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The impact of academic inbreeding on early-career researchers' productivity

Abstract

The study explores the impact of academic inbreeding on individual researchers' productivity within the system of science and higher education, where more than half of researchers are working at the same organisations in which they prepared dissertations. Based on data about 871 early-career researchers in natural sciences and mathematics, I found that within the institutional context where internal labour markets prevails over external ones, academic inbreeding has a positive effect on individual productivity of young scientists. The lower productivity of mobile researchers is explained by the adjustment period and the necessity to change research area at the new organisations. The positive effect of academic inbreeding is peculiar to the university sector where graduates are less strongly oriented towards a pure research career, and to the peripheral regions, where the level of academic mobility is low. The study contributes to the knowledge on academic inbreeding since, first, it attempts to estimate the causal relationship between inbreeding and productivity, second, it considered not only universities, but the large sector of research organisations for the first time.

Key words: *Academic inbreeding, academic mobility, publication productivity, research discipline, early-career researchers*

JEL codes: *I2, J6, O32, O33*

1. Introduction

Academic inbreeding at the individual level is a feature of a scholars' career, when they work in the same organisation where they studied. A number of countries (e.g., USA, UK, Germany) have such conditions within their academic systems that inbreeding is at a very low level (Navarro and Rivero, 2001). In other countries (e.g., Japan, Portugal, Sweden, Russia, Mexico), the level of academic inbreeding is very high (Horta et al., 2010). While academic inbreeding is natural for early stages of academic systems development, well-developed science and higher education systems with high levels of inbreeding may be related to the country-specific cultural peculiarities, to the underdeveloped institutes of the academic labour market, which all together create special conditions for career building and may lead to inefficient human capital allocation (Horta et al., 2010; Inanc and Tuncer, 2011). The impact of academic inbreeding on individual researchers' productivity in such an environment remains unclear. Results of

studies on academic inbreeding in countries where the internal academic labour market prevails over the external one are ambiguous. While some papers reveal negative correlation (Inanc and Tuncer, 2011; Karadag and Ciftci, 2022; Lovakov et al., 2019), others suggest that inbreds can perform just as well in such environments as their mobile counterparts (Alipova and Lovakov, 2018; Cruz-Castro and Sanz-Menéndez, 2010; Yudkevich et al., 2015). Moreover, inbreds may gain an advantage over their mobile counterparts and climb the career ladder more quickly due to the social ties already built at their alma mater in institutional settings where academic inbreeding is in order and is a common practice (Cruz-Castro and Sanz-Menéndez, 2010; Klemenčič and Zgaga, 2015; Yonezawa, 2015). As well, inbreds do not have to spend time adapting to the conditions and requirements of a new organisation, which frees up their time and energy for research activities, so they become even more productive than their mobile colleagues (Bäker, 2015; Fernández-Zubieta et al., 2016; Van Heeringen and Dijkwel, 1987; Wyer and Conrad, 1984). The last reveals the detrimental effect of mobility on researchers' performance at some point and especially at the early career stages, when they are less experienced. However, the effect of academic inbreeding and institutional conditions for these effects should be specified.

In this paper, I suggest that academic inbreeding does not negatively affect individual researchers' productivity during the early career stages within a internal academic labour markets¹. Verification of this assumption will clarify the specifics of the impact of academic inbreeding on the scientific productivity of researchers who have just entered the labour market. The article is intended to shed light on the impact of academic inbreeding, not just correlation, and to explain the mechanism of this effect. Another important contribution is the empirical analysis of the academic inbreeding factors which allows us to elaborate the further impact of the phenomenon.

To test the stated assumption, this study is focused on Russia. This country has a well-developed academic system, a very high level of academic inbreeding, and very

¹ Following the Musselin (2004), I propose that an internal labour market is one where career development is more likely to take place within one organisation and is governed primarily by its rules than within several

diverse conditions for researchers. The latter refers to the division of academic organisations into two sectors with fundamentally different structures and the presence of regions in the country with either a closer or more sparse geographical arrangement of academic organisations. These factors allow us to check the effect of academic inbreeding on researchers' productivity in different conditions.

Inbreds are considered as researchers which work at the same organisations where they prepared their dissertations since these organisations are the main places where researchers are being academically socialised. Individual researchers' productivity is seen as intensity and quality of their publication activity as publications are the final product of research work. The career entry point is chosen because, first, it largely determines the future career path since at this stage researchers are gaining reputation within the academic community, second, at this point, researchers are still not too experienced to face challenges of mobility in the country where inbreeding is widespread (Laudel and Bielick, 2019; Wang et al., 2019).

The paper is focused on researchers in natural science and mathematics because the conduct of research, particularly in natural science, is a team effort that often requires expensive equipment and a large amount of funds. The individual researchers' productivity may be seen as a kind of efficiency of use of funds, which is why academic inbreeding must be investigated as a factor of scientific performance. Additionally, these fields of study are the most competitive at the international level, within academia, compared to others in Russia. I explore mathematics along with the natural sciences for a clearer explanation of academic inbreeding's effect, since mobility and productivity patterns largely depend on field-specific research practices: length of research projects, publication process, equipment requirements, career stages sequences, research groups size, competitiveness (Laudel and Bielick, 2019). At least mathematicians do not need sophisticated equipment but their colleagues in natural science - do. This may create conditions for easier mobility of mathematicians since they do not have to be dependent on any equipment. Moreover, mathematicians mostly work in single or low-size collaborations, while studies in natural science are often carried out in big scientific

groups since research procedures there are more complicated. So, it may be easier for them to move between organisations with lower adjustment costs.

The study makes use of a dataset of 871 Russian early-career researchers in natural science and mathematics who are actively publishing in international journals. The dataset contains information for inbred-career identification: organisations where theses were prepared (alma mater), researchers' affiliations and productivity indicators within the next eight years after thesis defence. The results of the study are a description of the academic inbreeding predictors, an estimation of the impact of academic inbreeding on individual researchers' productivity and the explanation why academic inbreeding influences research productivity in such a way. The results of the study are of value to the global academic community, researchers in science of science, and policy makers since they touch on issues of scientific performance' factor leading to better understanding of the knowledge production process.

2. Related literature

2.1 Factors of academic inbreeding

An academic system produces human resources both for the public and commercial sectors as well as for itself. Some academic systems' units may employ their own graduates. Accordingly, to this extent, academic inbreeding is rather natural for the academic system and it is therefore determined primarily by the specifics of the institutional context (Clark, 1995; Musselin, 2004; Whitley, 2003), but also by various factors at the organisational and individual levels.

At the institutional level, academic inbreeding may be conditioned by a wide range of factors. First of all, it accompanies almost all early-stage higher education systems, where the academic labour market consists of very few institutions (Horta and Yudkevich, 2016). Higher education institutions train researchers and employ them, as there are no other sources of highly qualified staff. However, even in developed systems, inbreeding is inherent in organisations that are geographically distant from other units of

the academic system (Bojica et al., 2022; McGee, 1960). In this situation, transport infrastructure, which provides more opportunities for geographical mobility, and attitudes towards mobility in society at large, play an important role (Yudkevich et al., 2015). So, researchers who finished their postgraduate study at organisations located far from others, have higher chances to stay at their alma mater. The mobility to the new institution may be related, for them, with high relocation costs and disruption of social and family ties. In the same way, conditions for academic inbreeding can be created if a country has a very limited number of institutions specialising in a research topic. Mobility for a researcher specialising in such a narrow topic, may be associated with the significant change in the research field, which is often undesirable since it takes a lot of effort. As well as the dependence of the researcher's academic work on the unique facilities housed at the alma mater may decrease researchers' probability of moving to another organisation. However, the more organisations in the country with the necessary equipment, the greater the likelihood of academic mobility. Additionally, the resource availability is also a critical factor since relocation often requires support (Camacho, 2001). Especially when the system is highly centralised, resources may be allocated equally between organisations. This may reduce the competition among organisations since they cannot attract the best researchers. Conversely, researchers have no incentive to change affiliation. The perception of inbreeding among members of the academic community is also important, as it determines whether the practice will be encouraged or discouraged (Bojica et al., 2022). If the academic community is positive about academic inbreeding practice, researchers who want to move may be perceived with caution by the host organisation assuming that such researchers were not good enough at their previous job (Dezhina, 2014). This may cause a lack of competition on the labour market. Lack of transparency in the recruitment system, unavailability of information on vacancies, as well as the lack of vacancies, impede academic mobility and create conditions for internal labour markets (Musselin, 2004). Most of the described factors of inbreeding at the institutional level are inherent in the Russian academic system in one way or another.

