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FACTORS IN MANAGING PUBLICATION PRODUCTIVITY IN RUSSIAN UNIVERSITIES

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Abstract

Purpose of the study: Justification of the factors of effectiveness in managing publication productivity on the example of Russian universities. Specifically, this research focuses on Russia's universities' important role in the publication productivity development in these universities.

Methodology: The study's methodological basis incorporated multivariate statistical analysis, clustering, and multifactor regression modeling. The methods used for aggregation and data transformation were graph theory and questionnaires.

Main findings: This research proved that the quality, not quantity, of Russian university scientific publications, contributes to their increased citations, which appears to influence determining a useful model for university publication productivity management. It also established that the fundamental factors of effective Russian university publication productivity management are an increase in the number of young teachers with academic degrees and the popularization of science as a prestigious sphere of professional activity in Russia.

Study applications: A reasonable system of factors may become the core for determining the priorities and unique mechanisms of transition from extensive to intensive development of publication productivity in Russian universities, taking into account individual characteristics of their research activities. This measure will prove beneficial to increasing the scientific potential of respective universities, which will, in turn, contribute to better ensuring the publication flow of quality research papers in universities.

Study novelty/originality: This study's originality lies in providing an empirical assessment of university publication productivity factors, which enabled a more precise method to determine the most reliable balance between scientific publications' quality and quantity. This balance also resulted in increased citations and stimulated Russian universities' scientific activity.

Keywords: *Russian Universities, Publication Productivity, Management, Web of Science, Scopus, Citation.*

INTRODUCTION

Russian universities' development has enhanced the country's innovation and economic growth, causing, in turn, a radical transformation in Russia's higher education system (Analytical Center for the Government of the Russian Federation, 2014; Bohdan, 2019). Alongside progress made in higher education institutions' traditional educational mission (formation and development of students' professional competences), we have also seen rapid scientific activity growth. New university activity areas include developing and transferring scientific technologies and commercializing academic science products (Van Norman & Eisenkot, 2017).

To measure, the effectiveness of science in universities and determine research financing, most countries use the following criteria: publications in academic journals, citations, and derivative indicators (h-index, scientific publications co-authors number, professional expertise, etc.) (Hicks, 2012; Osipov et al., 2020; Kosyakov & Guskov, 2019). Despite this method's imperfection and the ample criticism it has faced (Bordons et al., 2002; Hicks et al., 2015; Stephan, 2012; Weingart, 2005), publication productivity is the fundamental and most representative characteristic of national and individual scientific contribution (Ball, 2005; Moed, 2009). However, it should be noted that from 2013 to 2018, more than 40% of the total Russian publication flow came from organizations in the Russian Academy of Sciences (RAS) (Erokhina, 2019), and only one third (30%) of all Russian publications originated in universities participating in the Project 5-100 (15 universities) (Ministry of Science and Higher Education of the Russian Federation, 2019b). The remaining publications came from the residual Russian universities (1,156 universities), individual researchers, and other research organizations (Ministry of Science and Higher Education of the Russian Federation, 2019b). Traditionally, Russian universities only performed an educational function; they were not research centers, as in Western countries (Podtserob, 2017). This disadvantage is one fundamental reason why their publication productivity is still lower than the world and European averages, especially for such leaders as the USA, Great Britain, and China ("QS Rating," 2019).

Currently, stimulating publication productivity in Russian universities is the primary goal of the National Project "Science" of the Russian Government (Presidium of the Presidential Council for Strategic Development and National

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Projects, 2018), as well as draft order "On the Approval of Performance Indicators for Federal Budget and Autonomous Educational Institutions of Higher Education (Ministry of Science and Higher Education of the Russian Federation), and the Work of Their Leaders" (Ministry of Science and Higher Education of the Russian Federation, 2019a). The National Project "Science" suggests developing the following aspects (Presidium of the Presidential Council for Strategic Development and National Projects, 2018):

- Scientific and industrial cooperation;
- Advanced infrastructure for research and development in the Russian Federation; and
- Human resources in research and development.

Quantitative indicators of the Project's target values in the sphere of publication productivity also include increases in publication quantity and young scientists' number. The first indicator introduces the Project's orientation toward extended productivity (i.e., more significant numbers). These publications' quality is evaluated only by the number of articles in journals in the first and second quartiles. The authors of this National Project consider the number of citations a more accurate measure, as this reflects the relevance of scientific productivity's results. However, this measure was not studied in the Project.

National Project "Science" considers young scientists (under 39) significant to scientific development (Presidium of the Presidential Council for Strategic Development and National Projects, 2018). Increasing the proportion of young scientists should contribute to the development of publication productivity in Russian universities accordingly, as they are more flexible in learning, creativity, and innovation (Akhmetova & Mukhametzyanova, 2013; Rybakov, 2012). Still, it is worth noting that older scientists who are more experienced in scientific and publication activities have both a research reputation and more scientific cooperation opportunities (Ryan & Berbegal-Mirabent, 2016). This fact casts doubt on publication productivity management's effectiveness, given the substantial recent influx of young scientists.

The aspects of the management and development of publication productivity in Russian universities form our study's object. Therefore, this work aims to determine the main management factors that lead to the significant growth of publication productivity in Russian universities. To solve this scientific problem, the authors empirically substantiated the interaction of the publication productivity management's quantity and citation in leading countries. The authors also identified and analyzed the primary factors of publication productivity in Russian universities that strike a balance between the numbers of these institutions' scientific citations in econometric databases. The paper is divided into several sections as follows: Section 2 reviews the literature;

- Section 3 outlines the factors and hypotheses of this study as well as the research methodology description;
- Section 4 describes the data collection process;
- Section 5 presents the data analysis and discusses the results;
- Section 6 summarizes the conclusions of this study;
- Section 7 offers recommendations.

LITERATURE REVIEW

Regardless of the publication productivity policy's objectives, the decision-making in research is based on the relationship between scientific publications' quantity and quality. According to Times Higher Education research, there is a strong correlation between productivity and quality. The more scientific works the universities publish, the more significant citation impact they have (Bornmann, 2019; Sathianathen et al., 2020). However, it is worth noting that these data are far from being perfect. They represent only a few of the world's research universities and reflect the evaluation score. However, other scholars proved in their studies that, at the individual level, an increase of the publications number is often connected with a higher citation impact ("About KTH," 2019; Matthews, 2019; Else, 2019). The study of more than 28 million researchers' publications over 33 years was published in Plos One in 2016. The researchers concluded that the more publications the researcher have, the more significant the proportion of citation (Larivière & Costas, 2016).

