https://doi.org/10.51408/issi2025_170

Fundamental Foundations of Scientific Heritage Formation: The Evolution of Scientific Knowledge and the Possibility of Applying Scientometric Tools

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Introduction

The rapid growth in the volume of scientific publications and the increasing complexity of the scientific knowledge structure leads to the formation of a confusing, unstructured system which makes it difficult to identify and evaluate key academic theories. In this regard, it is relevant to develop methodological approaches which facilitate the identification of emerging scientific theories, analyze their evolution, and predict their potential to become the scientific heritage. In this study, a scientific theory is understood as any scientific knowledge that can theoretically become the scientific heritage of an author, scientific school, organization, country, etc.

Understanding the regularities of the formation and consolidation of scientific theories has not only theoretical but also applied significance, as scientific heritage determines the basis for further research and influences the strategic development of science. This issue is especially relevant in the context of national scientific priorities, particularly for Russia during a period of external constraints, when the formation and support of its own scientific traditions become critical for the sustainable development of scientific and technological sovereignty.

Materials and Methods

In order to understand the mechanism of scientific theory development, the key concepts of the philosophy of scientific knowledge evolution were analyzed. The methodological basis of this work is grounded in Karl Popper's concepts of falsificationism and the evolutionary approach (Popper & Keuth, 1935; Popper, 1979), Thomas Kuhn's paradigm shifts (Kuhn, 1997), Imre Lakatos' research programs (Lakatos, 1976), Paul Feyerabend's epistemological anarchism (Feyerabend, 2020), and Larry Laudan's research traditions (Laudan, 1978), which are widely recognized as fundamental theories. The focus was on the criterion of scientific progress, the nature of theory change, and the sustainability of scientific concepts. The analysis was conducted using the methods of philosophical reconstruction, comparative analysis, and graphical modeling of the dynamics of scientific knowledge.

Results

Scientific Theory Development and the Network Path of Its Evolution

This study developed an original theoretical scheme of scientific theory development, including those studied earlier. According to the proposed model, a new scientific theory, even if initially formed in the works of one author, enters the scientific discourse rapidly, reaching a critical mass of recognition that corresponds to the phase of scientific revolution (T. Kuhn). From this point on, the theory develops and can give rise to offshoots – subtheories. At the same time, the original theory continues to exist and develop independently of these offshoots. Its further development follows the trajectory of successive falsifications and modifications (K. Popper). As critical anomalies accumulate, the theory reaches a bifurcation point, where it either faces the final crisis of the paradigm or a “protective belt” of auxiliary hypotheses is formed (I. Lakatos), supporting the main theory until the moment of anomalies re-accumulation, when variations are repeated cyclically (Figure 1).

Regarding the network path of scientific theory development, in the positive scenario,

the theory diversifies into many offshoots during its development, which nevertheless retain the rigid core of the original concept. At this stage, the factor of the scientific community manifests itself: competing interpretations and modifications (Feyerabend) contribute to the formation of a related sub-theories network, the stability and evolution of which are determined by the mechanisms of natural selection of ideas (late K. Popper).

The future fate of the entire theory depends on a number of factors: the depth of its embeddedness in the academic environment, the degree of diversification, the time interval of development, and resistance to external challenges.

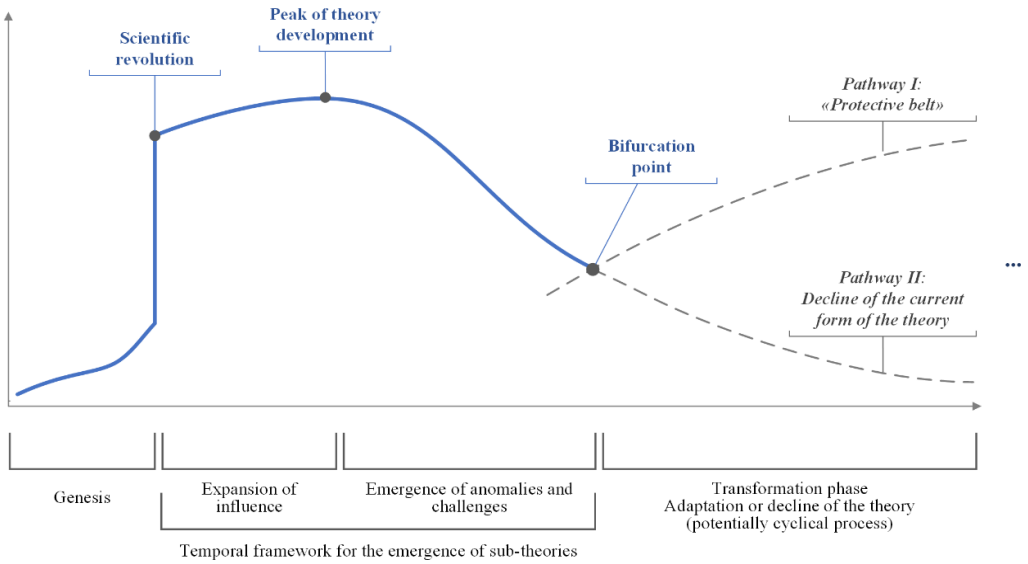

Figure 1. Conceptual framework of the development of an initial scientific theory.

At the same time, the model allows for the influence of exogenous factors – technological, social, and political transformations that can radically change the trajectory of scientific progress.

Methodology for Assessing the Dynamics and Determining the Status of Theories

The authors consider an approach to assessing scientific theories for their potential transition to the status of scientific heritage by analyzing the structure of the theory development network, in which the key indicator is the volume of citations – both for the theory itself and for the works that refer to it.

The authors suggest that a publication should be considered part of a sub-theory if it refers not only to works from the central (or previous) sub-theory but also to other works within the network. Thus, the analysis of the developmental network should include both top-down links from the core and horizontal links between nodes at different levels, which correspond to the complexity of the evolution of scientific knowledge.

Further analysis includes identifying regularities in the dynamics of the theory: the definition of its stages of evolution, critical points, and factors affecting its sustainability. In addition, based on the analysis of the current dynamics of the theory's development, including citation rates, researchers' activity, the emergence rate of new sub-theories, and the degree of their integration into scientific discourse, it is possible to assess the likelihood of its further successful development and potential transition to the category of scientific heritage.

Discussion

The authors intend to test the developed theoretical model using scientometric tools aimed at verifying the proposed scheme and assessing its applicability, which is reasonable in the context of the existing experience with scientometric analysis of network structures.

It is also envisaged that criteria will be developed for assessing the current stage of scientific theory evolution, based on the identification of general regularities and structural patterns inherent in the theories under study.

The model is to be validated through the application of bibliometric mapping, cohort analysis, citation path analysis, and network analysis, aimed at identifying the evolutionary phases of a theory, the structural interconnectedness of its sub-theories, and the degree of institutionalization of its conceptual core.

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