Organisational structure plays no less of a role in academic inbreeding spreading. Foremost, the practice of hiring own graduates is beneficial because it enables them to avoid search and recruitment costs, and to reduce the risks of hiring unsuitable staff (Horta et al., 2011; Simon and Warner, 1992). Then, academic inbreeding may be peculiar to prestigious universities. Such organisations almost have no competitors on the labour market. Their own graduates are limited in their choice of employer, as mobility to less elite universities is undesirable for them. At the same time, graduates from less prestigious organisations can barely meet the high requirements of elite ones (Eisenberg and Wells, 2000; Horta, 2013; Kosmulski, 2015). Academic inbreeding may also depend on the orientation of the organisation towards a predominantly educational or research function (Merritt and Reskin, 1997). This is primarily due to the fact that assessing teaching ability is more difficult than assessing research ability. While the latter can easily be reflected in the quality of publications, the former can be assessed mainly by observing the teaching staff's work with students. Therefore, heads of departments of predominantly education-focused organisations tend to favour their own graduates when recruiting, as they are likely to have already had the opportunity to observe their work (Kuzminov and Yudkevich, 2021). All of the above leads us, firstly, to control for mobility direction and organisations' level of prestige, secondly, to distinguish research and university sector assuming the significant differences in teaching loads.

Often, the future careers of young researchers are determined by the institutional and organisational environment, and only partly by personal factors. Such factors usually stay unobservable (personal motivations, professional conflicts, unexpected life circumstances, family issues, lack of sufficient personal funds to relocate etc.) but some individual factors can be taken into account. Particularly, high individual productivity makes the researcher more desirable to other organisations and more competitive on the labour market (Borjas, 1985; Ganguli, 2014; Zucker and Darby, 2002). However, if there are different mobility barriers in the system, a shortage of vacancies in the external academic labour market, or if the alma mater hasn't sufficient resources to attract external candidates, high individual productivity may be a good signal for the alma mater to keep

highly-productive young researchers in its team. As well, strong social ties, when researchers are heavily involved in the team of alma mater, may keep them there (Cruz-Castro and Sanz-Menéndez, 2010). Finally, different from the academic environment factor is that seminal responsibilities are often assigned predominantly to women, which makes them less mobile.

2.2 Effect of academic inbreeding on individual research productivity and its mechanisms

The correlation between academic inbreeding and research productivity in countries with external and internal labour markets may be diverse. In countries with external labour markets, inbreds often perform worse, since inbreeding is an undesirable practice, mobility is rewarded and perceived as a norm (Eisenberg and Wells, 2000; Hargens and Farr, 1973; Payumo et al., 2018). Conversely, countries with internal labour markets, in some cases, show a positive or neutral relationship between academic inbreeding and research productivity (Alipova and Lovakov, 2018; Cruz-Castro and Sanz-Menéndez, 2010; Klemenčič and Zgaga, 2015; Sivak and Yudkevich, 2015; Tavares et al., 2019), and a negative impact of mobility on performance (Abramo et al., 2022; Aksnes et al., 2013). Herewith, others do find a negative correlation between inbreeding and productivity in countries with internal academic labour market in general (e.g. Inanc and Tuncer, 2011), and some of such studies note that it is inherent to researchers on the later career stages, thus indicating the cumulative effect of inbreeding (Lovakov et al., 2019; Yonezawa, 2015). McGee (1960) and Wyer and Conrad (1984) found a positive correlation between inbreeding and productivity on data about American researchers, however, these studies were conducted many years ago, when the American academic system was less developed than it is today. Thus, within the system with internal labour markets, academic inbreeding may have positive or no effect since it is in the norm.

Mechanisms of a negative relationship between academic inbreeding and research performance are described more often in the literature than mechanisms of a positive correlation since the phenomenon is considered rather unfavourable, and the negative

relationship is a bit more common. The negative correlation between inbreeding and research performance may be due to a number of reasons. The socialisation process of the young inbred researchers after completing a degree takes place in a narrower circle for them, which can lead to assimilation of norms, reduced flexibility of thought and intellectual stagnation (Horta, 2013; Morichika and Shibayama, 2015). Staying at the alma mater, the scientists work and generate knowledge in the same environment in which they obtained it (McNeely, 1932; Pelz and Andrews, 1966; Yamanoi, 2005), respectively, the lack of diverse experiences may contribute to reduced flexibility of thought, limited information exchange, inbreds may be less able to interact with colleagues from other organizations (Gonzalez-Brambila, 2014; Horta et al., 2010; Lovakov et al., 2019; Tavares et al., 2021). All this, in turn, may hinder the innovativeness and value of research by inbreds (Mazzoleni et al., 2021).

There are only a few studies which found positive correlation. McGee (1960) found a positive correlation between academic inbreeding and individual researchers' productivity at the University of Texas and attributed this result to the university's distance from other academic organisations. Wyer and Conrad (1984) found that inbreds published more papers than mobile researchers and explained this to the time and effort that mobile researchers have to spend adjusting, causing them to be less productive. Some studies found a short-term decrease in productivity right after mobility (Bäker, 2015; Fernández-Zubieta et al., 2016; Van Heeringen and Dijkwel, 1987). These authors also tend to explain this consequence by the adjustment period. While mechanisms of the negative correlation between inbreeding and productivity are related to issues of stagnation of human and social capital, the positive correlation is about the temporary loss in human and social capital.

In the short term, inbreds may gain an advantage over their mobile colleagues. By remaining at their alma mater, researchers can avoid moving to institutions with worse conditions, as is the case with prestigious universities (Azoulay et al., 2017; Berelson, 1961; Eisenberg and Wells, 2000), and thus maintain their level of productivity. Inbreds may gain an advantage over their mobile counterparts and move up the career ladder

more quickly due to the social ties already built at their alma mater in an institutional setting where academic inbreeding is in order and is a widespread practice (Cruz-Castro and Sanz-Menéndez, 2010). Another mechanism for the positive impact of academic inbreeding on researchers' productivity is that inbreds do not have to spend time and effort adapting to a new work environment and a new team, instead continuing to build their productivity (Fernández-Zubieta et al., 2016; Wyer and Conrad, 1984). Moving to another organisation may be associated with interrupting social ties with colleagues from a previous institution and loss of access to resources of the previous organisation (Groysberg and Lee, 2009; Morichika and Shibayama, 2015). Moreover, changing affiliation is related to the necessity to get used to new bureaucratic procedures, to study new research methods and approaches, and, probably, to change the research field to some extent. Notably, Morichika and Shibayama (2015) found that inbred scientists change research subjects less frequently than their mobile counterparts. Regarding research performance this may require some time to gain new knowledge relevant to new affiliation. Changing research directions may also reduce mobile scientists' probability of getting new scholarships since they do not have sufficient background in the new field. In the long-run perspective it may stifle creativity (Mazzoleni et al., 2021), but in the short-term period changing fields may negatively affect productivity (Bäker, 2015). Early-career researchers may not be experienced enough to handle the adaptation period easily. The lack of career interruption associated with transferring to another organisation is particularly important in the early stages of a career when young researchers are just beginning to earn recognition from the academic community.

3. Institutional context

The Russian academic labour market is considered closed, as the internal recruitment market often prevails over the external one. This is due to a number of reasons. Firstly, there is virtually no tenure system in Russian academia. The vast majority of academic staff have fixed-term employment contracts, concluded for a period

of one to five years, after which they must undergo a competitive selection process for the position, often being the only candidates (Altbach et al., 2015; Kuzminov and Yudkevich, 2021). If an academic staff member meets the selection criteria each time, they can renew the employment contract indefinitely and work at the same institution for the rest of their working life. In other words, the level of competition in recruitment is quite low. In addition to this, recently graduated PhD candidates often start their career at their alma mater and stay there for a long time (Alipova and Lovakov, 2018). The high level of academic inbreeding is also partly a legacy of Soviet times. In the USSR, it was considered very prestigious for graduates to be employed in their own universities (Kuzminov and Yudkevich, 2007). Since then, academic inbreeding has continued to be perceived by the Russian academic community as the norm (Sivak and Yudkevich, 2015). Additionally, there was a massive reduction in teaching and research staff after 2012. The reduction was more characterised for universities rather than research organisations (Bondarenko et al., 2022; Vlasova et al., 2023). So, it was hard for young researchers to find vacancies in universities. The third reason is the low level of geographical mobility of the population (Abylkalikov, 2015). Due to the large size of the country, recruitment of external candidates may be difficult for academic organisations located in the periphery. It can be quite difficult for academics themselves to move to another city due to the high costs of relocation, and academic organisations rarely have sufficient resources to support their relocation. In addition, the geographical peculiarity of Russia is that a lot of academic organisations are located in the central part of the country and concentrated around two major cities, namely Moscow and St Petersburg (Dyachenko and Kocemir, 2018). Researchers who graduated in central regions have a bigger choice and greater availability of employers since they are located closer to each other and transport accessibility is better than in peripheral regions. Therefore, mobility levels are higher in the central regions and the labour market there is more competitive.