Nevertheless, Sarah de Rijcke, chief of the Centre for Science and Technology Studies at Leiden University and one of the authors of the Leiden Manifesto, declares that pressure to publish "becomes a problem when competition for journal publication leads to tensions in the journal space, the expansion of pay-to-publish and predatory journals, as well as the manipulation of journal impact and citation statistics. It is also a problem for individuals, as the scientific career is explicitly designed to emphasize traditional activity forms. It is harmful to science if these numbers are not correlated with a qualitative evaluation" (Baker, 2019). It is worth noting that the research conducted by Kolesnikov et al. (2018) shows that this relationship is ambiguous and much more complex. The researchers concluded that there is a substantial variation in degree and range of this interrelation that depends on the following factors: researchers' age, gender, work experience, career length, amount of staff, culture, academic discipline, or institutional environment.

Labor productivity and its payment level directly depend on the quality of human capital, namely, the employee's knowledge and competencies. The term "human capital," introduced by Theodore Schultz (Klein & Cook, 2006), was

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later classified by Becker (2013) into two types - general and specific. Available human capital includes knowledge and skills that can be applied to solve a wide range of problems in various fields; the specification describes the skills and techniques used in a particular narrow area and ineffective in others. The latter category includes scientific capital as a set of "active properties of the individual," which deals with the distribution of academic power and recognition (according to the definition and mathematical operationalization introduced by Katchanov and Shmatko (2014). The concept of "scientific capital" with a certain degree of conditionality includes the idea of "*cumulative advantage*" developed by Robert Merton. According to the researcher, the "*cumulative advantage*" consists of the social characteristics of a scientist (first of all, the professional status and recognition by the colleagues) that facilitate the resources search (Mongardini & Tabboni, 2018).

Scientists' productivity is influenced significantly by socio-demographic (age, gender) and psychological factors, the work (Yusuf et al., 2015), and family and material status (Fox, 2005). According to domestic studies, male university professors conduct and publish research more frequently than females (Roshchina & Yudkevich, 2009), and older professors more regularly than younger ones. This age asymmetry demonstrates the *Matthew Effect* described by R. Merton. It is represented in the Hirsch index, which rises as the author ages. This effect reflects a disproportionate number within the scientific community: scientists are more willing to support and encourage their colleagues' achievements who have already gained fame due to previous work and underestimate or withhold support from their not-so-famous and younger colleagues (Birkmaier & Wohlrabe, 2014).

Psychological factors can be conditionally divided into individual factors associated with the scientist's personal qualities, organizational, or environmental factors. An analysis of individual factors contributes to the formation of a rather detailed list of markers that determine the researcher's success: among them, flexibility, emotional stability, and sociability (Hermanowicz, 2006). Organizational and environmental factors stimulating researcher work engagement and productivity include not only the resources and infrastructure available (Hesli & Lee, 2011) but equal distribution, including the possibility for independent activities (Silman, 2014) and various forms of cooperation (Lee & Bozeman, 2005; Carayol & Matt, 2006; Zhang et al., 2020). These conditions influence job satisfaction and, ultimately, the effectiveness of scientists' activities.

The factors mentioned above impact the development of the publication productivity model, which is focused on quantity and quality. This model, in turn, predetermines the specifics of publication productivity management at universities and research organizations. The authors analyzed the work of James Wilsdon, a professor of research policy at the University of Sheffield, who studied the application of The Metric Tide in the UK in 2015. He admits that quantitative drivers cannot be considered relevant in these developed systems (Jump, 2019). In North America and some European countries, most scientists have a high level of self-motivation and tend to conduct only high-quality research.

The number of publications will remain the critical driver of publication productivity in Russian universities until 2024, according to the National Project "Science" (Presidium of the Presidential Council for Strategic Development and National Projects, 2018) draft order "On the approval of performance indicators for the federal budget and autonomous educational institutions of higher education, subordinate to the Ministry of Science and Higher Education of the Russian Federation, and the work of their leaders" (Ministry of Science and Higher Education of the Russian Federation, 2019a). How effective is this draft order for Russian universities? What factors determine publication productivity in current conditions? These are the issues of the survey. In this study's framework, the authors identified the following hypotheses that define the current approach to developing and managing publication productivity in Russian universities:

- H_1. An extensive model aimed at increasing the number of publications should become a foreground model of publication productivity development.
- H_2. Factors contributing to publication productivity development differ in structure and relative importance for young and senior university teachers.
- H_3. The academic degree is not a critical factor determining the quality of the teachers' publication productivity.
- H_4. Increasing students' interest in scientific research and promoting science as a prestigious activity intensifies the teachers' publication productivity.
- H_5. Fostering young scientists is more effective in publication productivity management.

MATERIALS AND RESULTS

H1 hypothesis testing

Assessment of the production impact on the quality of publication productivity

We conducted tests of H_1 on the priority implementation of an extensive model of publication productivity development in the Russian Federation in the framework of the interrelation of the qualitative and quantitative drivers of university publication productivity management based on the correlation coefficient (r) between the number of publications in Scopus and the number of citations. To cluster countries according to the character of correlation between the qualitative and quantitative drivers of the management of university publication productivity, the authors used $(r_{t=1})$ with a time lag

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of $t = 1$ and (r_t) with a maximum positive value and a lag of $t = 1, \ldots, 6$ years. The first of the indicators $(r_{t=1})$ characterizes the research relevance. As time lag increases, the research relevance may decrease due to constant development in all science areas. The second indicator (r_t) characterizes the relevance of research, regardless of whether the article was cited after *1, 2, ... n* years.

