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The effect of Russian University Excellence Initiative on publications and collaboration patterns

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ABSTRACT

The Russian University Excellence Initiative (Project 5–100) was initiated by the Government in 2013 to strengthen the positions of leading Russian universities at the global academic market (passive into active). We estimate the effect of this project on university publication activity with a special focus on the changes in the research output structure expressed in changes of quality and collaboration patterns. To do so, we use an econometric analysis of longitudinal data applying a linear growth model with mixed effects, with different characteristics of the research output as dependent variables. The dynamics of research collaborations were examined through university affiliations. We demonstrate that there is a significant positive effect of Project 5–100 on quantitative university research performance. That is, participating universities demonstrate a substantial, steady increase in publications measured in total numbers and per capita. We also show that the project has had a positive effect on publications in highest and lowest quality journals as well as on multi-authored publications. Participating universities have increased the number of publications (especially in high-quality journals) written in co-authorship with other organizations.

1. Introduction

Knowledge produced in universities and research centers is a decisive factor in the development of innovation, competitiveness, and the socio-economic progress of a state (Adams 1990; Henderson et al. 1998). In this context, many governments are striving to increase the scientific and intellectual level of national universities to be at the cutting edge of scientific development. In recent decades, there have been at least 37 university excellence initiatives across the world, 19 of which were initiated in European countries (Salmi 2015). Improving the position of the group of national universities in the global academic market is one of the main objectives of these programs.

Having limited resources, many governments choose to support a limited number of institutions in their efforts to improve performance and to enter the world-class university league. This method of preferential funding has some risks, including the inefficient use of resources and their suboptimal distribution among universities, and pursuing league table positions provided by non-reliable rankers (Lim and Williams Øerberg, 2017; Lim 2018) instead of building a high-quality research

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and educational environment (Salmi 2015). Despite the possible risks, the implementation of excellence programs is an acceptable way for developing countries to increase global competitiveness in creating, applying, and spreading new ideas and technologies (Altbach and Salmi 2011).

Despite orientation on clear-cut key indicators, excellence initiatives have a complex influence on research universities. The design of these programs often requires universities to transform their internal environment, such as their research and teaching processes, and scientific collaboration and governance models. These transformations are expected to promote university excellence. One of the key components of virtually every university excellence initiative is the promotion of 'world-class research', which is often perceived as more important than teaching (Pruvot et al. 2015), and is usually measured in publications in international scholarly journals. An analysis of publication output is a commonly used approach in assessing research performance, which is based on the premise that papers published in refereed journals are approved by the peer community and will be more recognized by other academics (Moed, Glänzel and Schmoch, 2004). Publications in prominent highly-cited journals characterize the quality of research and high quality studies contribute to a university's reputation (Linton et al., 2011, Butler 2003).

On the institutional side, excellence programs often stimulate participating universities to intensify collaboration with other organizations (Guskov et al., 2018; De Filippo et al., 2016; Möller et al. 2016). Performance assessment has led universities to be more active in attracting productive researchers and establishing collaboration with other universities and research institutions. Scientific collaboration is the fastest way to get access to knowledge and equipment, and also to increase the quality of research (Abramo et al. 2009; Khor and Yu 2016).

Thus, excellence initiatives create incentives and provide resources for universities to invest into robust research infrastructure. Publication growth that a university demonstrates after the start of an Excellence program is just the observable part among many changes, such as the emergence of new laboratories, access to new equipment, conference participation, and involvement of productive scientists and academically capable students. The success of excellence initiatives depends on various institutional factors among which are the program design, structure of national research and innovation systems, and prior record of participants' academic excellence and embeddedness among other features.

In this paper, we consider recent Russian Project 5–100 which provides a good example of such an initiative. This project has an annual assessment of results with annual approval of funding for the following year, which compels universities to demonstrate improved academic achievements each year. We study the impact of the Project on research output of participating institutions, as well as the structure of this impact: whether this program results in just a greater quantitative output, or whether qualitative changes also take place.

We also analyze the changes in scientific collaboration patterns of universities with other Russian and foreign organizations. Recent studies have emphasised the importance of cross-institutional and cross-country collaborations for academic research. These collaborations improve the quality of research (Abramo et al. 2014) and increase the visibility of universities (Sooryamoorthy 2009). Some of them, mainly multi-author papers resulting from large-scale multinational projects, can exert huge impact on publication and citation counts, which are among the main KPIs used by the 5–100 project designers. Also, internationalization is considered as a core target in several Excellence Initiatives (Salmi 2015), including 5–100 Project, so it is natural to look at internationally co-authored papers.

In order to assess this complex dynamic, we look at the relative growth of research output in 5–100 universities in comparison to the output of a control group of similar institutions not included in the first round of Project 5–100, building on and expanding the earlier work of Poldin et al. (2017). We also examined publication output of participating universities in the high- (Q1) and low-quality (Q4) segments according to the journal impact factor (JIF) (Miranda and Garcia-Carpintero 2019). In addition, in both groups, we analyze the number and share of papers co-authored with scholars from other organizations (including foreign ones) for all publications and for publications in high- and low-quality journals.

The Russian case is especially interesting because Russia represents a mature academic system with many disciplines having produced research at the top-level, although it is not always visible in the Web of Science (WoS) or Scopus (for a discussion of the reasons, see Moed et al. 2018). For a critical review of the modern Russian state research and innovation policy see Dezhina (2017). During the Soviet period, there was a clear divide between research (coordinated by the Russian Academy of Sciences) and teaching institutions (Gokhberg et al. 2009). To become world-class universities, teaching institutions should now not only increase their research performance but in many cases also reconsider their mission and structure, and reform the governance model to better fit their research goals. Such reforms and their quick implementation have a profound impact on the internal structure of universities, faculty contracts and salaries, career concerns of academics, and many other aspects of university life (Block and Khvatova 2017). In most cases, the ambitious goals of boosting international research performance are considered by a faculty as externally imposed by the university administration and public authorities, and sometimes are not supported by existing academic norms. Under these conditions, the issue of the resulting research performance is especially relevant.

As stated earlier, Excellence Initiatives have an impact on different components of university life. This paper considers the following questions: What is the effect of the Project 5–100 on universities publication output? Does the project foster scientific collaboration in participating universities?

We investigate research performance of 5–100 universities and their scientific collaboration 3 years prior and after the launch of Project 5–100. In section 2, the experience of implementation of excellence initiatives in different countries and the design of Russian Project 5–100 are described. Session 3 presents our data, methods, and approach. In Section 4, the estimates of project effect on university publication output are presented. The dynamics of scientific collaboration in 5–100 universities by an analysis of affiliations in university publications is presented in Section 5. Section 6 concludes with a discussion and final remarks.

2. Excellence initiatives across the world

Launched in recent years in a number of countries, government university excellence initiatives have the common aim of strengthening the position of national universities internationally, but often use different mechanisms of implementation. East Asian countries were among the first to launch large-scale public policies to improve both the quality of education and the research competitiveness of national universities. The Korean “21 project” was implemented in 1999–2005, and the main aim of the program was to promote a group of existing national universities in the global academic market along with the creation of new universities, focused on industrial development. Shin (2009) shows that during the program, the number of Korean publications in the WoS increased significantly. In addition, four new universities were established. However, as the researchers note, the same publication growth rates were observed in the US and Japan, and the growth in the number of publications in China is even higher than in Korea.

Another example is the Ÿ985 project, which was implemented in China. The program functioned in two periods, 1999–2003 and 2004–2007. The aim of the program was to strengthen the global positions of leading Chinese universities. The main criterion of efficiency was the number of publications in international journals. Zhang et al. (2013) show that, in general, there was an increase in the number of publications in international journals after universities joined this program, but the publication activity among participants was significantly different. A more recent study criticizes Zhang et al.'s methodology but confirms the publication growth, albeit finding a “homogenizing trend within 985 universities” (Zong and Zhang 2019).

Along with positive examples, there are some cases that may be interpreted as unsuccessful. For example, Taiwan's “World Class University Project” did not lead to the outrunning increase in the number and quality of publications in participating universities (Fu et al., 2018). The authors explain these unsatisfactory results by immature research environment in participating universities and by high publication activity of non-participants. During the project implementation, control group universities also had financial support, therefore publication growth of non-participants did not allow to reveal the significant effect of the Taiwanese project.