The next important feature of the Russian academic labour market is its division between two major sectors: the university sector and the research sector. The latter is represented by units of the Russian Academy of Sciences (RAS) and other research

institutes, while the university sector is represented by universities and other higher education organisations. The research sector organisations are mainly engaged in research activities and some of them have the right to train postgraduate students. University sector organisations are mainly engaged in teaching activities, and the most competitive of them (leading universities) receive extended sources for research activities (federal and national research universities, universities participating in excellence initiatives, Moscow State University and Saint-Petersburg University). Research and university sector organisations have different infrastructure and access to financial resources (Mindeli and Lushchekina, 2018). A possible consequence of this is the differences between the two sectors in the selection of potential PhD students and their training. Researchers which were prepared at research sector organisations, may have stronger motivation to do research, while researchers from universities may be more often oriented on teaching career, administrative career, or even career outside academic labour market. Another possible difference between the sectors is the degree of focus of young researchers on research activities and their research outputs. Different organisations have different quality requirements for the publication activity of their researchers. Researchers may respond to these requirements in different ways, which also depends on the prestige of the academic organisation. In some academic institutions it is sufficient to publish a few papers in any peer-reviewed journals to receive a promotion or award, while other institutions only require publications in journals that meet certain criteria (e.g. impact factor, quartile, indexing in databases). Thus, research outputs and the range of opportunities to build an academic career depend in part on the researcher's focus on quality outputs and on the requirements of the employer.

4. Data and methods

4.1. Data

The sample was based on researchers who defended their PhD theses at Russian dissertation councils in mathematics, physics, biology, and chemistry in 2012. I use 2012

as the year of the PhD defence for the following three reasons. First, the eight-year period (2012 to 2020) from the time of the dissertation corresponds to the definition of the initial stage of a career (Kweik and Roszka, 2022) and is generally sufficient for the accumulation of publications, allowing us to trace the trajectories of researchers' academic mobility. Second, in 2013 there were significant changes in the requirements for PhD candidates; the requirements went into effect in September, prompting many young researchers to rush to defend their PhDs before these changes, hence this may skew the sample. Third, PhD dissertation announcements for the years prior to 2012 are archived in the data source and are not available without special queries.

The website of the Higher Attestation Commission (VAK) became the main data source. Since every defence of a PhD thesis must be announced on a mandatory basis, it can be assumed that this data source covers all defences of PhD dissertations for a particular year, hence, the sample is not biased. In addition, this source allows us to obtain data on the place of preparation and the place of defence of the dissertation, which is fundamentally important for the study of inbreeding. However, the VAK website does not provide data on the academic mobility of researchers, so the second source of data was the bibliometric database Scopus.

A total of 2102 PhD dissertation abstracts of researchers have been collected from the VAK website. Of these, only 871 researchers actively published their papers in publications indexed in Scopus in 2018-2020; the year of their first publication in the database was no earlier than 2001, and their main affiliations were Russian and belonged to the academic sector. The year of researchers' last publication in Scopus was limited to 2020, as the data were collected in mid-2021. I made it mandatory to have a publication between 2018 and 2020 in order to evaluate researchers who had not left their academic careers and were still conducting research. I excluded scientists whose first publication in Scopus was in 2001 or earlier because they probably started their research career too long ago and do not fit the definition of early-career researchers. The choice of 2002 or later for the first publication is due to the fact that in some cases students may have started publishing papers as early as their first years of study, that is, 8-10 years before their PhD

thesis. I did not include scholars who transferred to foreign institutions in order to assess the effect of academic inbreeding precisely in the Russian context. The assessment of the effect of academic inbreeding on scientific productivity carried out in this study is valid only for 41% of the researchers who defended their dissertations in 2012 in the natural sciences and mathematics. For general understanding, I note that 11% of the PhD candidates who received their degree in this year left for the non-academic labour market, 5% left for foreign academic organisations, 22% remain out of the research focus because there is no freely available information about their current employment and publication activity, and 21% of researchers in 2018-2020 continued to publish research in Russian journals not indexed by international databases (Figure 1).

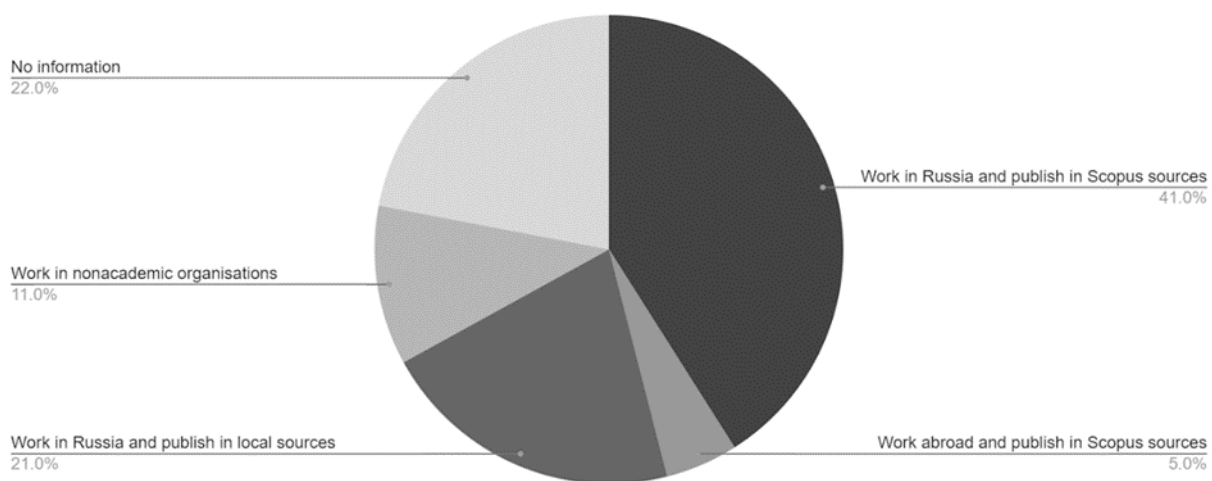


Figure 1 - Share of researchers who defended their thesis in 2012 in natural science and mathematics, their employment and publication activity (N=2102)

4.2. Variables

The main constructs of this study are academic inbreeding and individual academic productivity of researchers.

The following algorithm was used to determine researchers' mobility and immobility. First, the affiliation identifiers in Scopus of the researchers' alma mater (the organisation where they prepared their PhD thesis) were extracted. They were then

compared with the names of organisations from PhD thesis abstracts with its affiliation identifier in Scopus via the Russian Index of Scientific organisations (Sterligov and Lutay, 2021). Next, the affiliation identifiers specified in each publication indexed in Scopus, of each researcher, were extracted. The next step was to determine the baseline affiliation of the researcher in each year in which he/she has publications. To do this, I followed the algorithm described in Guskov et al. (2021), where baseline affiliation is defined as the most frequent affiliation in articles in a single year. I also defined baseline affiliation as the one most frequently encountered in a particular year. If a researcher had, for example, 2 publications with affiliation "A" and 2 publications with affiliation "B" in the same year, I manually checked such situations and selected that affiliation as the baseline if it was also the baseline in the previous and/or next period of publication activity. I then matched each year's baseline affiliation with the affiliation of the alma mater and identified years when the researchers worked at the same organisation where they wrote their dissertations and when they changed affiliations.

In general, this method of mobility identification is reliable (Kryachko, 2021), however, it has two important limitations. First, the publishing process may take a long time. For example, a study might be conducted in a year n and a paper on this study may be published in a year $n+1$. Thus, the affiliation in this paper reflects the affiliation where a researcher worked in the previous year. Second, if a researcher did not have any publication in the year n we cannot be sure about his or her employment in such year. Probably, he or she was unemployed. In the situation when such a year without publication occurs before the year when we observe new affiliation, it is not possible to say with certainty whether the researcher in the year without publications was still working for the previous organisation or already working for the new one.

Several different indicators are used to assess the scientific productivity of researchers. First, the intensity of researchers' productivity is studied through the total number of publications after the defence. All type of publications are included in the analysis. Second, the quality of publication activity is assessed through indicators such as:

1) Number of publications in the top 5% of journals (according to SCImago Journal Rank). This indicator shows researchers' ability to get into top journals and conduct research that meets the highest global standards.