Determination of the factors of publication productivity effectiveness

As noted in the study, both the effectiveness and productivity of publication activity depend on some subjective factors: the quality of human capital and socio-demographic and psychological characteristics. In this study's framework, an expert assessment method was applied, particularly a survey method for factor determination and H2-H5 hypotheses testing. Surveys were conducted in the following universities: Moscow University of Finance and Law, Moscow State (National Research) the University of Civil Engineering, Russian State Agrarian University–Moscow Timiryazev Agricultural Academy, Pirogov Medical University, Moscow Technical University of Communications and Informatics, Moscow State Institute of Culture, Chelyabinsk State Institute of Culture and Arts, South Ural State Agrarian University, Omsk State Technical University, Siberian Institute of Business and Information Technology, Togliatti State University, Samara Law Institute of the Federal Penitentiary Service of Russia, Rostov State University of Civil Engineering, and Ufa State Petroleum Technological University. These universities, selected due to their varied specializations, provided the identification of common problems of publication productivity within different branches of science. The universities that participated in Project 5–100 (15 universities) were not included in the sample. Data analyzed from these leading universities could result in an overestimation of publication productivity rates for the Russian average.

A questionnaire, developed in Google Forms, was emailed to 9,000 teachers of the universities, from which 4,034 responses were received. The sample included respondents of two age categories:

1) Young scientists (under the age of 39) - 1,573 people (39%) and

2) Senior scientists (39 years and above) - 2,461 people (61%).

According to the National Project "Science" (Presidium of the Presidential Council for Strategic Development and National Projects, 2018), the age limit of 39 was adopted for categorizing scientists as young or senior. Representatives of nine branches of science participated in the survey:

- Technical sciences - 21%;
- Medical sciences - 13%;
- Biological sciences -9%;
- Chemical sciences - 6%;
- Agricultural sciences - 11%;
- Economic sciences - 15%;
- Law sciences - 12%;
- Psychological sciences - 2%;
- Art studies - 11%.

The main criterion for the survey results representativity was the sufficiency of the sample. It is estimated by formula (1) for extensive coverage ($n > 30$) (Reid, 2015):

$$s = \frac{Z(p)^2 \times v \times (1-v)}{e^2} \quad (1)$$

where:

s – minimum sample, sufficient for the representativity of the survey results;

Z(p) – standardized deviate. Accepted confidence level, when the survey results are representative and statistically significant, comprises 90%. With this confidence level, the standardized deviate includes 1.65 (Reid, 2015);

p – confidence coefficient;

v – sample variation;

e – accepted level of error.

A student t-test was applied to distinguish factors common for all the categories and different for other ones. The exceedance of the empirical value (formula 2) over the table value indicates the statistical significance of differences in

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teachers' publication productivity depending on the university, branch of science, and age. The exceedance of the table value shows the insignificance (Rousseau et al., 2018).

$$t = \frac{|M_i - M_j|}{\sqrt{\frac{\sigma_i^2}{N_i} + \frac{\sigma_j^2}{N_j}}} \quad (2)$$

where:

M_i – an arithmetical average of the publication productivity value of the *i*-sample;

M_j – an arithmetical average of the publication productivity value of the *j*-sample;

σ_i – standardized deviate of the *i*-sample;

σ_j – standardized deviate of the *j*-sample;

N_i – *i*-sample size;

N_j – *j*-sample size.

H2 hypothesis testing

Through the Principal Component method, factor analysis was conducted to identify the factors, thus contributing to the publication productivity of "young" and "senior" teachers. The dataset for analysis was formed by binary (0; 1) values of indicators X1-X35 for young (sample 1) as well as senior teachers (sample 2). Factor weight values were applied to identify the factors' structure. The factor weight of $\geq |0.7|$ was accepted as significant for the survey (Menke, 2018). The sufficiency of the sample determines the representativity of the factor analysis. It comprises 1573 observations for young teachers and 2461 observations for the senior counterparts, which is higher than the standard of *2n+1by* 45 and 70 times, respectively. The factorization proportion also determines the representativity of the factor analysis. It comprises of 89% for young teachers and 97% for the senior ones. Meanwhile, H2 hypothesis is proved by the differences in factors' structure and relative importance (dispersion, %) for both young and old teachers. The lack of differences rejects the hypothesis.

H3 and H4 hypothesis testing

When determining the factors, the author analyzed the indicators of a direct impact on publication productivity, which determine its level, and indirect impact, which elucidate teachers' motives to develop their publications' productivity. In this regard, graph theory was used to structure publication productivity factors and test hypotheses H3 and H4. The graph theory postulates that two subsets are distinguished from a variety of factors:

$S(z_i)$ - a subset of reach and

$P(z_i)$ - a subset of predecessor vertices

A vertex z_j is called reachable if there is a path in the graph that leads from the vertex z_i to the vertex z_j (Kühn et al., 2017).

The vertex z_i is the predecessor of the vertex z_j if it reaches its peak. The vertices satisfying the condition of formula 3 form the First Level of the hierarchy. However, the objects that created the First Level of the hierarchy are excluded at the second iteration (Kühn et al., 2017). The purpose of the hierarchy development is to determine the levels of factors that impact the publication productivity.

$$P(z_i) = S(z_i) \cap P(z_i) \quad (3)$$

The authors applied the Statistica 12.0 program to make a multivariate linear regression model by adopting the step-by-step exclusion method. In turn, this technique allowed for evaluating the degree of impact of indicators on the publication productivity, which was inclusive of the factors that constituted the First Level of the hierarchy (direct impact factors). The constructed model made it possible to evaluate the impact of independent variables (in this study, indicators with binary estimates) on the dependent counterparts (the number of citations - question No. 4). Additionally, the researchers undertook a survey on both young scientists (1573 observations) and senior scientists (2461 observations), which led to the development of two regression models. These models' dependent variable was the number of citations in journals, indexed in the scientometric databases Scopus and Web of Science, published separately over the past five years (Y) for young and senior teachers. Independent variables comprise binary values of the indicators X2-X18, X22-X23 according to the respondents. The authors did not consider the impact of the Second Level of the hierarchy indicators. These were qualitative factors that indicate the priority approaches for publication productivity management regarding teachers' motivation. Besides, they influence the publication productivity through the factors of the First Level. Regression analysis was possible due to the quantitative assessment of dependent variables

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and the sufficiency of the sample. The number of observations is 82 times (for young scientists) and 129 times (for senior scientists), respectively, as much as the number of independent variables (with a sufficient level of 6-8 times). The indicators (X2-X18, X22-X23) influencing the publication productivity rate were assessed using the Student t-criterion. The excess modulo of calculated (empirical) values over the critical ones indicates the indicators' statistical significance. The higher the modulo value of the t-criterion is, the greater is the influence; a positive value of the criterion indicates a direct character of influence, a negative value indicates the opposite. The adequacy of the obtained results is proved by:

- The coefficients of determination of the developed models (R^2 = 0.81 for the model developed according to the questionnaire of young scientists, and R^2 = 0.88 for the model developed according to the questionnaire of scientists of the older age);
- Fisher F-test, the calculated value of which (139.4 and 146.1, respectively) exceed table 1.94;
- Normal distribution of the model residuals.