For many government university excellence programs, publication output is a key indicator of successful participation. However, these programs influence not only the publication activity of the participating universities but also their interaction with the wider academic environment. The German Excellence Initiative is one such example. It was launched in Germany in 2006 to increase the competitiveness and attractiveness of German universities. Möller et al. concluded that participation in the program contributed to the interaction of universities with the non-university academic environment. However, changes in the German academic system that have occurred since the beginning of the program are not massive (Möller et al. 2016). Recent paper (Civera et al. 2020) uses the case of German Excellence Initiative to show that targeting quantity may have a negative effect on quality of research output.

The experience of the first excellence programs shows that the creation of world-class universities requires not only targeted financial investments for increasing publication activity, but also the reorganization of higher education systems. The main goal of the G̈lobal University Projectïn Japan was the integration of 37 national universities into the international academic community. The key indicators of the program include factors of international cooperation: international co-authorship, participation in international research and educational projects, and citations. The program was launched in 2014 and intends to operate for at least ten years. While this policy has increased the productivity of participating universities, the gap between universities at the national level is also increasing (Yonezawa and Shimmi 2015). In addition, at this stage of the program, it is difficult to assess how the policy of global integration of Japanese universities will lead to qualitative improvements in the system. Zong and Zhang (2019) studying Project 985, also note that the publication gap between different types of universities is growing as a result of the excellence initiative.

The results of excellence initiatives in different countries suggest that such programs have a complex influence on national higher education and its research systems. To achieve the program aims, universities change their collaboration and governance structures, and also the higher education system itself (De Filippo et al., 2016). However, side effects might appear, such as the stratification and growth of university inequality inside the country. Thus, excellence programs have a large-scale impact on nationwide academic systems.

2.1. The Russian case

In Russia, the most high-profile program of targeted support of leading universities started in 2013 and aimed to improve “the competitiveness of Russian universities” (Yudkevich 2013). This aim requires efforts in several dimensions, namely the development of strong and committed leadership, attracting productive and promising faculty both in Russia and internationally, and the support of academic mobility and programs of international collaboration. Research performance was chosen as one of the key indicators of university progress. Each year the universities taking part in the program report to the Ministry of Science and Higher Education about their progress in a number of indicators to secure funding for the next year.

The indicators include both publication and citation counts in WoS and Scopus[1] . The key feature of the program, which differentiates it from many similar excellence university programs across the world is the short-term character of the control of performance and funding. Such a design creates strong incentives for universities to show quick results and pushes them to improve every year.

Recent research reveals that Project 5−100 has already had a positive effect on the publication activity of universities in the first years of participation. Turko et al. (2016) reveal that after joining the project, participating universities increased the total number of publications and the share of publications in 10 % of the most cited journals. However, this work has several drawbacks.: It does not take into account the size of the universities, the control group includes only five universities, the obtained data reflects the early stages of Project 5−100, and the indicators used are derived from the Scopus database. This database indexes a significant number of potentially unscrupulous journals, which are used for artificially increasing publication indicators, especially in Russia (Sterligov and Savina 2016).

Poldin et al. (2017) studied the effect of the project based on the Web of Science (WoS) database and took into account the funding and the number of scientific staff. They revealed that in the first two years of Project 5−100, universities outperformed their own publication trends and the general trend (taking into account the control group). In addition, participating universities increased the number of publications per capita in high-quality journals.

In Soviet period and in Russia until recently, the university sector was separated from the research sector represented by Russian Academy of Sciences. So, for Russian higher education institutions, research was not their base function for many decades. Therefore, for stable publication growth, universities are forced to reorganize in order to make research an important part of university mission. Agasisti et al. (2018) found that after joining Project 5−100, universities demonstrate growth in publication output and increased productivity and efficiency. The analysis is based on data about average entry exam scores,the number of students, R&D expenditures, and regional GDP per capita.

Participation in the project may also push the university administration to prioritize quantity over quality and to create incentives for faculties to publish faster, targeting low quality journals. Guskov et al. (2017) argue that participation in the program forced universities to change their publication strategies in favor of increasing the number of publications. Some participating universities use unfair strategies (for example, publishing in p̈redatorÿjournals) to increase their publication outputs (Guskov et al., 2018; Moed et al., 2018).

Until recently, higher education institutions in Russia mostly focused on teaching while now their missions have expanded to include research as well. Most of the participating universities use collaboration strategies with other scientific organizations (Guskov et al., 2018). Ivanov et al. (2016) analyzed the contribution of the Russian Academy of Sciences (RAS) to the growth of publication activity of Russian universities and reported growth in the number of publications written jointly by Project 5−100 universities and RAS.

The observed publication success of Russian universities has taken place during the implementation of several Russian government initiatives aimed at improving the research system. Among them the following should be mentioned: the competitive grant program (started in 2010) giving financial support and promoting scientific innovation, including the involvement of internationally recognized scientists in the creation of research laboratories in Russian universities and research institutions (http://www.p220.ru/en/). The creation of the Skolkovo Institute of Science and Technology in partnership with MIT in 2011 (https://www.skoltech.ru/en/). The establishment of the Russian Science Foundation which, since 2013, has provided research grants on a competitive basis (https://www.rscf.ru/en/). This complex of initiatives has had a cumulative effect on Russian universities and research institutes. In the present study, we look at publication output and collaboration activity of universities that participate in the Project compared to those that do not to identify the effect of Project 5−100.

3. Data

Our sample consists of 14 out of the 15 universities that have participated in Project 5−100 since 2013 (treatment group)[2] and other 13 Russian universities (control group)[3] . One institution, HSE University, was not included in the treatment group due to its special status (it reports directly to the Government, not the Ministry of Science and Higher Education, unlike the other universities in the sample). The control group includes universities which, at the beginning of the project, had comparable key indicators of research productivity to those of the treatment group, namely the number of publications in

[1] The list of requirements for reports on the realization of action plans of the universities selected through a competitive process for granting state support to the leading universities can be found at https://5top100.ru/en/documents/regulations/74076/

[2] Far Eastern Federal University (FEFU), Kazan Federal University (KFU), Moscow Institute of Physics and Technology (MIPT), National University of Science & Technology (MISIS), National Research Tomsk State University (TSU), National Research Tomsk Polytechnic University (TPU), National Research Nuclear University (MEPhI), Lobachevsky State University of Nizhny Novgorod (UNN), Novosibirsk State University (NSU), Samara National Research University (SSAU), St. Petersburg State Polytechnical University (SPbGPU), St. Petersburg State Electrotechnical University (LETI), St. Petersburg State University of Information Technologies (ITMO), Ural Federal University (UFU) (https://5top100.ru/en/universities/).

[3] Baltic Federal University (BFU), North-Eastern Federal University in Yakutsk (NEFU), Peoples Friendship University of Russia (RUDN), Siberian Federal University (SibFU), Tyumen State University (TyUU), South Ural State University (SUSU), Moscow Aviation Institute (MAI), Perm National Research Polytechnic University (PGTU), Saratov State University (SSU), Southern Federal University (SFU), Bauman Moscow State Technical University (MSTU), Voronezh State University (VSU), Ufa State Aviation Technical University (UGATU)

highly cited journals. Note that the bibliometric indicators were on average lower for the control group than those of the 5−100 universities, although we included those with a minimal gap from the treatment group. Bibliometric indicators also were used in the selection of 5−100 participants, therefore there is a prior difference between 5−100 universities and other Russian higher education institutions. So it is not surprising that five universities from our control group were included in the second wave of the project at the end of 2015. These universities started to receive 5−100 funding in 2016 only, thus we can assume that participation in the Project 5−100 cannot have greater influence on their publication and collaboration activity in 2016.

