this ambivalence is explained by the fact that establishment of integral model of functioning mechanisms of any kind of objects is leading to formation of classical antinomy i.e. non-compliance between morphology and functional view of its features dependencies.

According to “activity theory”, aforesaid situation in condition of digital economy may be avoided at the expense of quality management system transition to new ontology through shaping of new trajectory of development including complete change of scientific paradigm. Considerable experience in overcoming the process of “break of knowledge continuity” accumulated in the process of development of mathematics, physics and biology was generalized within the framework of discipline called “general methodology” and, based thereon, general practical recommendations were elaborated. Following these recommendations gave the below results [16].

4. Conclusions
Retrospective reconstruction of science development process enables comprehending of essence of modern interdisciplinary paradigm which is representing energy as a source of modifications and its quantitative measure as a consequence of difference of interacting complexes potentials. This representation is based on laws of conservation and transformation of energy comprising the common conceptual basis of all physical and social processes — the so-called “universal evolutionism” [17].

Thus, we have almost selected the scientific paradigm. Concept of universal evolutionism proposed by N. N. Moiseyev could be used as a basic scheme. Principles on which his theory is based will be used as primary and common (for solving of all subsequent modeling problems) set of admissible paradigm limitations. These limitations will, as may be necessary, be added by specific limitations necessary for setting such specific tasks. At that, in order to describe processes which are running in particular economic environment we will use energo-dynamic approach.

This concept constitutes the basis and the main direction in shaping the scientific worldview which includes all three spheres of existence: animate and inanimate nature and socio-economic life within a common system-evolution approach on the basis of underlying general scientific principles and innovative digital technologies. Within this concept, the modern science is implementing comprehension of global evolution as a common universal process of self-developing natural objects and the Universe as a whole. Based on universal evolutionism we could draw up a number of principles:

1. Social and evolutionary process of super system development takes place without external impact. Only energy can enter from outside.
2. Digital technologies provide considerably high growth of emerging structures diversity and organizational complexity.
3. Quality management system is based on standard social laws associated with reasonable people's activities. Digital technologies are playing supplementary role defining the process specificity not its essence.
4. Stochasticity of the material world is determined by the unpredictability of evolution and its irreversibility. Digitization is supplying evolution with relative stability and predictability.
5. Growing of systems complexity is causing their stability to decrease and thus accelerates the process of development.
6. Approach to evolution assessment, studying and updating is common for entire systems irrespective of their size.

Regrettfully, the concept of “universal evolutionism” has no adequate analytical tool [18]. In this situation, it becomes expedient to apply knowledge and provisions of thermodynamics identified by A. Einstein as “a unique physical theory which, I'm convinced, will never be disproved within its main concepts applicability framework”.

Main advantage if thermodynamics consists in ability to obtain large amount of consequences which relate to various phenomena. This is achieved with rather small amount of initial principles. At that, there is no necessity to create models of substance structure and to interpret ongoing phenomena from the viewpoint of their molecular mechanism and generally accepted realness of its consequences.

Potential of thermodynamic method is commonly known. According to I. Prigozhin [12], thermodynamic concept is assuming increasingly growing importance in today's world. Besides, on the background of increasingly growing digital technologies, thermodynamics was generalized within the framework of “energo-dynamics” of the fundamental science which is scrutinizing and generalizing common rules and characteristics of real (bounded velocity) processes causing various forms of energy to transfer and transform. And this may be applied in quality management theory. The proposed theory explains and construes basic principles and laws of animate and inanimate nature, social society in capacity of unified theory consequences in systems characterized by definite degrees of liberty. Such arrangement of fundamental disciplines is leading to a number of non-traditional conclusions and results in various fields of quality management system application.

Therefore, this scientific tool (obtained as a result of universal evolutionism supplementing by analytical mechanism of thermodynamics) enables the economic theory developers to investigate economic practice at any of its levels [19–21].

Researcher first of all receives a possibility to formulate the task put forward to any economic object. For local object – it is sustainability; for economy as a whole – it is development.

Based on proposed (in “Tectology: general organizational science” [13]) formation and regulation mechanisms we can solve explanatory problem formulated by J. Schumpeter [22] in regard of role and place of innovator in the economic system.

Besides, the researcher has a possibility to find out the reasons of antinomies known as “market failure” and “state failure”. Analytical tool of thermodynamics perfectly fits this purpose [9, 18].

Thus, transition to energetics paradigm which is new for quality management system, however, traditional for integral science is promising a breakthrough in economic development.

References
[1] Skidelsky R 2009 Keynes: the return of the master (London: Allen Lane, and Cambridge: Public Affairs)
[2] Galbraith J K 2004 The economics of innocent fraud: truth for our time (Boston: Houghto Mifflin)
[3] Bogle J C 2010 Don't count on it: reflections on investment illusions, capitalism, mutual funds, indexing, entrepreneurship, idealism, and heroes (Hoboken: John Wiley & Sons)
[4] Stiglitz J 2016 The Great Divide: Unequal Societies and What We Can Do About Them (Moscow: Eksmo)
[5] Kuhn T 2003 The Structure of Scientific Revolutions (Moscow: ACT)
[6] Stiglitz J 2003 Globalization and Its Discontents (Moscow: National public-scientific fund)
[7] Glaziev S 2010 Strategy of Russia's outstripping development in global crisis conditions (Moscow: Economy)
[8] Stiglitz J and Charlton A 2007 Fair trade for all. How trade can promote development (Moscow: All world)
[9] Etkin V A 2008 Energodynamics (synthesis of energy transfer and energy transformation theories) (Saint Petersburg: Science)
[10] Delyagin M, Glaziev S and Fursov A 2013 Strategy of big breakthrough (Moscow: Algorithm)
[11] Schedrovitsky G P 1995 Selected articles (Moscow: Politprosvet)
[12] Prigozhin I R and Kondepudi D 2002 Modern thermodynamics. From thermal motors to dissipative structures (Moscow: Mir)
[13] Bogdanov A A 1989 Tectology: common organizational science (Moscow: Economy)
[14] Volkova V N and Gorelova G V 2015 Modeling of systems and processes (Moscow: Urait)
[15] Yakovlev A A 2017 Theory of economic processes modeling. Genesis and functioning (Saint Petersburg: Victory)
[16] Yakovlev A A and Yakovlev A V 2018 Azimuth of scientific research: economics and management 7 (1-22) 287–291
[17] Moisseyev N N 2003 Selected articles (Moscow: Tydex Co)
[18] Stiglitz J 2015 The Price of Inequality: How Today's Divided Society Endangers Our Future (Moscow: Exmo)
[19] Delyagin M and Sheyanov V 2015 Empire jumping. China from inside. Kak i dlya chego “Aleet vostok” (Moscow: Knizhnyj mir)
[20] Delyagin M and Sheyanov V 2015 Main event of XXIst century. Possibilities and risks for Russia (Moscow: Knizhny mir)
[21] Khazin M L 2011 This time everything will be different. Eight centuries of financial heedlessness (Moscow: Kariera Press)
[22] Katasonov V 2017 Global world of finance: from crisis to chaos (Moscow: Knizhny mir)
[23] Schumpeter J 2007 Theory of economic development (Moscow: Eksmo)