The lack of multicollinearity in the regression models is proved by the fact that the empirical values of Student t-criterion for assessment of the significance of pair correlation coefficients between the independent model indicators do not exceed the table value | 1.96 | at p = 0.05, f = 1571 (for young scientists) and f = 2459 (for scientists of the older age).

If the criterion's empirical value exceeds the table one for indicators X2, X3, hypothesis H3 is rejected with a 95% probability. Hypothesis H4 is adopted if the empirical value of the t-criterion exceeds the table one for the indicators X16, X17.

H5 hypothesis testing

The authors conducted a comparative assessment of publication productivity effectiveness influenced by young and senior teachers' development. It was proposed to evaluate the correlation of the elasticity in the number of citations of young and senior teachers (question No. 4) and changes of factors of direct impact (First Level of the hierarchy). For identifying the elasticity coefficients based on the constructed linear multivariate regression models, the following values were calculated:

- Result indicators ($\bar{Y}$) with an average level of independent variables in the corresponding sample;
- Value of the result indicator (Y') with an increase of 1% for each independent variable.

Hypothesis H5 is accepted if the calculated elasticity coefficients for young teachers are higher than the senior ones.

DATA

The analysis of productivity impact on the quality of publication productivity was based on the number of articles and citations in 20 leading countries from 1986 to 2018 (*Scimago Journal*, 2019). The following countries were analyzed: China, United States, Japan, Germany, India, France, United Kingdom, Russian Federation, Spain, South Korea, Italy, Canada, Poland, Australia, Brazil, Iran, Taiwan, Switzerland, Netherlands, and Sweden (*Scimago Journal*, 2019). The authors highlight that calculating the correlation coefficients between the publications number and the citations number is possible because a linear relationship between these values is observed for all the countries studied. Because a scientific publication requires time to accumulate citation, the correlation coefficient's calculation was carried out with the time lag (t) = 1- 6 years. The development of significant publication productivity requires a close relationship between the publications number and citation. For the accumulation of citations, a specific time lag is necessary. This type of relationship indicates the quality of published articles. As a result, an intensive model of publication productivity development is observed. The lack of a close relationship between these values leads to the conclusion that the publication number increases do not increase citations.

The authors identified dominant factors of the publication productivity effectiveness in Russian universities. For this purpose, the questionnaire survey was conducted. The questionnaire included general questions (block 1) aimed at obtaining information about the university where the respondent works (question No. 1), the field of science (question No. 2), and the age of the respondent (question No. 3). Question No. 1 is open-ended, question No. 2 suggests one or more possible answers, and question No. 3 presupposes one answer. As a result, factors influencing the publication productivity were differentiated into universal and characteristic for individual teachers' categories.

The questionnaire included the question of the number of citations of the articles in journals, indexed in the scientometric databases Scopus and Web of Science, published over the past three years (question No. 4). This allowed the determination of the qualitative aspect of publication productivity.

The list of the First Block questions (general questions):

1. The university where you work? _____
2. Branch of science to which you belong?

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a) technical sciences;
b) medical sciences;
c) biological sciences;
d) pedagogical sciences;
e) physical-mathematical sciences;
f) geographical sciences;
g) chemical sciences;
h) agricultural sciences;
i) economic sciences;
j) philological sciences;
k) historical sciences;
l) law sciences;
m) psychological sciences;
n) sociological sciences;
o) art studies;
p) your own variant _____.

3. Your age:
   a) under 39 years of age;
   b) of 39 and over.
4. The number of your articles citations in journals, indexed in the scientometric databases Scopus and Web of Science, published over the past five years?_____

To test the hypotheses H2 and H5, question No 3 was included in the questionnaire. That allowed us to identify the differences in the publication productivity development of young teachers and senior teachers, to evaluate the statistical significance of these differences basing on the answers to the questions of block 2 and the number of citations (question No. 4). To test hypothesis H3, questions corresponding to indicators X2, X3, which relate to the presence of a doctor/candidate of science degree, were included. To test the hypothesis H4, the authors analyzed indicators X16 and X17. The list of other questions of block 2 is based on the literature review, introducing the indicators affecting the rate of publication productivity of young teachers and senior teachers.

The respondents answered ("Yes" or "No") to the questions of block 2 (Table 1), evaluating for each position their productivity, the level of human capital development, socio-demographic, and psychological state. If the statement applies to the respondent, he answers "Yes." Otherwise, he answers "No." Answers to these questions suggest a corresponding binary rating (X1-X35), where the answer option "Yes" corresponds to the "1" point, "No" means "0" points.

Table 1: Factor weight values, influencing the qualitative development of publication productivity in Russian universities

Question Form	**Binary Evaluation Value**	**Young Scientists, %**						**Senior Scientists, %**				
		F1 23.4*	**F2 20.6**	**F3 16.4**	**F4 14.3**	**F5 10.6**	**F6 4%**	**(F1+F2) 34.9**	**F3 9.1**	**F4 18.6**	**F5 29.7**	**F6 4.8**
Marital status	X1	0.11	0.31	0.16	-0.24	0.46	0.02	0.23	-0.54	0.12	0.06	0.22
Doctoral degree	X2	*0.98**	0.32	0.14	-0.13	0.24	0.22	*0.95*	0.11	0.34	0.19	-0.07
Candidate degree	X3	*0.94*	0.20	0.14	0.32	-0.18	-0.21	*0.84*	0.21	-0.22	0.16	-0.04
University work under the terms of	X4	*0.75*	0.53	-0.44	0.05	0.36	0.04	*0.70*	0.29	-0.11	0.08	0.12