Publication patterns in different disciplines can vary substantially, so prior to comparing the treatment and control groups, we investigated the distribution of their publications by subject areas. We did this by calculating and comparing specialization indices[4] for four publication sets (the treatment and control groups, 2012 and 2016). This exercise allowed us to conclude that both groups of universities are 1) very much like Russian universities as a whole, 2) similar to each other 3) and there were no noticeable changes in 2016 compared to 2012. For both the treatment and control groups, the two main areas are Applied Physics and Materials Science, the other prominent areas being Condensed Matter Physics and Physical Chemistry. Both groups of universities largely lack biochemistrymolecular biology papers compared to the World Specialization Index 0,6 for the treatment group, and 0517 for the control group, which is typical for Russia (Moed et al., 2018).

The noticeable differences are mainly in High Energy and Particle Physics, where the treatment group has many more such papers (Sp. Index = 8.86 vs 1.1, the same for Nuclear Physics), and in Mathematics, where the control group has more (4.5 vs 1.8). We hypothesize that the difference is due to the increased participation in the Large Hadron Collider and similar projects by some 5−100 universities. Apart from this, there is no substantial variation between the two publication sets: both groups of universities largely pursue a typical post-Soviet disciplinary path.

We use data about the total number of journal articles and reviews from 2010 to 2016 attributed to university profiles in WoS (Science Citation Index Expanded and Social Sciences Citation Index, document types “article” and “review”), and the number of publications in the journals of the highest (Q1) and the lowest (Q4) quartiles according to their JIF.[5] Data about publications was extracted from WoS in August 2017 and journals' ISI were extracted from InCites in February 2018. Using quartiles instead of rough JIF values attenuates the problem of varying journal citation levels across different subject areas. We also collected data about the number of scientific staff at each university and the amount of R&D funding from the statistics of the then Ministry of Education and Science. As the citation windows suitable for most disciplines are more than three years, we cannot directly compare citation counts for recent years (2015–2016). So, JIF quartiles provide a viable alternative indicator of quality (see Waltman (2016) for a review of using JIF for such purposes), although they should be used with caution (see Miranda and Garcia-Carpintero 2019 for a detailed review of advantages and drawbacks of such approach).

Thus, we see that there is growth in the number of publications in the treatment and in the control groups, including per capita. Although there was a difference in the number of publications and funding, the contrast became notable after the project started. We also observed that 5−100 universities are more stratified in publication output per capita than in total publication growth. In the next sections, we analyze whether and to what degree the 5−100 universities outperform the general and their own publications trends.

4. The evaluation of publications activity and collaboration: methods and approaches

We investigate the 5−100 project effect from two sides. First, how the publication output and its quality change and second, what the role of scientific collaboration in the observed output is, namely how the scientific collaboration of universities changed after the project was launched.

Publication output was estimated by the following variables:

(i) Indicators which measure the universities' publication activity : the total number of publications and the number of publications per capita.
(ii) Indicators that estimate quality aspects: the number of publications in Q1 and Q4 journals and also their normalized values per capita. The Quartile of a publication is defined by a journal impact factor (JIF) which reflects the average number of citations to the recent papers published in this journal, but has to be normalized because of huge differences between citation rates across different subject areas. We use a quartile method, which is promoted by the Web of Science database, that calculates and publishes journal quartiles on a regular basis. The highest journal quartile (Q1) means that this journal is in the top 25 % in a certain subject category and the lowest (Q4) means that the journal is in the bottom 25 % by JIF. (see Miranda and Garcia-Carpintero 2019 for a detailed explanation of quartile-based approach). We use a

[4] A specialization index X for a given Web of Science Subject Category and publication set is calculated as follows: X = A/B, where A is the share (in %) of all publications in the surveyed publication set that are attributed to this Subject Category, and B is the share (in %) of all publications that are attributed to this Subject Category in the surveyed years.

[5] We use a “generous” approach to assigning quartiles to individual articles in journals with multiple subject categories, so that a paper in a journal which is attributed to Q1 in one category and Q2 in the other, will be assigned to Q1.

"generous" approach to quartile assignment: if a paper is published in a journal which is attributed to several subject areas and has different JIF quartiles, a paper is assigned the highest quartile.

We also account for the number of publications with more than 10 authors and its value per capita to estimate the effect of the large-scale research projects on publication outputs in our case.

In our previous study (Poldin et al. 2017), we demonstrate that publication growth varies among universities. This means that each university has its own dynamics of publication growth. Individual dynamics of universities can be counted by including dummy variables for each university in the model, but the model becomes unwieldy and there is a risk of multicollinearity. Using the linear mixed-effects model (LME) allows us to avoid these problems. LME takes into account individual variations between universities (Verbeke 1997). This model consists of fixed and random components. The fixed part is the general intercept and the slope of all observations and the random part is the random deviation of individual intercepts and slope from the underlying fixed line. For the estimation of the effect of Project 5−100 and the variation of the effect by years, we use LME with a correlated random trend, which allows correlation between random effects (Wooldridge, 2010). The model is applicable to the presence of individual growth in the sample. As other linear models, LME also has several assumptions: linearity, homogeneity of variance and normal distribution of residuals. Publication growth rate of all universities from our sample is not stable over the years and has increased since 2013. We use logarithm of dependent variables to linearize the growth. Thus, our model has a log-linear form. Homogeneity of residuals variance and normality of its distribution allow us to apply LME to our sample.

The basic model is:

$$In(publications)_{it} = \alpha_0 + \alpha_i + (\beta_0 + \beta_i)(year)_t + \lambda_t + \delta^{2014} d_i(year = 2014)_t +$$

$$+\delta^{2015} \cdot d_i(year = 2015)_t + \delta^{2016} \cdot d_i(year = 2016)_t + \varepsilon_{it}$$

where:

α_i, β_i – random intercept and trend coefficients (not estimated);
α_0, β_0– fixed intercept and trend coefficients;
$(\text{year})_\text{t}$– time trend (. . . -3, -2, -1, 0, 1, 2, 3. . .);
λ_t – time dummies (for taking into account control group);
δ– average treatment effect, ATE;
d_t– dummy for project years;
d_i – dummy for participants;
ε_it– standard errors.

Variable covariates have been added for the response variable of the total number of publications, and the covariates are *R&D funding* and the *number of scientific staff.* For the response variable of the number of publications per capita, the covariate is *R&D funding per capita.* As response variables, the total number of publications, the number of publications in Q1 journals, the number of publications in Q4 journals, and the number of multi-author publications and their normalized values by the number of scientific staff were used.

Papers with more than 10 authors were considered as multi-authored. To define this threshold (the number of authors) we analyzed the distribution function of publications by the number of authors and the Pearson correlation between all publications and publications with a certain number of authors. Both university groups have very similar distribution functions: smooth and with gradual fading (see Fig. 1.A.(a) in Appendix). Articles with more than 10 authors represent ∼1% of all publications with a continuous decrease of this percentage with an increase in the number of coauthors. For 5−100 universities, 10 % of publications have more than 10 authors, and for the control group this value is about 2%. To define an exact border, we calculated the Pearson correlation between the time trend of all publications and the time trend of publications with a certain number of authors for 2009–2016. The correlation decreases after 10 authors (see Fig. 1.A.(b) in Appendix), so papers with more than 10 authors have different dynamics from the rest.

We analyze the dynamics of the affiliation by author in the treatment and control groups to investigate the change in scientific collaborations of universities after Project 5−100 was launched. This approach allows us to estimate inter-institutional collaborations and also analyze the number of papers prepared within one university. The number of authors and number of affiliations for all, Q1, and Q4 publications were extracted from the WoS publication records.

To avoid counting the exact number of affiliations per each author that proves to be a very time-consuming and error-prone process (due to the lack of standardization of organization names in the Web of Science metadata), and requires advanced algorithms and excessive manual checking (Waltman and Van Eck 2015) we resorted to simpler methods. First, for project participants and for control group universities, we analyzed the *average number of affiliations* in publication and *share of publications prepared in one university*.

Next, we analyzed the number *of author's affiliations in solo-publications* and that in Q1 and Q4 journals. Publications with one author (solo-publications) give a very simple and demonstrative indicator for analysing tendencies of scientific collaboration in university. This indicator does not require additional normalization for analysis of author or institution contribution and allows us to look at the specific form of institutional "collaboration". That said, it has clear limitations: it is clearly very field-specific, and the share of such papers is rapidly declining for all subject areas, but with different speed (Huang 2015).