2) Number of publications in the top 5% of most cited journals. This indicator means the researcher's work is very important to the global academic community,

3) Field Weighted Citation Impact (FWCI) The indicator of the significance of the researcher's publications within their field.

4) Total citations which are an overall measure of research impact.

5) H-index. The indicator of publication activity and influence at the same time.

The use of the first two indicators allows to determine the impact of inbreeding on researchers with the highest performance. The third and the fourth indicators will reflect the effect of inbreeding on the impact of researchers' work on academic community. Using several indicators, I try to understand, first, which cohort of researchers is more affected by inbreeding (highly productive researchers or researchers with the medium performance), second, I intend to divide the effect on quality and intensity of researchers' performance.

4.3. Descriptive statistics

The total level of academic inbreeding among early career researchers, who are visible to the international academic community and work at Russian academic organisations, is 62%. This number differs for researchers in different fields of study (Figure 1). The lowest share of inbreeds is among mathematicians (34%), the highest - among physicists and chemists (68%). Scientists who prepared their theses at organisations of the research sector stay in alma mater much more often than their colleagues from the university sector. As expected, the level of academic inbreeding is a bit higher among researchers who prepared their theses outside of central regions. There are no differences in inbreeding level between male and female researchers. Inbreeds publish all their works before defence in co-authorship with research supervisor more often than their mobile colleagues (44 and 33% respectively). 41% of mobile researchers

moved to organisations with higher productivity than their alma mater and 51% of mobile researchers moved to organisations with lower productivity.

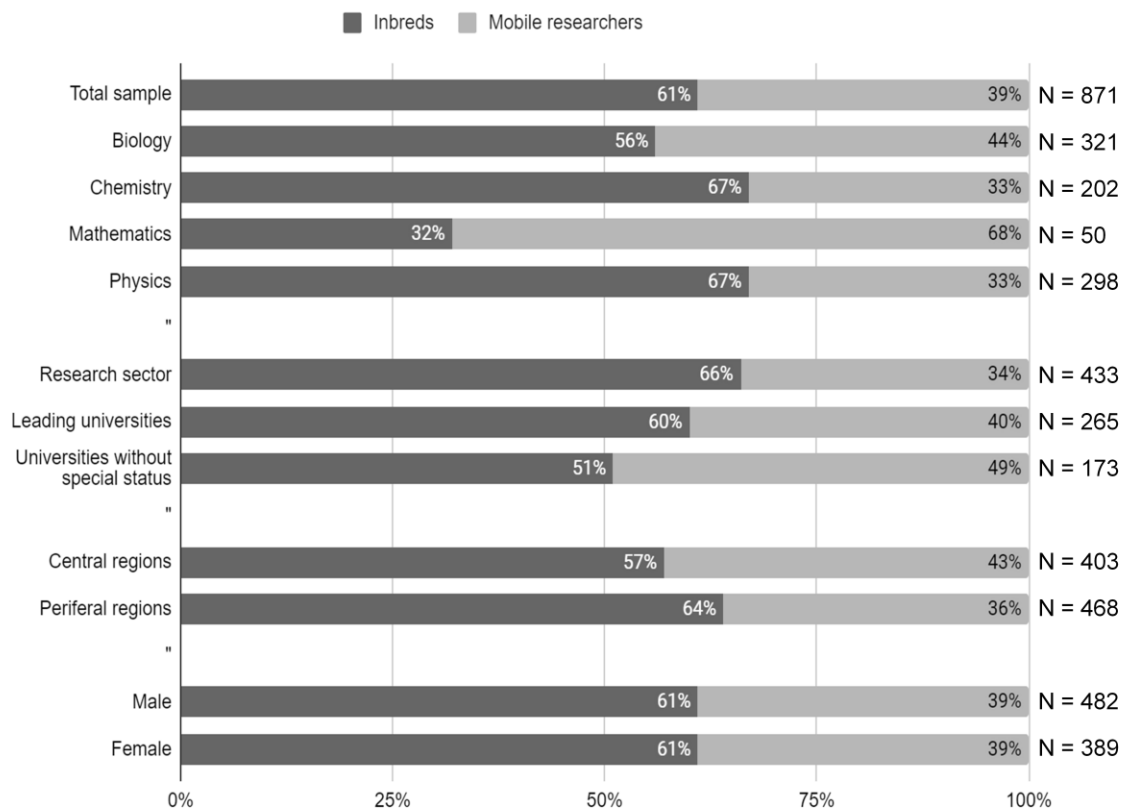


Figure 2 – Share of inbreds and mobile researchers by fields of study, sector, regions, gender, and others variables

The descriptive statistics for the productivity variables and some other control variables are in Table 1.

Table 1 – Descriptive statistics for characteristics in the pre-defence period and for productivity variables

	Variable	Inbreds				Mobile researchers			
		Mean	SD	Min	Max	Mean	SD	Min	Max
Characteristics before defence	Number of publications before defence	4.36	4.33	0	29	3.40	3.42	0	22
	Share of publications in co-authorship with supervisor	0.62	0.43	0	1	0.45	0.45	0	1

Productivity 8 years after defence	Number of publications after defence	18.53	19.95	1	118	15.03	15.86	1	95
	Number of citations of publications after defence	96.89	134.26	0	671	72.17	105.48	0	628
	Researcher's H-index	5.95	4.62	0	24	4.78	3.56	0	23
	Field Weighted Citation Index	0.545	0.446	0	2.96	0.509	0.493	0	3.99
	Number of publications in top 5% journals by SJR	1.15	2.72	0	20	1.01	2.77	0	22

In this study I also control for the direction of mobility for mobile researchers, presence of multiple affiliations, and match of the place where their dissertation was prepared and the place where it was defended². There are 76% of inbreds and 66% of mobile researchers who defended their theses at the same organisation as they prepared them. In the sample of mobile researchers, 43% moved to organisations with a higher productivity than the productivity of their alma-mater. Organisational productivity was measured by the composite score of publication performance (CSPP) which was calculated in the Russian Science Citation Index system base. Since the indicator has a large variation in values, I use its logarithm.

4.4. Methods of Empirical Analysis

Inverse Probability Treatment Weighting (IPTW) is used to assess the impact of academic inbreeding on the individual scientific productivity of researchers. The basic idea is to compare the productivity of researchers from two groups (in our case inbred and mobile groups), comparing researchers who are more similar to each other in a number of characteristics and, accordingly, receive approximately the same score. The mechanism of IPTW is that observations with extremely high scores are given significantly higher or lower weights. This method helps to preserve the sample size and avoid bias in the distributions of the matched and original samples. In addition to avoiding the self-selection problem by comparing observations with similar characteristics in the two groups, the method also solves the endogeneity problem

² In Russia, there is no requirement to defend the thesis at the organisation where it was prepared. Also, some academic organisations have the right to train postgraduates, but do not have their own dissertation councils. So, their graduates have to defend theses at different organisations.

because it creates a pseudo population through additional score weighting (Desai and Franklin, 2019).

The IPTW method is implemented in two steps. First, a model is estimated that predicts the likelihood of continuing a career at the alma mater or transferring to another organisation, based on the characteristics of the researcher in the period before the dissertation. In the second step, based on the calculated model, weighted scores are assigned to each researcher in the sample, and then the productivity of inbred and mobile researchers with the same score for the first eight years of their career in academia is compared. The scheme of the method is represented in Figure 3.