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a long-term employment contract (more than 3 years)												
Senior position in the university	X5	*0.74*	-0.35	0.07	-0.15	0.29	0.04	*0.72*	-0.08	0.34	-0.15	0.01
Member of the Council on award of the degrees	X6	0.66	0.24	0.16	0.34	0.08	0.16	*0.75*	0.15	0.34	0.19	0.31
Command of one foreign language	X7	0.16	*0.85*	0.14	0.28	0.17	0.07	*0.87*	0.41	0.32	0.19	0.21
Command of two and more foreign languages	X8	0.60	*0.79*	0.39	0.51	0.49	0.30	*0.76*	0.27	0.39	0.57	0.34
Work on the dissertation abroad (in the current or retrospective period)	X9	0.37	*0.87*	0.11	0.21	-0.34	0.18	*0.90*	0.37	0.11	-0.04	0.31
Participation in foreign conferences	X10	0.19	*0.93*	0.04	0.09	0.11	0.09	*0.92*	0.31	0.16	0.08	0.01
Organization of international conferences	X11	0.61	*0.74*	0.24	0.35	0.51	0.18	*0.70*	0.09	0.27	0.29	0.04
Internship abroad	X12	0.29	*0.91*	0.28	0.09	-0.02	0.01	*0.88*	0.21	0.18	0.31	0.01
Participation in international scientific or pedagogical projects	X13	0.19	*0.78*	0.37	0.11	0.06	0.03	*0.72*	0.18	0.14	0.14	0.09
Teaching abroad	X14	0.09	*0.86*	0.11	0.18	0.11	0.04	*0.85*	0.34	0.19	0.13	0.09
Management of international scientific projects	X15	0.61	*0.73*	0.28	0.41	0.34	0.09	*0.71*	0.26	0.27	0.19	0.05
When you were a student, you formed an opinion that science is	X16	*0.89*	0.38	0.25	0.31	0.20	0.04	0.68	0.31	0.31	0.14	0.24

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prestigious												
You started participating in the scientific research being a student	X17	*0.87*	0.21	0.34	0.29	0.21	0.09	0.63	0.25	0.28	0.16	0.09
More than one job (official or unofficial)	X18	*0.74*	0.16	0.16	0.28	0.20	0.1	*0.82*	0.29	0.19	0.34	0.31
You enjoy your job	X19	0.18	0.19	0.28	*0.87*	0.19	0.19	0.13	0.19	*0.87*	0.18	0.18
University promotes personal development	X20	0.28	0.11	*0.89*	0.36	0.18	0.05	0.24	*0.71*	0.16	0.21	0.28
Your university provides career opportunities	X21	0.26	0.24	*0.86*	0.34	0.08	0.16	*0.25*	*0.70*	0.34	0.19	0.31
Scientific consulting for organizations over the past 5 years	X22	*0.76*	0.34	0.25	0.54	0.06	0.04	*0.71*	0.21	0.24	0.08	0.02
Academic advising for students (top places in national and international competitions of scientific works)	X23	*0.73*	0.32	0.18	0.29	-0.08	0.43	*0.71*	0.06	0.36	-0.04	0.06
The university where you work provides the opportunity for professional growth	X24	0.27	0.13	*0.95*	0.21	0.06	0.13	0.11	*0.71*	0.21	0.08	0.05
You are satisfied with the payment for the scientific activities results	X25	0.34	0.06	0.51	0.38	*0.79*	0.02	0.21	0.01	0.68	*0.98*	0.04

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You repeatedly received awards for your scientific activities	X26	0.26	0.34	0.11	0.41	0.67	-0.03	0.29	0.30	0.24	*0.91*	-0.08
Your university is characterized with full external financing of the publication productivity (from the university, state, foundations, other countries)	X27	0.21	0.31	0.31	0.11	*0.75*	0.11	0.11	0.25	0.26	*0.92*	0.24
Your university is characterized with partial external financing of the publication productivity (from the university, state, foundations, other countries)	X28	0.16	0.25	0.27	0.11	*0.77*	0.28	0.19	-0.01	0.21	*0.98*	0.28
You are satisfied with the university benefits package	X29	0.14	0.49	0.06	0.19	*0.71*	0.16	0.38	0.34	0.02	*0.91*	0.10
Work at the university attracts you because of a long vacation	X30	0.16	0.26	0.05	0.13	0.27	*0.76*	0.31	0.29	0.01	0.37	*0.75*
You have the opportunity for the creative development in the university	X31	0.38	0.06	*0.94*	0.09	0.21	0.11	0.42	*0.72*	0.23	0.41	0.05
You get	X32	0.11	0.27	0.19	*0.80*	0.27	0.01	0.26	0.08	*0.92*	0.05	0.24

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psychological satisfaction with scientific activity												
You have the opportunity for self-expression in the scientific activity	X33	0.62	0.09	0.34	*0.78*	0.23	0.11	0.31	0.31	*0.92*	0.55	0.06
Your university is characterized by a developed material and technical base for scientific activity	X34	0.01	0.34	0.41	0.17	0.31	*0.77*	0.16	0.41	0.31	0.19	*0.81*
You are credible at the university	X35	0.36	0.19	0.19	*0.71*	0.19	0.12	0.16	0.02	*0.89*	0.21	0.20
Explanation of Symbols: *F1 – F6* – factors influencing the quality of the publication productivity; * - factor dispersion value, %; **– significant factor weight, ≥ |*0.7*|	The total share of dispersion – 89%							Total share of dispersion – 97%				
	F1 - The factor of scientific and pedagogical potential; *F2* - The factor of communicative competencies and international activity; *F3* - The factor of professional growth prospects; *F4* - The factor of psychological satisfaction with the job; *F5* - The factor of financial satisfaction; *F6* - The factor of material and technical resources and working conditions											

RESULTS

The pair correlation coefficients (r_t) are calculated based on publications and citations number across countries for 1996-2018 (*Scimago Journal*, 2019). The fitted value (r_t) of the leading countries in the publication productivity context is presented in Table 2.