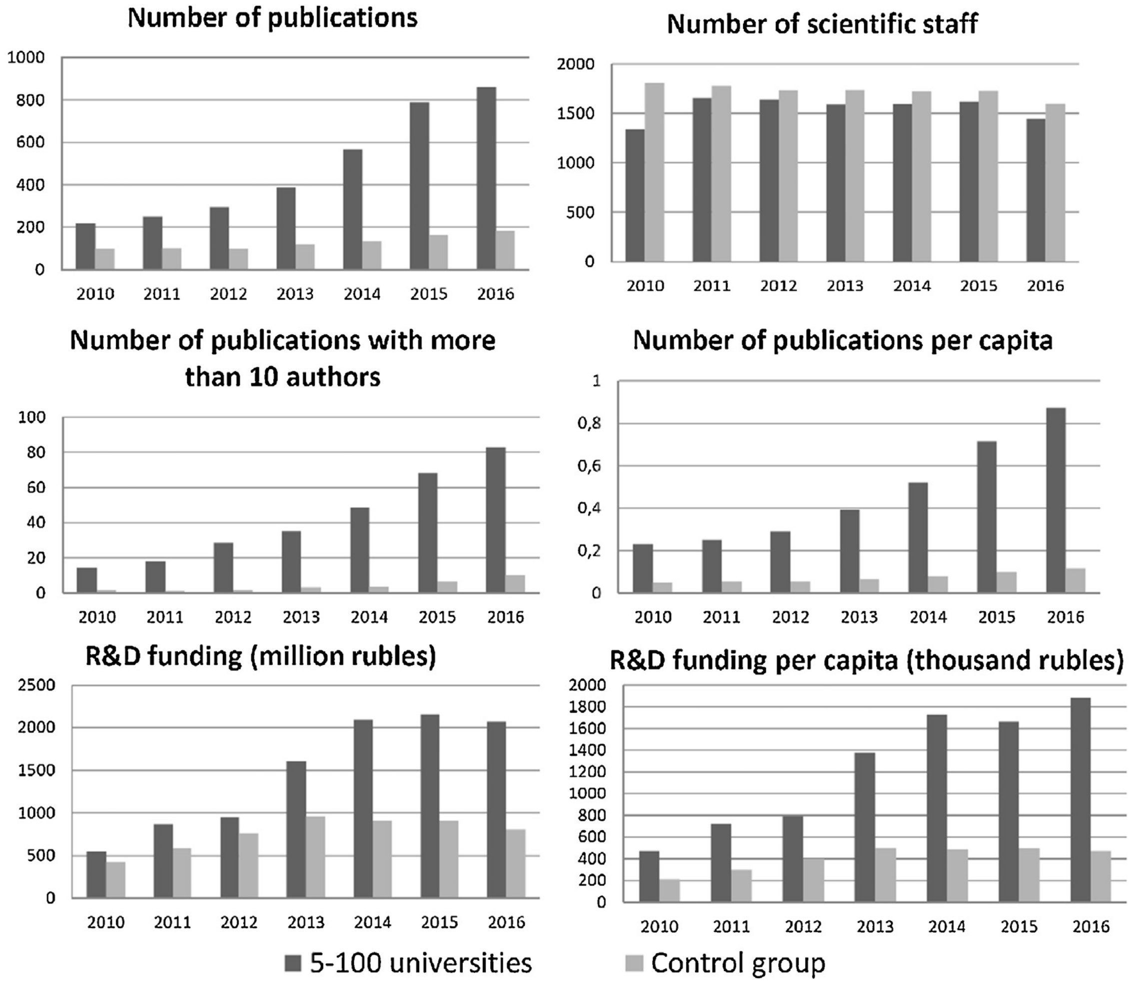

Fig. 1. Descriptive statistics for two groups of universities: mean values.

In addition, in both university groups, we analyzed a *share of international collaboration* (papers with affiliations of more than one country as a share of all papers). Internationalization is a crucial mechanism to become world-class universities, and international papers tend to be much more cited. Collaboration with foreign colleagues not only increases the quality of research (Ni and An 2018), but also changes university governance especially for universities in a non- English-speaking system (Yonezawa and Shimmi 2015).

5. Results

First of all, we look at how similar were the treatment and control groups in publication output and R&D funding. Figs. 1 and 2 show mean values of variables for universities in control and treatment groups in the certain year. During the whole period, both groups demonstrated growth in publication output, although there were some differences in the rate of growth and in the number of publications. Before the program started, the total number of publications, the number of publications per capita, and the amount of funding per capita in the 5−100 universities were approximately twice that of the control group (Fig. 1). After 2013, the gap in publication output and funding between the treatment and control groups became wider. In both groups, the number of scientific staff was unstable, with increases and decreases in different years, and the control group has more academic staff than 5−100 universities.

In Fig. 2 we observe that both university groups increased publication output in Q1 and Q4 journals, including per capita values, although the absolute number and the pace of growth are different. In 5−100 universities, the absolute number of publications in Q1 and Q4 journals is much higher than in the control group. In 2010–2012 5−100 universities and ones from a control group have approximately the same number of publications in Q1 journals per capita. Since 2013 5−100 universities have demonstrated the largest growth rates of Q1 publications, so that in 2014–2016, the absolute number of publications in high-quality journals is higher than in low-quality ones. The control group has uniform publication growth rates with a prevalence of Q4 output.

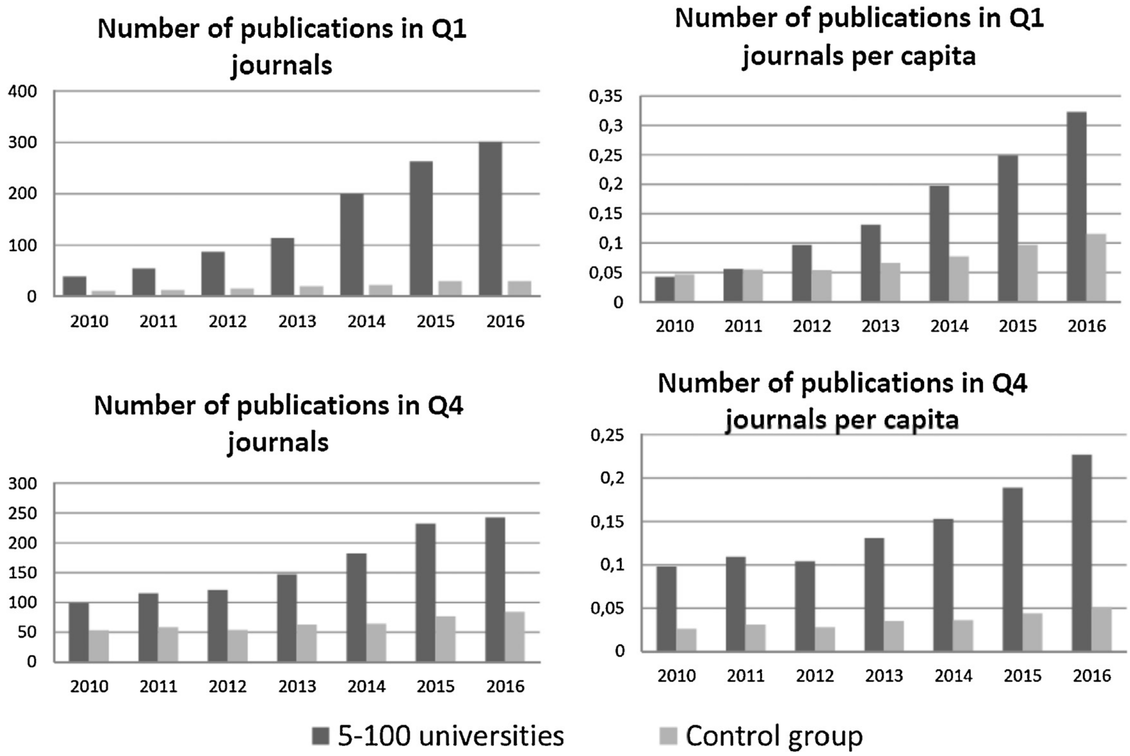

Fig. 2. Dynamics of publications in Q1 and Q4 journals: mean values.