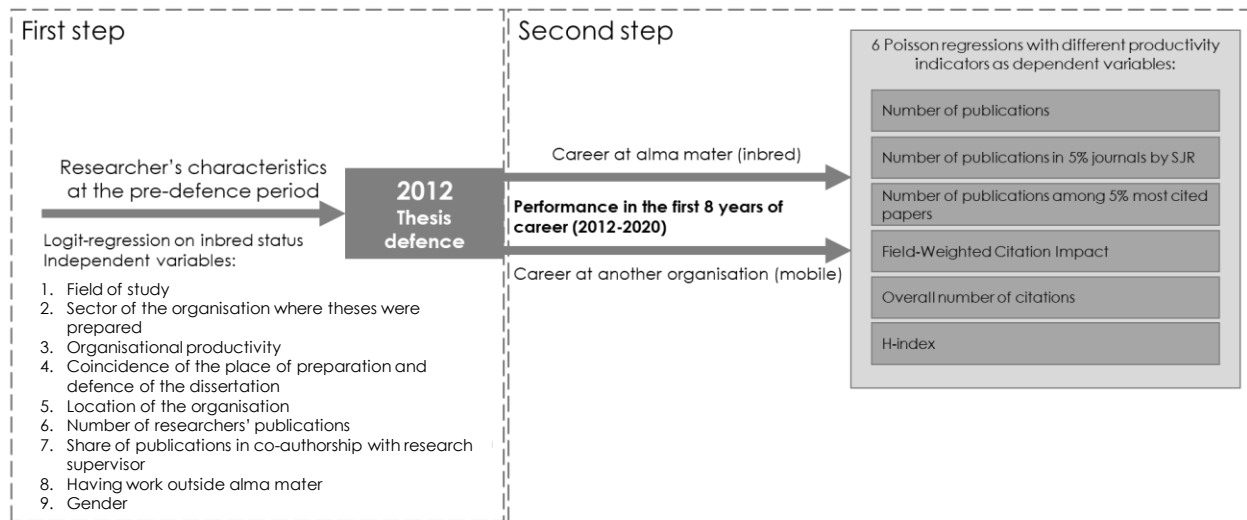


Figure 3 – Schematic representation of the IPTW method for the study on academic inbreeding

To implement the IPTW method, a logit regression is estimated in the first step (Equation 1). The choice between logit and probit models was made on the basis of the Akaike information criterion.

$$P(Y=1|X) = \frac{\exp(X_i\beta_j)}{\Sigma(\exp(X_i\beta_j))} \quad (1)$$

where the dependent variable Y is the binary variable of the inbreeding status of the researcher, and the independent variables X are a number of characteristics of researchers in the pre-diploma period, which can be considered as determinants of the future career trajectory. As such determinants, I consider:

1) Fields of study (mathematics researchers, unlike researchers in biology, chemistry, and physics, are less dependent on sophisticated equipment to conduct research, which in turn may enhance their opportunities for academic mobility);

2) Organisational productivity of the alma mater as measured by the quartile among all Russian organisations by their output in Scopus database in 2010-2020 years (suggesting that researchers who have completed their dissertations at the most "strong" organisations have fewer opportunities for mobility, as it is not desirable for them to move to less productive organisations (Azoulay et al., 2017);

3) Location of the alma mater in central regions (in Russia, the concentration of research and higher education organisations is higher in central regions; accordingly, researchers who have prepared their dissertations there find it easier to move to another employer, since they will not have to move far to change a job);

4) Coincidence of the place of preparation and defence of the dissertation (first, not all scientific organisations in Russia have their own dissertation councils, and second, applicants are not obliged to defend the dissertation in the place where they prepared it, so the places of preparation and defence of the dissertation may not coincide. Similar to the previous variable, experience interacting with different organisations during the dissertation defence process can potentially increase the likelihood of academic mobility);

5) Gender of the researcher (women are thought to be less mobile because they tend to be more burdened by family responsibilities (Leemann, 2010; Ryazanova and McNamara, 2019) and there may be discrimination against women in the labour market, and not all employers are willing to hire them due to the fact that women are the ones who go on maternity leave more often than men);

6) Share of publications written in co-authorship with the scientific supervisor in the period before the defence (active interaction with the scientific supervisor in the period before the defence can indicate a high involvement of the researcher in the scientific team of the alma mater, as a result of which the researcher has increased opportunities for career development in the alma mater and after the thesis defence).

7) Number of publications in the period before the defence (on the one hand, the alma mater may be interested in retaining more productive researchers, so the most productive ones will have a better chance of becoming inbred, on the other hand, they will also be more competitive in the external academic labour market, which increases their opportunities for mobility. Depending on the prestige of the alma mater and the developed network of organisations in the sciences, the productivity of the researcher in the period before the defence can have different effects on the further career trajectory);

8) Sector of organisations (organisations in different sectors may have different resources for research, hence this may provide different levels of research training and different opportunities to pursue a research career; there may be different motivations for graduate students in research organisations and in universities (in the latter graduate students may be more interested in building a career as a teacher rather than a researcher), in addition, supervisors who make the decision to hire a researcher may often be guided not only by the achievements of the applicant, but also by the institution where he or she studied/prepared the dissertation (Crane, 1970).

9) Binary variable indicated that a researcher was working at organisation different from the alma mater in the period before defence (the variable is based on affiliations in pre-defence publications, it is biased relatively those researchers, who did not publish papers in Scopus indexed journals before defence since).

In the second step, a baseline of the average effect of inbreeding using the IPTW is estimated (Horvitz and Thompson, 1952) (equation 2).

$$\hat{\tau} = \frac{1}{n} \sum_i \frac{1(t_i = 1)y_i}{\hat{e}(w_i)} - \frac{1(t_i = 0)y_i}{1 - \hat{e}(w_i)} \quad (2)$$

where $e(W)$ is the score model, y is the dependent variable, t is the group indicator (inbreds and mobiles), n is the number of observations. The distribution of the dependent variable productivity is non-normal and shifted to the left, so this method uses Poisson regression for the final estimation of the effect of inbreeding, which takes into account this feature. Several productivity measures, described above in the "Variables" section, are used as the dependent variable of productivity; accordingly, six separate models are calculated, each using a different productivity measure as dependent variable. A comparison of the productivity of researchers from the two groups will be an estimate of the degree of influence of inbreeding on scientific productivity. The Poisson regression model includes the following factor variables that are important in analysing scientific productivity:

- 1) Field of science;
- 2) Number of publications in the pre-defence period as very approximate measure of researcher's abilities;
- 3) H-index of the supervisor (in the dissertation process, the supervisor plays a key role in translating the quality standards of the research, accordingly, it is suggested that more productive supervisors are likely to produce more productive researchers);
- 4) Predominant type of collaboration as proxy of social ties' structure of a researcher (it is suggested here that the more diversified ties contribute more to researchers productivity; institutional, national, international, and single types of collaboration are considered).
- 5) Upward mobility (in other words, moving to an organisation with higher productivity: new higher quality standards can stimulate the publication activity of the mobile researcher);
- 6) Gender.

The sample for this method is 871 researchers who defended PhD theses in Russian dissertations in 2012 in biology, chemistry, mathematics and physics, who have

publications in Scopus-indexed sources in 2018-2020, and whose base affiliations belong to Russian science and higher education organisations.

4.5 Changing research field

In order to check whether researchers change the research field of their study after mobility, I define the subject area of each researchers' article using Scopus All Science Journal Classification (ASJC). ASJC Code contains four numbers where the first two numbers are related to enlarged areas (e.g. Agricultural and Biological Sciences or Arts and Humanities), the second two numbers are related to particular discipline within each enlarged area (e.g. Forestry, Insect Science in Agricultural and Biological Sciences and History, Music in Arts and Humanities). I identified the two most common enlarged subject areas before and after the mobility event and matched them. For inbred researchers changing research area was counted as difference between areas within the first period (2013-2016) and second period (2017-2020). If at least one area before and after their move coincides, I conclude that researchers did not change their research field significantly, and if both areas before and after move do not coincide, they did.

5. Results

5.1. Factors of academic inbreeding

The implementation of the Inverse Probability Weighting method consists of two steps. The first one allows to estimate the characteristics predetermining the career of a researcher as an inbred, and the second stage is to compare the productivity of mobile researchers and inbreds who are the most similar in their main characteristics in the pre-defence period.

According to the results of the logit regression, which are presented in Table 2 (column 1), the probability of continuing a career at the alma mater decreases by almost 30% if the researcher did not work at organisation where he or she completed dissertation before defence. This factor is statistically significant for researchers in all groups. The greater the proportion of publications the researcher co-authored with the supervisor in

the period prior to the defence, the more likely he or she is to remain employed at his or her alma mater. This factor also statistically significant for researchers in all groups except for female researchers. In addition, it is clear from the results that because a dissertation was completed at an organisation located in the central regions decreases the likelihood of remaining at the alma mater. Compared to mathematicians, the probability of becoming inbred is, on average, higher among science researchers, which can be explained by the fact that the level of inbreeding is significantly higher among them. The other variables included in the model were statistically insignificant.

In order to better understand the factors of academic inbreeding, the logit regression was calculated separately for central and peripheral regions, as well as separately for researchers from organisations of the research and university sectors, and for researchers of different gender. The marginal effects of these logit regressions are also presented in Table 2 (columns 2-7).