Table 2: The value (r_t) of the publication number and citation number in countries with significant publication productivity for 1996–2018

Country/Lag	***t - 1***	***t - 2***	***t - 3***	***t - 4***	***t - 5***	***t - 6***
China	0.875	0.950	0.971	0.973	0.657	0.556
United States	-0.612	-0.525	-0.427	-0.305	-0.135	0.061
Japan	0.593	0.703	0.649	0.622	0.389	0.172
Germany	-0.414	-0.231	0.018	0.308	0.570	0.757
India	0.599	0.799	0.906	0.945	0.953	0.941
France	-0.425	-0.284	-0.080	0.150	0.418	0.597
United Kingdom	-0.434	-0.274	-0.061	0.186	0.471	0.670
Russian Federation	-0.726	-0.543	-0.328	-0.163	-0.095	0.001
Spain	0.361	0.113	0.595	0.767	0.868	0.929
South Korea	0.586	0.786	0.910	0.966	0.986	0.989

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Italy	-0.312	-0.131	0.109	0.364	0.528	0.639
Canada	-0.263	-0.069	0.155	0.395	0.569	0.737
Poland	0.316	0.611	0.779	0.867	0.899	0.910
Australia	0.127	0.443	0.710	0.870	0.946	0.971
Brazil	0.137	0.368	0.538	0.674	0.739	0.787
Iran	0.826	0.926	0.960	0.971	0.962	0.945
Taiwan	0.578	0.777	0.906	0.960	0.947	0.885
Switzerland	-0.120	0.152	0.450	0.681	0.858	0.939
The Netherlands	-0.177	0.076	0.360	0.624	0.831	0.923

The obtained values (r_t) contributed to the clusterization of the studied countries based on the characteristics of the interactions of the quantitative and qualitative factors of publication productivity.

Cluster 1: China, Japan, India, South Korea, Iran, Taiwan, Spain, Poland, Australia, and Brazil. In these countries, the policy of publication productivity is based on increasing the volume of relatively high-quality scientific publications. The time lag for these countries is 1 year and 2 years. With this condition, a positive, medium, and high (according to the Cheddock Scale) correlation was observed between the number of publications and citations. Thus, the number of publications significantly ($r > 0.5$) impacts the quality of publication productivity. This impact proves the mobility, dynamism, relevance, and demand for the research.

Cluster 2: Germany, France, United Kingdom, Italy, Canada, Switzerland, and the Netherlands. For these countries, the correlation coefficient of the time lag at 1 year becomes negative. However, after 3–4 years, a significant impact of the number of scientific publications on the number of citations was observed. Thus, the interaction becomes a positive medium, high, and very high.

Cluster 3: the United States and the Russian Federation. These countries were found to have negative correlation coefficients with a time lag of 1–5 years. At the same time, it was observed that with a time lag of 1 year, the degree to which the number of publications impacts the number of citations at $t = 1–5$ remained negative despite the decrease in (r). Thus, it can be stated that the quantity does not contribute to the development of a qualitative component of publication productivity in these countries, especially in Russia. According to the statistical analysis results, it can be stated that the extensive development of publication productivity at Russian universities does not reflect a qualitative component of scientific publications since it does not impact the increase in their citations. A directly proportional dependence even characterizes it. This conclusion refutes hypothesis H1 on the necessity to implement an extensive model for developing publication productivity at Russian universities.

Analysis of the answers to the first and second block of questions, which was used to assess the factors related to the effectiveness of publication productivity management, showed that statistically significant differences were only observed in the groups of young and senior teachers. Regarding publication productivity (question No. 3), the student criterion's empirical values exceed the table values (at $p = 0.05$). The excess of the table values of the *t*-criterion over the empirical ones calculated in pairs by branches of science and universities (questions No. 1 and No. 2) indicates that the differences in the quality of publication productivity, in terms of universities and the specialization of teachers, are statistically insignificant. Publication productivity problems are common for all Russian universities and branches of science. Thus, it is possible to calculate the average for the entire sample of respondents. The only significant difference was observed for question No 3. Therefore, two categories of teachers (young and senior researchers) were analyzed. For senior teachers who completed the questionnaire, the average number of citations in Scopus and Web of Science journals published over the past five years was 2.9 times when the questionnaire was conducted. For young researchers, the average number of citations was 1.1, which is 2.6-times lower.

Factor analysis contributed to determining the factor weight values of the binary estimates, which impact the qualitative development of publication productivity at Russian universities (Table 1). The factor weight values were used to determine the publication productivity effectiveness in universities (Table 3). This analysis made it possible to identify the differences in the list of factors that impact the publication productivity management for young and senior teachers. Their significance was estimated using the dispersion percentage. That confirms hypothesis H2. The typical percentage of dispersion proves that the selected factors determine teachers' publication productivity by 89% (for young scientists) and 97% (for senior scientists). For young and senior teachers, the most significant factors impacting publication productivity development are:

- Scientific and pedagogical potential (professional competencies of the teacher);
- Communicative competence (command of foreign languages);
- International activity, which determines the possibilities of international scientific cooperation.

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For young scientists, these are factors F1 and F2. For senior researchers, due to the lesser degree of communicative competencies (command of foreign languages) and lower international mobility, these factors are combined (F1 + F2).

The next significant factor for young scientists is professional promotion, which provides professional and creative development. That is the factor of psychological satisfaction with work. For senior scientists, this is a factor of financial satisfaction. The influence of the material and technical resources and working conditions is less significant; it is estimated to be 4% for young scientists and 4.8% for senior researchers. The selected factors include all indicators, except the X1 indicator, which characterizes marital status. When this indicator is singled out separately, its significance is 0.9–1%, which is 4–5-times lower than the significance of the previous factor. Thus, marital status does not significantly influence publication productivity; therefore, it is not singled out as a separate factor. The impracticability of denoting this factor is also confirmed by the Kaiser criterion applied to determine the optimal number of factors.

Table 3: The factors related to publication productivity effectiveness for Russian universities teachers

Factor Description		**Teachers (Dispersion, %)**	
		Young	**Senior**
The factor of scientific and pedagogical potential	F1	23.4	34.9
The factor of communicative competencies and international activity	F2	20.6	
The factor of professional growth prospects	F3	16.4	9.1
The factor of psychological satisfaction with the job	F4	14.3	18.6
The factor of financial satisfaction	F5	10.6	29.7
The factor of material and technical resources and working conditions	F6	4.0	4.8

The obtained factors are structured with a directed graph (Figure 1). Moreover, iterations were conducted to determine the hierarchy of the factors that impact publication productivity (Table 4).