Table 1
Results for total number of publications.

	(1)	(2)	(3)	(4)
Year = 2014×participant of 5–100	1.352*** (0.078)	1.367*** (0.084)	1.273*** (0.082)	1.252*** (0.076)
Year = 2015×participant of 5–100	1.578*** (0.141)	1.588*** (0.148)	1.456*** (0.147)	1.441*** (0.143)
Year = 2016×participant of 5–100	1.523*** (0.145)	1.512*** (0.145)	1.353*** (0.154)	1.367*** (0.161)
Year (β_0)	1.186*** (0.028)	1.196*** (0.029)	1.196*** (0.030)	1.178*** (0.035)
Scientific staff (thousands)	1.099* (0.058)	1.109* (0.065)	1.011 (0.040)	1.006 (0.033)
Funding of R&D (bln. rubles)		0.932 (0.072)		1.106 (0.102)
Control group	yes	yes	no	no
Time effects	yes	yes	no	no
N	189	189	98	98

Standard errors in parentheses *$p < 0.1$, ***$p < 0.01$.

If one takes into account the number of scientific staff in the treatment and control groups, the effectiveness of academic staff in Q1 and even Q4 output is higher for 5–100 universities (see the number of publications in Q1 and Q4 per capita in Fig. 2)

We run the LME model for several variables, which describe the publication output of universities, such as the total number of publications, publications per capita, number of publications in the top and bottom quartiles, the number of publications with more than ten authors, and its normalized per capita value (see Table 1 for the results of the regression analysis). Participation in Project 5–100 positively affects the number of publications. The greatest effect was observed in 2015, the second year of the project, and the value of the effect decreased in 2016. Estimates are calculated in exponential form. Tables 1–4 present the linear modifications. Thus, the coefficient 1.352 for the variable *Year = 2014×participant of 5–100* in the first column means that in this model specification, in 2014, 5–100 universities outperformed the general publication trend by 35.2 %. If the value of the coefficient is less than one, the growth of the factor is explained by the reduction of the response variable. Number of observations (N) corresponds to the number of universities' publications for all years. For full specifications N = (14treatment group + 13control group)×7years = 189. For specifications with the treatment group only N = 14*7 = 98.

We consider 4 specifications of the model: specifications 1–2 are for the full sample of universities and specifications 3–4 are for Project 5–100 universities only. This separation shows the effect on participating universities in comparison with the general publication trend and how these universities outperform their own trend. Table 1 shows that the values of the effect are slightly higher for the full sample. Universities outperform their own publication trends to a lesser degree.

Table 2
Results for number of publications per capita.

	(1)	(2)	(3)	(4)
Year = 2014×participant of 5–100	1.354*** (0.101)	1.314*** (0.102)	1.330*** (0.116)	1.274*** (0.088)
Year = 2015×participant of 5–100	1.557*** (0.172)	1.559*** (0.155)	1.522*** (0.187)	1.560*** (0.149)
Year = 2016×participant of 5–100	1.694*** (0.215)	1.689*** (0.198)	1.649*** (0.238)	1.685*** (0.194)
Year (β_0)	1.181*** (0.028)	1.155*** (0.031)	1.156*** (0.030)	1.081*** (0.026)
Funding of R&D per capita (mln. rubles)		1.306* (0.206)		1.681*** (0.138)
Control group	yes	yes	no	no
Time effects	yes	yes	no	no
N	189	189	98	98

Standard errors in parentheses.

Table 3
Results for the model's specification taking into account the control group and funding.

	Year = 2014× participant of 5–100	Year = 2015× participant of 5–100	Year = 2016× participant of 5–100	Funding of R&D (bln. rubles)	Scientific staff (thousands)	Number of observations
Number of publications in Q1 journals	1.434*** (0.164)	1.332* (0.213)	1.341*** (0.045)	1.022 (0.180)	1.043 (0.111)	182
Number of publications in Q4 journals	1.257*** (0.089)	1.477*** (0.122)	1.489*** (0.124)	0.965 (0.065)	1.195*** (0.062)	189
Number of publications with more than 10 authors	2.771*** (0.534	3.553*** (0.954)	4.419*** (1.262)	0.943 (0.230)	0.746* (0.114)	163

Standard errors in parentheses $^{*}p < 0.1$, $^{***}p < 0.01$.

Table 4
Results for the model's specification taking into account the control group and funding. Dependent variables are normalized per capita.

	Year = 2014× participant of 5–100	Year = 2015× participant of 5–100	Year = 2016× participant of 5–100	Funding of R&D per capita (mln. rubles)	Number of observations
Number of publications in Q1 journals per capita	1.367*** (0.154)	1.332* (0.197)	1.282 (0.222)	1.688** (0.363)	182
Number of publications in Q4 journals per capita	1.167* (0.110)	1.363*** (0.138)	1.503*** (0.182)	1.226* (0.135)	189
Number of publications with more than 10 authors per capita	2.326*** (0.426)	3.128*** (0.763)	4.364*** (1.257)	1.690* (0.472)	163

Standard errors in parentheses.
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

The inclusion of R&D funding in the model (with Project 5–100 subsidies included in this amount) as an explanatory variable allows us to consider the non-financial effects of participation, such as improved management and intangible incentives. As follows from the estimates in columns 2 and 4, such effects exist. The number of scientific staff positively correlates with the number of publications in the full specifications. In the sample with only 5–100 universities, a significant correlation between these variables was not detected. The insignificance of the correlation may be explained by the reduction of scientific staff in 5–100 universities over several years (see Fig. 1).

We estimate the effect on publications per capita to understand how Project 5–100 affects the productivity of scientific staff. The effect is positive, and its value varies depending on the model specification. When we take the control group into account, the values of the effect get higher (specifications 1–2), that is, participating universities enhance the general trend by a larger value than their own. This effect increases during the whole period (from 35.4 % in 2014 to 69.4 % in 2016), but this growth can be partly explained by the reduction of scientific staff in 2016.

$^{*}p < 0.1$, $^{***}p < 0.01$

We found that participation in Project 5–100 allowed universities to surpass the general publication activity by more than 35 % in 2014, and more than 50 % in 2016. However, to be able to conclude whether the Project was successful, one needs to understand its influence on publications of different quality. So, we look at the project effect on high-quality (Q1) publications in comparison with Q4 output.

Despite these differences, in 2010, the treatment and control groups had a practically equal share of publications in Q1 journals: 17 % in the treatment and 15 % in the control group (Fig. 3). Then, 5–100 universities significantly increased the share of high-quality publications to 31 %, while for the control group this share reached 20 % and remained at this level. These results indicate that in participating universities, one third of all publications from our sample are published in high-

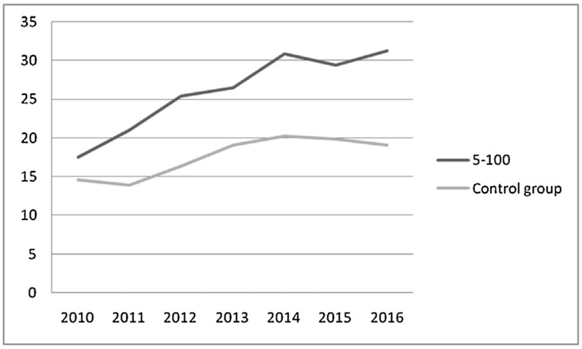

Fig. 3. Share of publications in Q1 journals.

quality journals, and the control group is not far behind. To obtain a more accurate view of the Project 5−100 effect on the quality of publication output, we run LME.

The results of several model specifications for all publications do not exhibit substantial differences (see Tables 1 and 2). Further we present the results of the most comprehensive specification, which takes into account the control group and R&D funding. Tables 3 and 4 demonstrate the effect of the Project 5−100 on different types of publications: Q1 publications, Q4 publications and multi-authors publications. Number of observations (N) in Q1 publications and multi-authors publications is less than 189 since not all universities from our sample have Q1 and multi-authors publications in all observed years. A positive significant effect of the Project on high-quality publications is observed in the first two years (Table 3), although the values of the effect are lower in 2015 (43.4 % in 2014 and 33.2 % in 2015). A significant correlation between the number of publications in Q1 journals and the number of scientific staff was not found, which can be explained by the large variation in the number of scientific staff.

