The Study and Assessment of Research Performance at the Micro Level: The Age Phase Dynamics Approach

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Introduction
One of the central problems in micro level evaluation of scientific activity effectiveness is the relationship of productivity and quality of scientific publications to the age of the scientist. Despite the progress achieved in this field, the topic still remains actively researched and debated (see for example Bonaccorsi & Daraio, 2003; Costas, van Leeuwen & Bordo, 2010; Peltz, Andrews, Hofseth, Scholottet al., 2011; Reijnholdt, Costas, Noyons, Boerner & Sharnhorst, 2013).

In the present study, investigations of the relationship between scientist’s age and their publication activity are being carried out in the context of Age Phase Dynamics (APhD) model of scientific performance (Peltz & Andrews, 1966; Malitsky, 1988; Rybachuk, et al., 2005).

Methodology

D. Peltz and F. Andrews (1966) were first to describe a bimodal dependence between productivity and age of the scientists. They divided the life cycle of scientific performance into several stages characterized by alternating peaks and valleys of scientific productivity of researchers after the age of 30-35 years. They also highlighted a number of factors responsible for the "saddle-like" curves of age dynamics of the scientist’s research performance, in particular, changes in the nature of scientific activity, "creative" in younger years versus "productive" and "tutorial" in adulthood, as well as in personal motivation.

M. Fox (1983) interpreted the discovered waver-like pattern to be a consequence of authors’ including in the analysis not only the major works of the scientist, but a wide spectrum of publications, including articles, patents and applications, books, reports, presentations as well as manuscripts. However, D. Peltz and F. Andrews obtained the same characteristic relationships not only according to the number of printed publications, but also for the categories of "unpublished reports" and "peer reviews". D. Peltz also observed a bimodal pattern in the case of age-dependence of the number of citations of work scientists and psychologists (1973, p. 291).

Later, B. Malitsky (1988) defined the basis of the model proposed by D. Peltz and F. Andrews, reformulated and further developed it to become a "principle of phase dynamic research of a scientist's scientific activity".

Methods

This work presents preliminary results of age phase dynamics analysis (APhD-analysis) of the personal scientific bibliographies of scientists. The productivity curves in each phase of scientific career in a different period from each other and during different historical periods. Data of APhD-analysis for seven representatives: a German and Russian physical chemist, 1909 Nobel Prize laureate in Chemistry Wilhelm Ostwald (1853-1932); a Russian and Ukrainian geochemist, Vladimir Vernadsky (1863-1945); an Ukrainian mathematician and cybernetician, Viktor Glushkov (1923-1992), a British chemist, Thomas S. West (1927-2010); an Austrian economist, Gennady Dobrov (1929-1989); a French, 1991 Nobel Prize laureate in Physics, Pierre-Gilles de Gennes (1932-2007); and an American, 2001 Nobel Laureate in Physiology/Medicine, Leland H. Hartwell (born 1939) are presented.

Published personal research bibliographies of scientists (see references list) were used as sources of input data. The main criteria for selection of bibliographies for analysis were all-inclusive coverage of publications and the availability of their bibliometric data. Unpublished materials, reports, electronic and media publications were not included. References in analyzed bibliographies were confirmed in Scopus and Google Scholar scientometric databases.

Results & Discussion

Figure 1 shows general pattern of APhD of researcher’s scientific activity. The productivity performance life-cycle clearly indicate the most common type of scientific activity (movement of knowledge), and the nature of scientific and organizational functions of the scientists (preparation, guiding, training, consulting) in the corresponding period of their career.

Figure 2 illustrates the differences in the types of individual APhD profiles detected group of scientists as related to some of these factors. As evident, the typical “saddle-shaped” form of age-related patterns of change in the productivity of scientific activity, as described in the works by Peltz & Andrews (1966), Malitsky (1988), and Rybachuk, et al. (2005), is more or less common to all these examples, most prominently in Fig. 2a. At the same time, the specificity of individual APhD-profiles is also obvious.

Figure 2b shows the differences in the types of APhD as related to the researcher’s field of science: Physics (P.-G. de Gennes), Molecular Biology and Genetics (L. Hartwell), and Economics and Sociology of Science (G.M. Dobrov). Figure 2c reflects the consistent sequential change of priority in scientific and technical work of the scientist within the appropriate time interval (VM Glushkov): theoretical study - the first peak, applied research and development - the second peak, development and innovation - the third peak.

Figure 2d illustrates APhD of prominent scientists of late XIX - early XX centuries (W. Ostwald and V.I. Vernadsky), when scientific papers were published mainly as the works of individuals.

Conclusions

In our opinion, the age phase dynamics approach integrates the elements of econometric models and models of human capital, in terms of the sociology of science. Age phase dynamics methodology can be useful for evaluation of the efficiency and effectiveness of research activities at macro and meso levels.

Further Research

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References


The indicated general pattern of APhD graphs may be complicated by the influence of various non-systematic factors that reflect specific circumstances (e.g. psychological characteristics, personal involvements) and external conditions during the scientist’s career, in particular, the nature of the research (e.g. theoretical or experimental, research or development), the field of science, the change of scientific focus, degree of scientific communication and cooperation, industry affiliation of scientific institution, following the principle of “Publish or Perish” etc., and so forth may alter the pattern.

Figure 1. Age dynamics of publications of T.S. West (Kalyane & Munnoli, 1995) (A) in comparison with productivity obtained for groups of scientists by B. Malitsky (1988, p. 95, Fig. 11). The scientific productivity indicator axis is approximate.

Figure 2. APhD of the publications of G. Dobrov, L. Hartwell, P.-G. de Gennes, V. M. Glushkov, F. W. Ostwald, and V. I. Vernadsky. APhD-curves of publications of G. M. Dobrov in 2b and 2c are shown for comparison. Graph of the number of publications W. Ostwald (2d) reflects only the books.

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