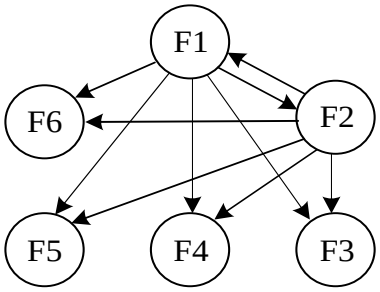

Figure 1: The graph of the correlation of factors that impact the publication productivity of teachers

Table 4: The hierarchy of the factors that impact the effectiveness of publication productivity

i	***S(zi)***	***P(zi)***	***S(zi)∩P(zi)***	**Hierarchy level**
1st iteration				
1	1,2,3,4,5,6	1,2	1,2	1
2	1,2,3,4,5,6	1,2	1,2	1
3	3	1,2,3	3	-
4	4	1,2,4	4	-
5	5	1,2,5	5	-
6	6	1,2,6	6	-
2nd iteration				
3	3	3	3	2
4	4	4	4	2
5	5	5	5	2
6	6	6	6	2

For senior teachers, scientific and pedagogical potential (F1) and communicative competencies and international activity (F2) are combined. For graph development, the complete list of factors influencing teachers' publication productivity was used: F1-F6. The direction of the arrow in Figure 1 shows the dependence of the factor lying at the top of the edge (arrow) on another one lying at the base of the graph's edge.

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Factors F1 and F2 have a cyclic correlation. This is connected to the fact that the development of communicative competencies and international activity contributes to improving the scientific and pedagogical potential of a teacher. Mastering new knowledge, skills, and foreign experience are necessary for scientific activity and flexibility in changing scientific activity approaches. Besides, the improvement of scientific and pedagogical potential (defense of a dissertation, obtaining a degree, concluding a long-term contract) requires the development of command of foreign languages, the necessity of international internships, and advanced training. Conditions for developing scientific and pedagogical potential, communicative competencies, and international activity are created with the following factors:

- The factor of professional growth prospects (F3);
- The factor of psychological satisfaction with the job (F4);
- The factor of financial satisfaction (F5);
- The factor of material and technical resources and working conditions (F6).

As a result, a 2-level structure of factors influencing publication productivity is determined. These are factors of direct impact - F1, F2 (1st level of management factors), and indirect impact - factors F3-F6 (2-1 levels of management factors). Factors of direct impact introduce the objective factors (competencies, experience, and international communications) that determine the course of scientific activity, researchers' reputation, and the quality of articles. Factors of indirect impact include the factors that characterize the teacher's motives for scientific activity and the development of factors of the First Level, namely: financial and psychological satisfaction, satisfaction with working conditions, professional growth prospects, the material and technical base of the university.

Table 5 introduces the regression models of the First Level factors' influencing the quality of publication productivity for young and senior teachers, indicating the values' statistical significance. Models presented in Table 5 are developed with a backward selection method. Thus, the influence of all the indicators included in the model is statistically significant. This is proved by the excess of Student criterion's empirical values over the table one at p = 0.05.

Table 5: The regression models of the First Level factors' influencing the quality of publication productivity in terms of the age of the university teachers in Russia

Model	**Statistical Significance Indicators**				
	R^2	F_{emp}	F_{tab}	T_{emp}	t_{tab}
Young scientists					
$Y = 0.44 \times X2 + 0.37 \times X3 + 0.29 \times X7 + 0.36 \times X9 + 0.39 \times X10 + 0.34 \times X12 + 0.33 \times X14 + 0.33 \times X16 + 0.32 \times X17 - 0.28$	0.81	139.4	1.94	$t_{X2} = 8.11;$ $t_{X3} = 7.11;$ $t_{X7} = 3.95;$ $t_{X9} = 4.94;$ $t_{X10} = 6.91;$ $t_{X12} = 5.91;$ $t_{X14} = 4.38;$ $t_{X16} = 5.38;$ $t_{X17} = 4.99$	1.96
Senior scientists					
$Y = 0.58 \times X2 + 0.26 \times X3 + 0.33 \times X7 + 0.33 \times X9 + 0.41 \times X10 + 0.40 \times X12 + 0.25 \times X14 + 0.31 \times X18 + 1.29$	0.88	146.1	1.94	$t_{X2} = 7.98;$ $t_{X3} = 3.28;$ $t_{X7} = 4.18;$ $t_{X9} = 5.73;$ $t_{X10} = 6.39;$ $t_{X12} = 5.09;$ $t_{X14} = 3.98;$ $t_{X18} = 2.48$	1.96

Explanation of Symbols:
R^2 – determination coefficient;
F_{emp} - empirical value of Fisher F-test;
F_{tab} - table value of Fisher F-test;
t_{emp} - empirical value of Student t-test;
t_{tab} - table value of Student t-test.

Regression analysis proved that the publication productivity is mostly influenced by:

- Existence of a degree (values of binary ratings X2, X3);
- Command of foreign language (X7);

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- International activity (values X9-X10, X12, X14).

The development of these aspects of the teachers' scientific activity improves professional and communicative competencies, helps create international cooperation. This will increase the number of publications and their citation. For young scientists, the prestige of science (X16) and scientific activity in the student years (X17) is of great importance. This significance is leveled with the development of the scientific potential of teachers when he becomes older. This fact is proved by the excess of the t-criterion table value for these values over the senior teachers' sample's empirical ones.

More than one job (official or unofficial) (X18) reduces the publication productivity of young scientists, as the time for the scientific activity is limited. However, this factor's reverse effect is also possible if other jobs do not take up the predominant part of the time but contribute to the development of scientific potential and professional competencies. The result of this impact is reflected by the increase of the senior scientists' publications citation.

An assessment of the significance of publication productivity management values with a probability of 95% made it possible to reject hypothesis H3 about the scientific degree as a critical factor determining the quality of teachers' publication productivity. Although, it was accepted the hypothesis H4 declaring increasing students' interest in scientific research and promoting science as a prestigious activity helps to intensify the teachers' publication productivity. However, this hypothesis is confirmed exclusively for young teachers.

Table 6 introduces the elasticity coefficients of the resulting value (the number of the scientist's citations) of the publication productivity impact (X2-X3, X7, X9-X10, X12, X14) calculated with the regression models.

Table 6: Values of elasticity coefficients characterizing the effectiveness of publication productivity management in terms of university teachers' age in Russia

Value	Elasticity coefficient value, %	
	For young teachers	For senior teachers
X2	0.08	0.16
X3	0.31	0.06
X7	0.08	0.02
X9	0.03	0.01
X10	0.14	0.11
X12	0.19	0.13
X14	0.02	0.01

According to Table 6, elasticity coefficient values prove that in the context of the values of binary estimates (X3, X7, X9-X10, X12, X14) characteristic for the model of the publication productivity management of young and senior scientists, the elasticity coefficients are higher for the sample of young teachers. This means that a more significant increase in citations is observed with the development of scientific potential, communicative competencies, and young scientists' international activity. This is induced by their greater flexibility, mobility, and adaptability compared to older researchers. The highest Elasticity coefficient in the group of senior teachers is observed only for indicator X2 (the existence of a doctor's degree). That is caused by its significantly higher value in the sample of senior teachers compared to young teachers. Thus, hypothesis H5, that the development of young scientists is more effective for publication productivity management, is accepted.