The government observes general output without any differentiation between quality segments; major indicators set by the Program authorities are of quantitative nature (the most important being Web of Science Scopus paper count). Thus, to maximize this value, universities may be interested in increasing low-quality output (Guskov et al., 2018), which is in general cheaper, easier, and faster to produce. So, we look at the relative dynamics of Q4 output. 5−100 universities outperformed the general publication trend by 35.2 % Participating universities outperform the general publication trend for Q4 journals by 25.7 % in 2014, and 48.9 % in 2016.

The effect of Project 5−100 on the number of publications in Q1 journals per capita was detected in 2014 and 2015 (Table 4). The highest values of this effect were observed in 2014 (36.7 %). Funding per capita positively correlates with the number of publications in Q1 journals per capita. The significant effect of the Project on the number of publications in Q4 journals per capita was also revealed in all years (Table 4). The highest value was in 2016 (50.3 %). For the number of publications in Q1 journals, we observe the opposite results: the effect was highest in 2014 and decreased in 2016.

Analysis of multi-author publications reveals additional points for consideration. These publications assume a special form of collaboration with a modest average relative contribution per author. However, they are very important in terms of Russian 5−100 bibliometric KPIs, because those are defined using a standard whole-counting method (any affiliated organization can assume full credit for a publication and its citations regardless of number of authors and affiliations). Most of these publications with 11 or more co-authors in our sample and, generally, in Russia are based on experiments in large high-energy physics installations and are highly cited compared to the average: for 2012–2016, the citation rate (normalized by year, subject field, and document type) for Russian articles and reviews in physics was 0.52 for papers with 1–10 authors and 2.65 for papers with more than 10 authors.

The growth of these articles can be observed for those five 5−100 universities (see Fig. 1), which have experience in relevant fields. It should be noted that from preliminary data for 2017–2018, the list of 5−100 universities participating in such “mega collaborations” became noticeably longer, which suggests a strategic approach of some 5−100 universities to such collaborations as a tool for increasing publication-based KPIs.

Tables 3 and 4 show that the effect of the Project on these articles is large for the total number of such publications and also for their number normalized by scientific staff. The value of the effect increases from 2014 to 2016. For example, 5−100 universities outperformed the general trend by 270 % in 2014 and by 400 % in 2016 (the coefficients 2.771 and 4.419 in the last line of Table 3).

Thus, the regression analysis of the effect of Project 5−100 shows that there is a positive effect on the total number of publications and the number of publications in Q4 journals during these three years of participation. The Project’s effect on publications in Q1 journals decreases over time – in 2015 it was weaker than in 2014 and was not found in 2016. In addition, we found a large increase in the number of publications with more than 10 authors in 5−100 universities during these three years.

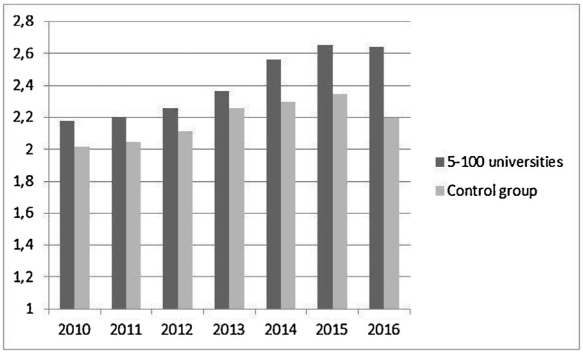

Fig. 4. Average number of affiliations per publication.

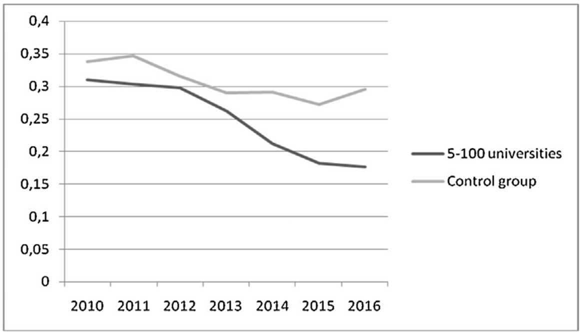

Fig. 5. Share of publications with single affiliation by years.

5.1. The effect of the project on collaboration patterns

A common strategy to quickly increase the publication output is to intensify cooperation with other higher education institutions and research organizations inside and outside the country. Does this effect really take place? We address this question by studying the number of affiliations in publications. Initially, affiliations reflect geographical location of authors and its changes. Thus, changes of authors' affiliations can be used as an indicator of academic mobility (Laudel 2003; Robinson-Garcia et al. 2019). With the growth of technology scientists got an opportunity to work in several organizations. It has become common when one author has several affiliations. In this case academic mobility may be considered in a broad term as a the change of employment (move from one institution to another or dividing time between several institutions) even if it is not associated with a geographical mobility (move to another city or region).

Fig. 4 shows the dynamics of affiliations per publication in 5–100 and control groups. Here, only publications with no more than 10 authors are considered to exclude multi-authored papers with the expected high number of affiliations. In all studied years, the publications with participation of 5–100 universities have more affiliations than publications of a control group. At the same time, since 2013, in 5–100 universities the growth of number of affiliations per publication has been observed. The change is not large: from 2.2 authors per publication in 2012 to 2.6 in 2016. This does not reveal significant changes in universities' collaboration patterns. For a detailed analysis, we look at changes of the share of publications prepared by scholars affiliated with one organization.

We observe that the share of single-affiliation papers in 5–100 universities is less than in the control group and continues to decline during the 2010–2016 period. Moreover, the share of these publications has fewer single-affiliation papers while in the control group this share is relatively stable and even grew in 2016 (see Fig. 5). In 2010, 5–100 universities had on average 31 % of publications prepared by one or more scholars from one university, and in 2016 the share of these publications dropped to 17 %.

One may assume that to produce low-quality output, a researcher needs less collaboration. On the contrary, for high-quality production, external cooperation with stronger researchers and teams may be critical. So, we look at the dynamics of multiple affiliations – in general and in particular segments (Q1 and Q4 journals) – to test the following hypothesis: increasing cooperation (as reflected in bibliometric indicators) is much more viable in the high-quality segment and there is no substantial change in the low-quality segment. When we consider publication sets large enough, aiming at Q1 journals means more highly cited papers, which is crucial for university rankings implemented in the design of Project 5–100 (namely THE and QS subject rankings).

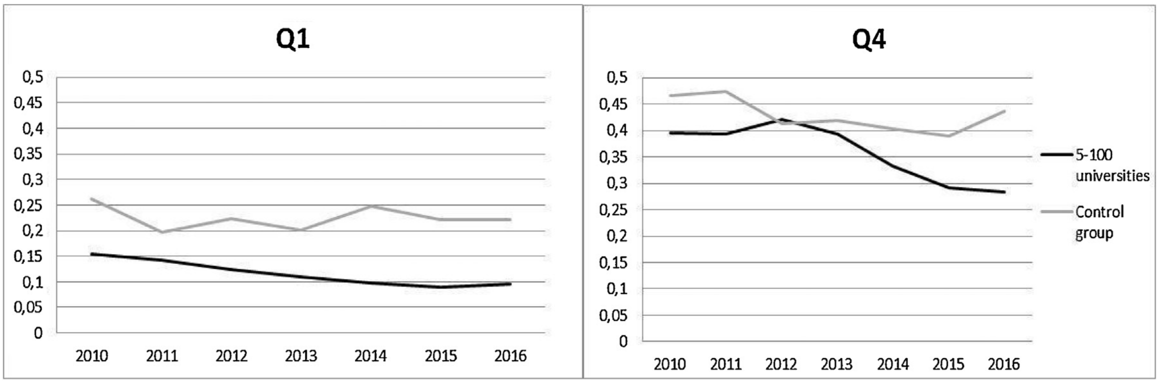

Fig. 6. Shares of publications with single affiliation in Q1 and Q4 journals by years.