Thus, in peripheral regions, the only factor that predetermines an inbreeding career is the share of publications co-authored with a research supervisor. Preparation of a thesis at universities without special status decreases the probability of inbreeding. Outside the central regions, the probability of becoming an inbred is the same for researchers from any field of study. Meanwhile, researchers who prepared their dissertations at organisations in the central regions are more likely to continue their careers at their alma mater if they a) do research in the natural sciences, b) defend their dissertations in the same place where they prepared them, and c) if their publications include a high proportion of papers co-authored with an academic supervisor. Male researchers have lower probability to stay at alma mater in central regions.

Table 2 – Marginal effects of the logit-regression which estimates the impact of researchers’ pre-defence characteristics on the inbreeding status (standard errors in brackets)

	Total sample	Central regions	Peripheral regions	Research sector	University sector	Male	Female
	1	2	3	4	5	6	7
Mathematics (base)							
Biology	0.160** (0.079)	0.340*** (0.115)	-0.031 (0.104)	0.111 (0.280)	0.132 (0.087)	0.222** (0.104)	0.062 (0.106)
Chemistry	0.186*** (0.081)	0.338*** (0.114)	-0.005 (0.111)	0.096 (0.282)	0.223** (0.090)	0.196** (0.105)	0.170 (0.111)
Physics	0.229*** (0.078)	0.462*** (0.108)	-0.019 (0.106)	0.088 (0.279)	0.294*** (0.083)	0.250*** (0.097)	0.161 (0.114)
Central regions = 1	-0.114*** (0.035)			-0.147*** (0.045)	-0.067 (0.054)	-0.128*** (0.046)	-0.103* (0.053)
Research sector (base)							
Universities without special status	-0.068 (0.048)	0.011 (0.088)	-0.099* (0.054)			-0.039 (0.059)	-0.099 (0.073)
Leading universities	-0.050 (0.042)	-0.041 (0.062)	-0.041 (0.057)			0.039 (0.056)	-0.169*** (0.061)
Male = 1	-0.055 (0.034)	-0.084* (0.051)	-0.026 (0.047)	-0.095** (0.047)	-0.019 (0.048)		
Dissertation was defended at the alma-mater	0.076 (0.040)	0.119* (0.065)	0.061 (0.047)	0.125** (0.055)	0.021 (0.059)	0.048 (0.053)	0.106* (0.055)
Logarithm of alma mater’s CSPP	0.007 (0.012)	0.011 (0.018)	0.005 (0.017)	0.019 (0.016)	0.004 (0.016)	0.011 (0.018)	0.009 (0.017)
Number of publications before defence	0.008 (0.005)	0.09 (0.006)	0.004 (0.007)	0.016*** (0.006)	-0.003 (0.007)	0.011* (0.006)	0.002 (0.009)
Working outside alma mater before defence	-0.308*** (0.049)	-0.314*** (0.068)	-0.276*** (0.057)	-0.306*** (0.081)	-0.299*** (0.062)	-0.319*** (0.055)	-0.210*** (0.073)
Share of publications in co-authorship with supervisor	0.120*** (0.037)	0.103* (0.056)	0.145*** (0.052)	0.107** (0.052)	0.114** (0.054)	0.191*** (0.046)	0.030 (0.063)
N	842 ³	390	452	417	425	464	378

*** $p < .01$, ** $p < .05$, * $p < .1$

³ Outliers are excluded from the analysis

There are also differences in the factors of academic inbreeding among researchers who prepared their dissertations in organisations of the research and university sectors⁴. Scientists from the research sector have higher probability to leave alma mater in central regions, while the location of alma mater does not matter for researchers graduated from university sector. The number of publications during the period before the defence and the defence being conducted at the place of the thesis preparation have a positive influence on academic inbreeding among scientists from the research sector.

Female researchers tend to leave alma mater more often if they prepared their dissertations at leading universities. Number of publications and share of publication in co-authorship with research supervisor are not statistically significant factors of inbreeding for female researchers, while for male scientists - are.

According to the results of the evaluation of the logit-model, inbreeding is not peculiar to territories with a high concentration of academic organisations and good transport infrastructure (central regions). The experience of work at the alma mater and even more collaboration with a research supervisor contribute greatly to the likelihood of being inbred. Researchers' productivity in the pre-defence period has a very weak positive effect on academic inbreeding only among male scientists and those who prepared theses at the research sector.

5.2 The impact of academic inbreeding on individual researchers' productivity

Next, based on the results of the logit regression constructed for the entire sample, the inbreds and non-inbreds who are most similar in characteristics in the period before the thesis defence were determined. Poisson regression was used to calculate the difference in their productivity. Several regressions with different dependent variables describing different aspects of academic productivity were calculated. The average effect of academic inbreeding for different measures of productivity is presented in Table 3.

⁴ I count regressions separately for the research and university sector. I did not count regressions for researchers from universities without special status and leading universities separately since in this case the sample sizes for each regression is too small and the regression is insignificant.

Table 3 - Average effect of academic inbreeding on researchers' productivity by regions, organisations sectors and gender

Group of researchers	Average effect of academic inbreeding													
	Total sample		Central regions		Peripheral regions		Research sector		University sector		Male		Female	
Dependent variable	ATE	Mean	ATE	Mean	ATE	Mean	ATE	Mean	ATE	Mean	ATE	Mean	ATE	Mean
Number of publications	3.01**	14.83	1.17	15.97	6.44***	12.30	3.06	14.88	3.83**	14.34	5.27***	16.06	1.48	12.69
Citation count	14.42	72.73	3.14	91.12	23.63**	58.04	16.95	77.49	11.25	67.54	26.56**	72.61	-7.62	80.98
H-index	0.619**	5.01	0.247	5.83	0.949***	4.34	0.394	5.73	0.740**	4.34	0.835**	5.35	0.199	4.78
Field-weighted citation impact	0.051	0.484	0.71	0.504	0.040	0.465	0.074	0.472	0.041	0.481	0.030	0.543	0.046	0.443
Number of publications in 5% journals by SJR	0.128	0.686	-0.094	1.01	-	-	-	-	0.161	0.603	-	-	-0.750	1.23
N	842		390		452		417		425		464		378	

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

I found a positive statistically significant effect of academic inbreeding on the publication activity and H-index of Russian researchers from natural sciences. There are no statistically significant differences in citation rate, field-weighted citation index, and number of publications in 5% journals by SJR between mobile researchers and inbreds. Thus, academic inbreeding contributes to researchers producing more publications.

However, if to go deeper into the analysis of the impact of academic inbreeding on scientific productivity in the context of different groups of researchers, it can be found that inbreeding has a positive effect on the productivity of researchers mostly for researchers from peripheral regions, as well affecting the impact of their publications. In turn, inbreds in central regions do not differ from their mobile colleagues. Inbred-researchers graduated from university sector have higher intensiveness of their publication activity and higher H-index. Inbreds from research sector do not perform better than mobile scientists. Academic inbreeding also has no effect on productivity of female researchers, while male researchers benefit from immobile career. Generally, academic inbreeding positively affects quantitative productivity indicators.

In central regions with higher levels of competition, academic organisations hire their graduates mainly if they are productive enough. Subsequently, under the conditions of higher competition, there are almost no differences in the level of publication activity between inbred and mobile researchers, with inbreds producing more in-demand papers within their narrow topic. In peripheral regions, with a lower level of competition, inbred researchers become those who are more involved in the team of their alma mater, and subsequently their productivity is significantly higher than that of mobile researchers, both in terms of quantitative and qualitative indicators. As for the different sectors, in the research sector, academic inbreeding has no effect on the individual publication activity of scientists. In universities, on the contrary, inbreds are much more productive compared to their mobile counterparts. Moreover, an important result is also that academic inbreeding has no effect on the productivity of mathematicians, among whom the level of academic mobility is significantly higher than among natural scientists. The possible

mechanisms of such a positive effect of academic inbreeding on scientific productivity will be discussed in the next part of the results.

5.3 Why academic inbreeding positively influences individual researchers' productivity?

The short answer to the question on the explanation of the effect of academic inbreeding on researchers' performance is adjustment period. Next, I will show why it is the adjustment period that explains the positive effect.

It can take a long time to produce high-quality research that can be accepted by an internationally peer-reviewed journal. When researchers move to new organisations they often have to interrupt previous projects and start new ones. Thus, papers with a new affiliation may be published after some break, especially when a researcher had to change a research topic to some extent at the new job.

Mobile researchers more frequently have years without publications than inbreeds, especially in the first four years after defence. The years without publications or with fewer publications by mobile researchers often occur in the period immediately before the transition to another organisation. The results of the regression analysis of the number of publications in the years prior to changing affiliation in comparison to the productivity of full inbreeds, show a significant decrease in the level of publication activity one year before moving to another organisation (Table 5). The number of publications in the two years prior to transition does not determine the probability of mobility, while the number of publications in the three years prior to transition is positively correlated with the probability of mobility.