For senior teachers, the factors of scientific and pedagogical potential (F1) and communicative competencies and international activity (F2) are combined. For graph development, the complete list of factors influencing teachers' publication productivity was used: F1-F6. The direction of the arrow in Figure 1 shows the dependence of the factor that lies at the top of the edge (arrow) on another that lies at the base of the edge of the graph.

Factors F1 and F2 have a cyclic correlation. This is connected to the fact that the development of communicative competencies and international activity contributes to improving the scientific and pedagogical potential of a teacher. Mastering new knowledge, skills, and foreign experience are necessary for scientific activity and flexibility in changing scientific activity approaches. Also, the improvement of scientific and pedagogical potential (defense of a dissertation, obtaining a degree, concluding a long-term contract) requires developing a command of foreign languages, international internships, and advanced training. Conditions for developing scientific and pedagogical potential, communicative competencies, and international activity are created with the following factors:

- The factor of professional growth prospects (F3)
- The factor of psychological satisfaction with the job (F4)
- The factor of financial satisfaction (F5)
- The factor of material and technical resources and working conditions (F6)

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As a result, a 2-level structure of factors influencing publication productivity is determined. These are factors of direct impact – F1, F2 (1st level of management factors), and indirect impact – factors F3-F6 (2-1 levels of management factors). Factors of direct impact introduce the objective factors (competencies, experience, and international communications) that determine the course of scientific activity, researchers' reputation, and the quality of articles. Factors of indirect impact include the factors that characterize the teacher's motives for scientific activity and the development of factors of the first level: financial and psychological satisfaction, satisfaction with working conditions, professional growth prospects, the material and technical base of the university.

DISCUSSION

In this study, the authors examined the hypotheses behind the strategy of Russian universities to improve publication productivity, which is reflected in Russia's 'Science' national project and "On the approval of performance indicators for the federal budget and autonomous educational institutions of higher education, subordinate to the Ministry of Science and Higher Education of the Russian Federation, and the work of their leaders" (Ministry of Science and Higher Education of the Russian Federation, 2019a). As a result, it was proved that at modern research institutes in Russia, the number of scientific publications in journals does not impact the publications' quality. This conclusion supports the results of Butler's research (2005) that systemic stimuli, which increase the volume of publications, do not always influence the frequency with which those publications are cited in other scientific publications. The correlation coefficient in Russia between the number of publications and their citation in 1996-2018 has a negative value even with a 1-5 years' lag.

This conclusion contradicts the results of Ulf Sandström and Peter van den Besselaar's study, which found a strong correlation between higher productivity and increased citations in scientific publications (Matthews, 2019). The determination of the correlation coefficient between productivity and citations contributed to the different conclusions in the studied countries, from negative to positive. It should be noted that this is caused by the publication productivity management models and the structure of the education system. The authors of this study conclude that the number of scientific publications does not always determine the quality of publications. This conclusion significantly affects how to determine a useful management model of publication productivity in Russia. This led us to conclude that the correlation between productivity and the number of citations is much more complicated than that and depends on numerous factors.

The hypothesis regarding the influence of university professors' age on publication productivity is supported and reflected in management models. Evidence of this can be found in the research results of Yusuf et al. (2015) and Birkmaier and Wohlrabe (2014). Their research showed that an increase in the number of young professors, due to the national project "Science", caused an increase in publication productivity in Russia. However, this Project's practical implementation is complicated because working as a scientist is considered one of the least prestigious professions in Russia today due to the low level of wages and associated social status (Pavelieva, 2016).

The existence of a scientific degree primarily ensures the qualitative component of publication productivity. This managerial strategy aspect can be implemented by encouraging more postgraduate and doctoral studies in Russian universities. It has been implemented by the national project "Science" (Presidium of the Presidential Council for Strategic Development and National Projects, 2018).

However, it should be noted that state policy for youth education should be changed—not the upbringing of young people in general, but precisely that of those going to university. They must leave the university professionally prepared and able to solve the most severe problems. In this regard, we must talk about the development of state policy in science. It should consider the problem of scientists' development. One of the main ideas the state should implement to solve the above problems is measures regarding the attraction and consolidation of talented youth in science and higher education. The effectiveness of this strategy was confirmed in this study. The promotion of the students' interest in scientific research and the popularization of science as a prestigious activity contributes to the development of professors' publication productivity in Russian universities.

CONCLUSION

In light of the rejecting or accepting the hypotheses about the effectiveness of publication productivity management, the following conclusions were drawn:

1) In current conditions, the development of the publication productivity management model in Russian universities should be improved.

2) In the management process, the structural difference between the management factors of young and senior researchers' publication productivity should be considered. For young and senior teachers, the main factors influencing publication productivity are the scientific and pedagogical potential, communicative competencies and international activity, prospects for professional development, and psychological satisfaction. The financial aspect is particularly crucial for older teachers. This confirms the existence of differences in factors contributing to the development of publication productivity in these groups.

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3) In current conditions, an effective method of publication productivity management in Russian universities is needed to improve staff quality. We should foster the growth of young teachers with a high degree and encourage the promotion of science as a prestigious activity among young people. In this regard, the development and implementation of models for scientific and pedagogical personnel management should also become a significant field for strategic transformation. This would contribute to the improvement of personnel potential for the higher education system in general.

LIMITATIONS AND STUDY FORWARD

The study sample was formed by universities not participating in Project 5-100. Thus, the obtained findings on publication productivity are valid for universities not participating in Project 5-100. The study is based on a limited sample of survey respondents from only 14 Russian universities. Although the respondents' samples' validity is proven in the study, this limits the application of the results and the consequences of the proven hypotheses on the specifics of managing publication productivity in Russian higher education institutions in general and in each case.

CO-AUTHORS CONTRIBUTION:

The 1st and 2nd authors contributed to the concepts, theories, and methodology. All authors discussed the concepts. All authors processed the data. The data analysis was conducted altogether by all authors. All authors discussed the results of the study.

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