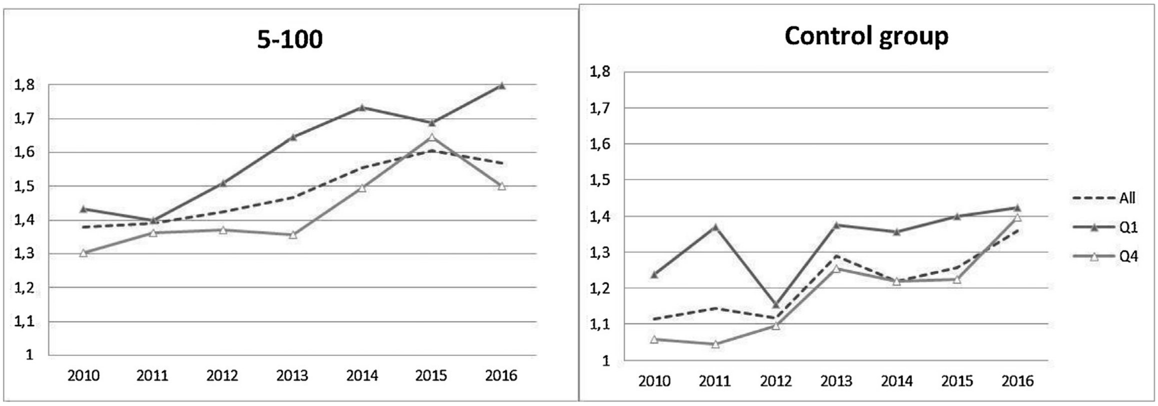

Fig. 7. Number of affiliations in single-authored papers.

The following results partly confirm our hypothesis about the difference of collaboration patterns of universities in Q1 and Q4 segments. In both university groups, high-quality publications are more often prepared with the participation of several organizations (Fig. 6). About 10 % of Q1-publications in 5–100 universities and 22 % in the control group were made in one university. This is only natural as higher quality publications need more resources, both human and financial. At the same time, after joining the Project 5–100, universities have intensified collaboration in the Q4 segment with other organizations. In Q4, the share of publications with one affiliation in 5–100 universities dropped from 40 % in 2013 to 27 % in 2016.

That is, participating universities intensified collaborations with other organizations after 2012. This result can be a consequence of two mechanisms both associated with the pressure of annual reporting and assessment. First, universities may become more active in building cooperative projects with other (preferably stronger) institutions and benefit from such cooperation in terms of increased research output. Second, universities may attract highly productive scholars from other institutions offering them competitive conditions for part-time employment and requiring them to mention this university affiliation along with their principal one. While it is hard to distinguish these mechanisms in their individual impacts on total output, both mechanisms to some extent can be effective in sharing experiences and increasing research skills and resulting research quality.

Based on our data, we cannot judge how fair university collaborations are and how far do they go beyond a simple “affiliation purchase”, but we can reveal the tendencies in university collaboration patterns, which emerged after the start of Project 5–100. We analyzed the changes in the average number of author affiliations for publications with one author. Single-authored publications with multiple affiliations correspond to cases where the transfer of knowledge and technologies between universities is associated with one person. This type of collaboration has minimum organizational costs and is easily arranged. However, it is very difficult to estimate the contribution of each organization, and in some cases collaborating institutions could even be against such conduct of their staff on the grounds that thus they donate publication points to the external organization which did not invest (comparable) resources in the research on which the paper is based.

We found that since 2013, the number of affiliations in single-authored papers of 5–100 universities has significantly increased (Fig. 7). This shows that after joining the project, 5–100 universities increase the number of publications partly due to the works of scholars who have multiple affiliations, i.e. work in organizations outside Project 5–100. The number of affiliations in Q1 and Q4 publications has also increased after 2013, which reflects the increase in papers which were

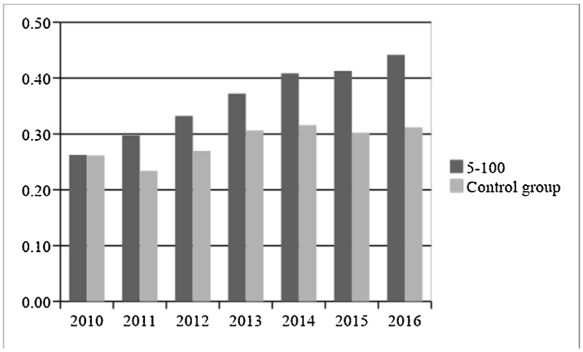

Fig. 8. Share of international collaboration.

prepared in collaboration with other organizations. In the control group, an increase in the number of affiliations by author is observed in Q4 segments, but it can be explained by low-base effect. In 2016, researchers from the control group had one average 1.4 affiliations.

The growth of author affiliations, especially in the Q1 segment, suggests that after joining Project 5−100, universities become more active in attracting the most prolific researchers. For instance, in 2016 one researcher had on average about 2 affiliations in Q1 articles and 1.5 affiliations in Q4 publications.

Finally, we study the dynamics of papers written in international collaboration (Fig. 8). In 2010, the 5−100 universities and the control group had equal shares of publications co-authored with foreign colleagues. In 5−100 universities, this indicator increased from 33 % in 2012 to 44 % in 2016. The control group intensified international collaboration in 2011–2013, and then the share of such publications was stable.

These results suggest that participation in Project 5−100 stimulated universities to intensify their research collaboration, including its international aspect. We observed that in 5−100 universities there was a significant increase in the number of academics with several affiliations, especially in the high-quality segment. For example, since 2013, in the Q1 segment about 90 % of solo publications has had more than one affiliation. Since it is unlikely that they worked on a large number of high-quality projects at the same time, we can assume that many academics from other institutions were partially employed at 5−100 universities. Attracting leading scholars is a good opportunity for universities to facilitate knowledge exchange, get access to 'frontline' research, and enhance university prestige. How well universities will take advantage of these opportunities is a question for future studies.

6. Discussion and conclusion

While Project 5−100 had a profound effect on participating universities as well as on the rest of the higher education system (Lovakov et al. 2019) in many aspects including the quality of students, the composition of the faculty, and the quality of governance or overall efficiency, in our study we focus on one important dimension of this impact, i.e. changes in research output. Our analysis shows that Project 5−100 had a significant effect on participating universities and also affected other institutions not participating in the program, though in different ways. We demonstrate that this impact goes beyond simple quantitative growth, also reflecting the structure of research output. We see that some pervasive effects may have taken place and are expressed in the growth of low-quality output from some universities, and after an initial boost in high-quality papers the effect of the program on research excellence is getting weaker. We attribute this phenomenon to the fact that we only consider the first several years of the program, while high-quality research takes longer to produce and publish.

The value of the effect varies by type of publication and by year. For the total number of publications, publications in Q4 journals, and for multi-authored papers, the effect increases with each year of participation. In 2014, participating universities outperformed the general publication trend by more than 35 %, and by more than 50 % in 2016. The maximum value of the effect is observed for publications with more than 10 authors (more than 440 % in 2016). To understand how Project 5−100 affects the productivity of scientific staff, we estimate the effect on publications per capita. The effect is positive, and its value varies depending on the model specification.

We also estimated the relative growth of high-quality (Q1) publications in comparison with low-quality (Q4) output. In 2014, the Project's effect was higher for Q1 journals (43 %) than for Q4 (26 %). In the last two years, the results were reversed: the effect for Q4 journals was higher than for Q1.

This positive publication growth is observed against the background of several government programs aimed to improve university performance. These measures could have a cumulative effect on the publication activity of Russian universities. The process of creating knowledge is often complex and resource-intensive; it is difficult to differentiate the effect of one project from others. To measure the effect of Project 5−100, we assessed the publication activity of participating universities in comparison with universities from the control group in the same institutional environment.

We also show that the collaboration patterns of universities rapidly changed over the course of the project, having a qualitative impact on the general research output of universities. The analysis of affiliations shows that 5−100 universities have greatly increased the share of co-authored publications after 2012.