Table 5 - Results of the logit regression of the number of publications in the years prior to transition on the fact of mobility (marginal effects)

	Mobility event
1 year before mobility	-0.063 (0.012)***
2 years before mobility	-0.002 (0.012)
3 years before mobility	0.024 (0.013)*
Mathematics (basic)	0
Biology	-0.087 (0.044)**

Chemistry	0.085 (0.085)
Physics	-0.078 (0.043)*
Research sector (basic)	0
Universities without special status	0.054 (0.043)
Leading universities	0.065 (0.041)
Male = 1	0.022 (0.035)
N	668 ⁵

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Regressions for different groups were not calculated because the groups of mobile researchers are too small in this case, but the differences between groups are shown on the Figure 4. The figure presents the average level of publication activity of researchers in the period before and after the transition to a new organisation, where 0 is the year when new affiliation was identified. The peak of publication activity at the moment of transition is related to the limitation of bibliometric data: the fact of moving to another organisation can be recorded only by the years in which one or more publications with a new affiliation are observed. Accordingly, in year zero, when mobility was recorded each mobile researcher had at least one publication. It is obvious that researchers on average have decreased their publication activity in the year before moving. This is inherent to researchers from the research sector. However, researchers who prepared their dissertation at universities have a slightly bigger decrease in productivity in the year after mobility than their colleagues from research organisations. Male researchers and researchers which finished PhD in central regions, have quite sharp decrease of their activity in the years before and after mobility.

⁵ The sample includes inbreds and only those mobile researchers who changed affiliation in 2015-2018 inclusive in order to observe years before and after the mobility event.

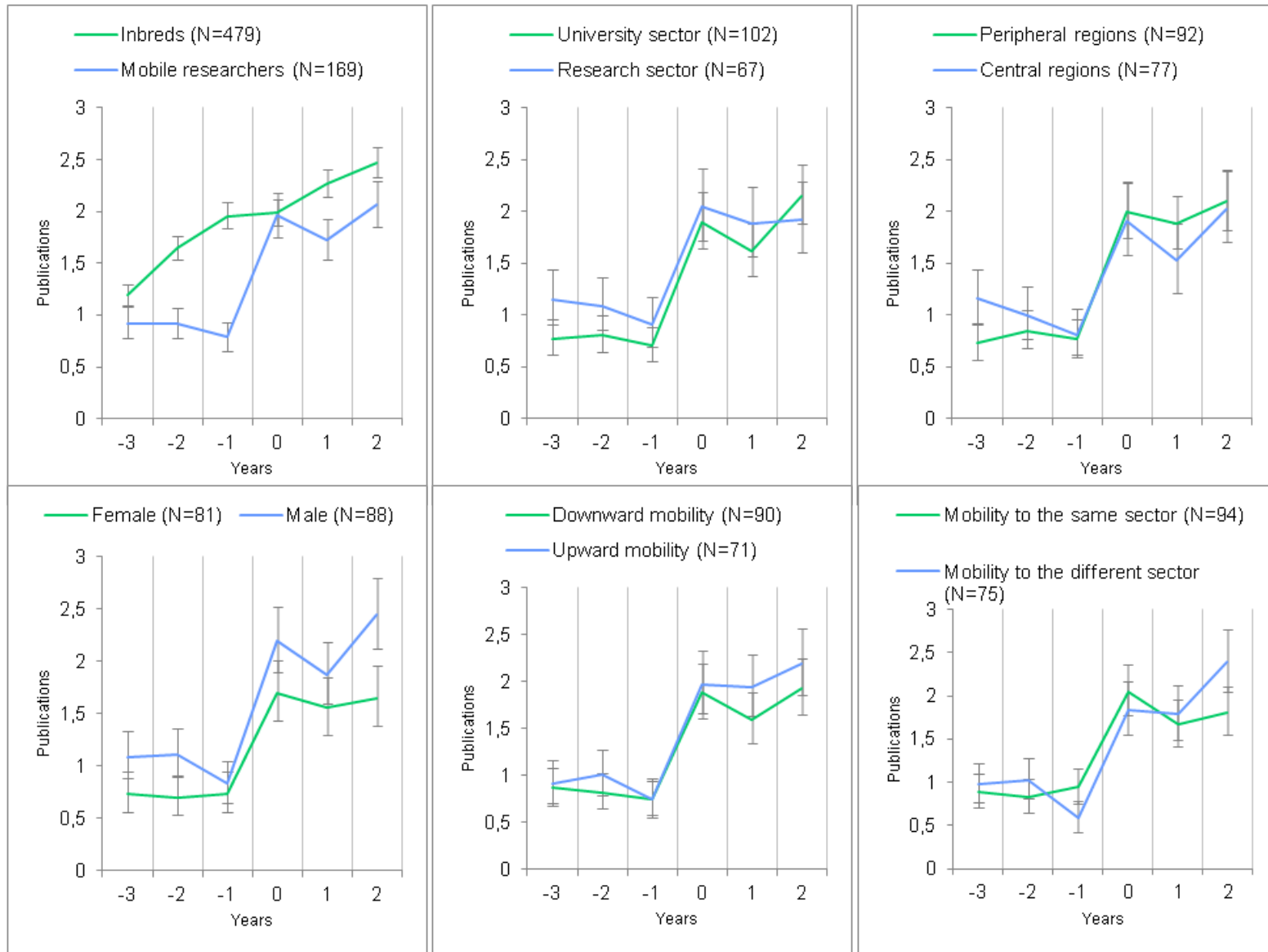


Figure 4 - Average publication activity of researchers in years before and after mobility by groups

Researchers which move to organisations with higher productivity have sharper decrease of publication activity than their counterparts which move to organisations with lower productivity. However, the latter show a sharper decline in productivity one year after the transition. Changing affiliation within the same sector is not so harmful for individual productivity in the years before mobility event identification in contrast to those who move to different sector. But changing sector leads to higher productivity in the second year after transition.

Thus, the trajectory associated with academic mobility at the beginning of a career looks less advantageous than the trajectory of inbreeding, due to the fact that moving to another organisation is steadily preceded by a decrease in publication activity. Given that a third of mobile researchers (32.8%) changed employers more than once during the first eight years of their academic career, it is quite obvious why the cumulative productivity of inbreds is higher than that of mobile researchers. In addition, the costs associated with the adaptation period tend to decrease with each subsequent transition from one organisation to another due to the learning effect (Fernández-Zubieta et al., 2016), but since the paper considers early career researchers, the adaptation effect contributes significantly to the lower productivity of mobile academics.

The presence of the inbreeding effect among researchers from the university sector can be explained by the peculiarities of the selection and training of highly qualified specialists in these sectors. The research sector probably attracts more motivated scientists, who are more focused on an academic career and probably have higher research abilities. Our data support this fact. Scientists from the research sector, on average, begin publishing earlier than their colleagues from the university sector (2009.9 and 2010.8 average year of the first publication for each sector respectively). As a consequence, scientists from the research sector have more publications by the time of their thesis defence (4.5 in the research sector versus 3.4 publications in the pre-doctoral period in the university sector). Having more experience makes scientists from the research sector better prepared and less vulnerable to the period of adaptation in the environment of the new organisation.

Thus, in the Russian realities of the academic labour market, inbreeding has a positive effect on the scientific productivity of young researchers in the natural sciences who have prepared their dissertations in organisations of the university sector. The effect of inbreeding on productivity is absent for those scientists who prepared their dissertations at research institutions. This effect is due, first, to the absence of the need to undergo an adaptation period for inbred researchers, and second, to the peculiarities of selection for graduate school in organisations of different sectors. It can also be observed that the effect of academic inbreeding is characteristic of territories with lower overall mobility.

Additional factor which may contribute to the adjustment period, is a changing research topic. Half of researchers (50%) change their field of their study when moving to other organisations. Inbreds change research topic less frequently during their career at alma mater (44%). Mobile researchers who prepared theses at the research sector organisations, change fields more frequently than their colleagues from universities (59 and 43% respectively). Changing fields is negatively correlated with the overall number of publications and citation rate (Table 6). There is no significant correlation with H-index and number of publications in 5% journals by SJR. Regression model where dependent variable the Field-Weighted Citation Impact is not shown since it is not statistically significant. Changing the research field after moving to another organisation may reduce the intensity of work by 15% and the impact of researchers' papers by 13%.

Table 6 - The Poisson regression of changing subject area on research productivity indicators (IRR)

	Number of publications	Citation count	H-index	Number of publications in 5% journals by SJR
Changing research area = 1	0.85 (0.015) ***	0.87 (0.007) ***	0.967 (0.03)	0.94 (0.08)
Mathematics (basic)				
Biology	1.31 (0.07) ***	2.44 (0.072) ***	1.58 (0.154) ***	2.78 (0.851) ***
Chemistry	1.71 (0.089) **	2.85 (0.083) ***	0.94 (0.187) ***	2.76 (0.836) ***
Physics	1.76 (0.09) ***	2.33 (0.008) ***	0.62 (0.154) ***	2.57 (0.769) ***
Central regions = 1	0.87 (0.016) ***	0.87 (0.008) ***	0.96 (0.032)	0.87 (0.079)
Research sector (basic)				

Universities without special status	1.03 (0.027)	0.90 (0.012) ***	0.96 (0.047)	0.50 (0.085) ***
Leading universities	1.08 (0.023) ***	0.99 (0.01)	1.00 (0.99)	1.12 (0.111)
Male = 1	1.23 (0.024) ***	1.141(0.01) ***	1.08 (0.036) **	1.60 (0.153) ***
Number of publications before defence	1.07 (0.002) ***	1.08 (0.001) ***	1.07 (0.004) ***	1.08 (0.01) ***
Logarithm of the alma mater's CSPP	1.01 (0.007) *	1.09 (0.004) ***	1.04 (0.013) ***	1.13 (0.041) ***
Upward mobility = 1	1.04 (0.025) *	1.11 (0.012) ***	1.05 (0.045)	1.09 (0.134)
Constant	7.31 (0.474) ***	15.68 (0.543) ***	1.884 (0.224) ***	0.086 (0.032)
N	809	809	809	809

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Thus, results of this part of the paper have shown that academic inbreeding does not harm individual researchers' productivity at the early career stage as inbreds do not face an adjustment period. Publication activity of mobile researchers from universities tends to decrease right before the first publications with the new affiliation. This allows assuming that article preparation at the new organisation takes more time than at the old one. Researchers lose their intensity of work especially when they change research fields, which may be related to the need for additional training. So, in the short term, academic inbreeding looks like an advantageous career trajectory for productivity indicators of early-career researchers, while movers have to adapt to the new environments and not spend time on papers.

6. Discussion and conclusion

The study explores the impact of academic inbreeding on individual researchers' productivity at the early-career stage in natural science and Mathematics. Academic inbreeding has a positive effect on the qualitative and quantitative indicators of the productivity of researchers in natural science who have prepared their dissertations in the organisations of the university sector. In turn, inbred scientists from research organisations practically do not differ from their mobile colleagues in terms of productivity and research quality. Additionally, I did not find the effect of inbreeding on mathematicians' productivity, while there are differences in performance between mobile and immobile researchers in natural sciences. The latter has more sophisticated

equipment and their studies often demand bigger teams. Consequently, mobility for researchers in natural sciences seems a more complicated step than for their colleagues in mathematics. Similarly academic mobility is difficult in peripheral regions, resulting in an inbreeds' career trajectory being more favourable to their productivity. The main explanation for all these facts is the need for mobile researchers to go through a period of adjustment in a new organisation. Changing research areas contributes to the lower publication activity of mobile researchers.

There is no regulation against academic inbreeding in the Russian academic labour market, the funding system for science and higher education institutions is highly centralised, and in general, funding for science is low relative to other countries. Large country size and generally low levels of population mobility further reduce the incentives for researchers to change organisations. In the context of downsizing of staff research organisations retain most talented graduates within alma maters, universities strive to keep talented young scientists through involving them into alma maters' research team in the pre-defence period. When academic inbreeding is not prohibited this may mean that the academic community still perceived it as a norm. The other side of the coin is that, probably, there are not so many opportunities to change employer for young researchers. Many researchers stay in their alma mater, and this decision at the beginning of the career seems profitable for research performance in the academic system where internal labour market prevails. Other researchers enter the external academic labour market, face an adjustment period, and often have to change research area.

Previous studies performed on Russian data are few and show ambiguous results. The study by Alipova and Lovakov (2018) is based on survey data for universities and for all fields of study. In turn, survey data can be biased both because of the problem of self-selection and because such data are self-reported, this reduces the precision of performance evaluation compared to bibliometric data. Data accuracy is certainly higher in Lovakov et al. (2019), however, that study focused on late-career mathematicians. The authors found a negative correlation between academic inbreeding and cumulative scientific productivity. On the one hand, it cannot be excluded that the cumulative

productivity of inbred researchers in our sample, after a couple of decades, will also not become lower than that of their mobile colleagues (cumulative inbreeding effect), but this cannot be verified yet. On the other hand, (Lovakov et al., 2019) talk only about mathematicians. In our data, the effect of academic inbreeding was often statistically insignificant for this field of study. Mathematicians are much more mobile than scientists in the natural sciences. Taking into account the results on mathematicians of both studies, the study by (Lovakov et al., 2019) and the current one, it is reasonable to assume that in a high mobility environment academic inbreeding does not affect individual performance in the short term, but in the long term, it leads to the reduction of knowledge production.

In turn, the results of the study are somewhat similar to those obtained by some foreign authors. Thus, it is observed that inbreds are more productive than mobile researchers; in other words, mobility reduces the cumulative productivity of researchers in the natural sciences, who have prepared their dissertations in organisations of the university sector. Similar results were obtained by Wyer and Conrad (1984). The authors attributed this effect to the adjustment period. Mobile researchers have to bear various costs associated with this period at a new organisation. Indeed, academic mobility is often associated with a short-term decline in scholarly productivity from the adjustment period (Bäker, 2015; Horta, 2022). Moving to another organisation may be associated with the need to start new projects, the preparation of the results of which requires a certain amount of time. Given that the focus of our study is on young researchers, they may not yet have enough experience, and the adjustment period has a significant impact on their productivity. McGee (1960) found a positive relationship between academic inbreeding and individual research productivity at the University of Texas and attributed this effect to the university's distance from other academic institutions. Our study showed that the effect of academic inbreeding was present in both central regions and peripheral regions. Therefore, it is likely that the distance of academic institutions from each other does not directly affect the significance of the effect, but the type of organisation does. It is assumed that this is due to the stronger research training of graduate scientists from research organisations and the fact that they have a much lower level of teaching load

both during graduate school and after, which frees up resources for research activities and allows them to cope more quickly with the costs of the adjustment period afterwards.

The results of this study have a number of limitations. First, the findings cannot be extrapolated to all Russian scientists: they apply only to specific fields of study and to a certain cohort of scientists at the initial stage of their career. At the same time, the sample is fully representative of researchers who defended their PhD theses in these specific fields of study in 2012. Second, the paper uses open data sources that do not provide a number of additional important pieces of information about scientists (e.g., their teaching load, positions, salaries, personal motivation to move, etc.). Third, because of the long publication process, bibliometric data may reflect mobility information with some delay. Fourth, the study covers only those researchers who are actively publishing in international journals, excluding researchers who are actively publishing articles in local journals, as well as those PhD candidates who have chosen an academic career unrelated to research activities or research activity outside the academic labour market.

The conducted study has shown the necessity to support early-career mobile researchers in order to save their individual productivity when they change employer. Measures themselves, to stimulate the intensity of academic mobility, may lead to more challenging conditions for researchers' work and probably to an exodus of staff from academia. Therefore, the academic system should be transformed first of all in order to make mobility easier and more profitable for researchers. The common need to change subject area may be related to the insufficient number of organisations with similar research directions, as this reduces competition in the labour market. Increased public expenditure on science and higher education, aimed at developing new research centres with a variety of research areas, could contribute to the development of the labour market. Decentralisation and attracting funding from private companies would create additional incentives for increased competition at both organisational and individual levels.

This work opens up many perspectives for further research. First, the study addressed the question of the impact of academic inbreeding on research productivity at

the individual level. At the organisational level, inbreeding may have a different effect, which has so far remained outside the scope of empirical research on Russian data. Second, the revealed importance of the interaction between the researcher and the academic supervisor suggests the crucial role of social capital in the mechanisms of academic inbreeding which should be additionally explored. Consequently, the relationship between academic inbreeding and researchers' social capital, as well as the role of social capital in the academic productivity of scientists, remains relevant for further study. Finally, I observed a difference in the effect of academic inbreeding on researchers' productivity in the research sector and the university sector. In order to explain the mechanism behind this difference I need to realise additional organisational factors. A more detailed study of these factors is required. Of course, the study should be extended for researchers in later career stages and researchers in other fields of study.

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