5−100 universities also increased the number of academics with multiple affiliations. This growth is particularly evident in Q1 output. The share of publications in Q1 journals, in which one author has only one affiliation, has dropped after 2012 in 5−100 universities. This reveals that after joining Project 5−100, universities increased the number of publications partly due to those researchers who work in different organizations outside Project 5−100. Our analysis cannot explicitly identify whether there is a collaborative effort of several Russian scientific teams or just the attracting of individual scientists from other organizations with their own research. In addition, we show that 5−100 universities increased the share of international collaboration from 33 % in 2012 to 44 % in 2016. This cooperation may take both forms, i.e. collaboration between research teams and attracting individual scientists from foreign organizations to work in 5−100 universities.

Going beyond the simple analysis of research output, one may notice that changes in collaboration patterns between institutions and in particular the dynamics of single-authored papers with several affiliations are associated with academic mobility between institutions, with strong institutions attracting productive researchers from lower-quality ones, and with productive researchers increasing the number of institutions they are affiliated with. This indirect evidence suggests that Project 5−100 significantly affected academic mobility and cooperation between institutions both within the Project and with the rest of the system. It also allows us to conclude that Project 5−100 affected the level of national cooperation and internationalization of participating institutions. Our analysis is based on institutional level data, so we do not see the affiliations of individual scientists. The issues addressed to what this collaboration is, how stable it is, as well as the extent to which such a cooperation and mobility between institutions results in actual geographical mobility, constitute important subjects for further analysis.

Our analysis explores a very interesting case: the number of affiliations in single-authored papers has increased in both groups of universities. This means that many researchers from universities under study work in several organizations at the same time. Our preliminary results show that in the project period (2013–2016) about 30 % of 5−100 single-authored papers were also affiliated with the institutes of RAS. With that, about 20 % of 5−100 single-authored papers have additional affiliation with other Russian or foreign organizations. This is a very specific type of "collaboration" between organizations which is mediated by one person. On the one hand, the costs of this collaboration are not substantial. It is cheaper to engage one researcher than the whole group. On the other hand, the transfer of knowledge between organizations via a single person is also limited. Moreover, the stability of this collaboration over time is largely determined by the decision of a single person and this collaboration might be unfair when a researcher simply adds extra affiliation for a fee with no significant involvement behind that. A high share of solo publications with many affiliations within the general collaboration activity of universities may bring some risks, such as a low return on resources and their inefficient use.

Our study has several limitations. One is related to the control group. In the control group, we included universities which at the start of the project had the closest bibliometric characteristics to the 5−100 universities, than other Russian universities. There are some other factors, which are out of the scope of our analysis, but which also contributed to the observed publication growth. These factors include university governance structure, organization culture, faculty size, disciplinary orientation, and location. Our analysis covers only the first several years of program while the long-term effects may be observed in next periods only. However, since 5 universities of the control group became the participants of the second wave of Project 5−100 in 2016, it does not allow us to extend the time frame of our study by adding a few more years. In addition, there is a global trend of publication growth (Khan et al. 2016) which should be taken into account in interpreting the results.

In order to evaluate universities' research output and collaboration we focus on the articles and reviews indexed in the WoS SCIE and SSCI databases. These databases cover the most important journals with international scope using a long-established notion of core journals, and provide excellent coverage of such journals for science and social sciences. We omit arts and humanities and non-journal publications because of the insufficient or skewed coverage of such literature in citation databases (Moed 2006 and Waltman 2016). It is important to note that our dataset does not fully cover publication output of Russian universities. The analysis of different types of universities publications (e.g. proceedings papers) and using other databases may be provided in further research.

WoS papers are a fraction of total publication output of surveyed universities, albeit the most important one. Using Russian Science Citation Index database, which contains both WoS and Scopus indexed publications (RSCI, see Moskaleva et al. 2018 for a comprehensive review), we were able to compare the share of WoS and Scopus-indexed papers for 2012−2016. Unfortunately, this database does not distinguish between WoS and Scopus in this metric. Manual collection of such data would be too burdensome due to the need of matching hundreds of thousands of RSCI papers to WoS papers. However, it is clear that both the averagemedian share and its growth is substantially higher for the treatment group, which reflects both their higher initial and acquired research capacity, and their more pronounced orientation towards international publications that are counted in international rankings and provide more international reputation.

The choice of WoS database that does not include most of the local journals leaves an interesting question open: what is the influence of Project 5−100 on the local publications of participating universities both in terms of their absolute and relative contribution to total research output? Many journals are managed by international teams andor published by entities in the jurisdictions differing from their editorial office locations. Due to the complexity of defining "local" publications, they are out of the scope of the current study. However, such analysis could become the subject of other scholarly publications on this topic.

Our findings underline the highly problematic nature of excellence initiatives based on rankings and formal scientometric assessments: there is a marked and rapid increase of publication output, including an increase in the number of papers in highly-cited and highly selective international journals. However, the scope and speed of this increase means that the majority of research leading to these papers was not prepared using 5−100 funds. Nowadays, even the publication of already prepared manuscripts can take several years, especially for top journals in some disciplines (Björk and Solomon 2013), in addition to 1–2 years needed for research design and completion. This means that Project 5−100's real success at the early stage was mostly in adding university affiliations to papers prepared elsewhere, with the help of authors with multiple affiliations. Such a specific collaboration pattern primarily aims at a quick increase of bibliometric KPIs and ranking positions (Bornmann and Bauer 2015) and is becoming more widespread as we see a rapid increase in the share of authors with multiple affiliations in the control group in the most recent year observed. Increased collaboration, which is at least partly driven by the global advent of formalized evaluation regimes (Dahler-Larsen 2015) means that it is becoming more difficult to assess individual organizations using the standard bibliometric analysis employed by funders and governments.

Collaboration per se is almost universally accepted not only as a positive and even defining trend of modern academia, but as a proxy for higher citation counts, or 'excellence' (Bornmann 2017). In this sense, the rapid increase of collaboration – both national and international – forced by blunt bibliometric or ranking KPIs can be viewed as an unintended, but beneficial consequence. Thus, the true effect of Project 5−100 on the production and research capacity of participating universities is much more complicated than can be judged by publication counts alone.

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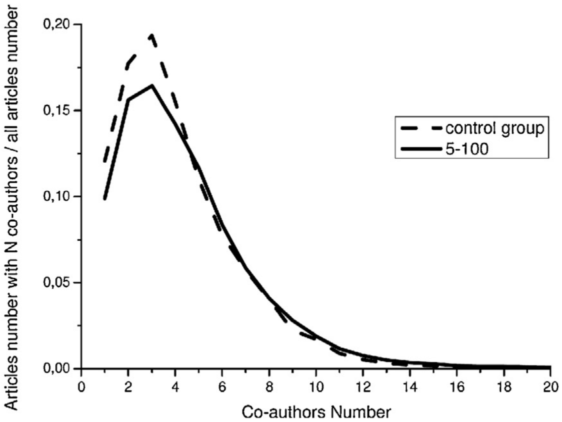
Author contributions

Nataliya Matveeva: Collected the data, Performed the analysis, Wrote the paper, Writing- Reviewing and Editing.
Ivan Sterligov.: Contributed data and analysis tools, Data curation, Wrote the paper, Writing- Reviewing and Editing.
Maria Yudkevich: Supervision, Conceptualization, Wrote the paper, Writing- Reviewing and Editing.



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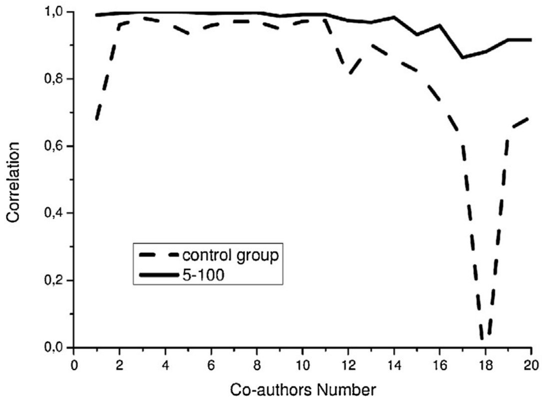

b

Fig. A1. (a) The distribution function (b) Pearson correlation of all publications and publications with certain number of authors.

Appendix A.

Fig. A1.

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