



# Universities vs. research institutes? Overcoming the Soviet legacy of higher education and research

Andrey Lovakov<sup>1</sup> · Maia Chankseliani<sup>2</sup>  · Anna Panova<sup>1</sup>

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## Abstract

Universities and non-university research institutes have been recognised as two key sectors producing research globally. The Soviet model of research organisation included a large network of research institutes, affiliated with the USSR Academy of Sciences and republican academies, as well as industry research institutes, affiliated with sectoral ministries. Universities played a minor role in research. Post-Soviet higher education and research systems went through reforms in the last three decades which led to changes in the patterns of knowledge production. This study offers an overview of the reforms and a bibliometric analysis of 319410 publications in journals indexed in the Web of Science database to examine how selected post-Soviet countries have overcome the Soviet legacy of organisational separation of higher education and research. While universities now produce the bulk of research output in selected countries, in the majority of national contexts, Academies of Sciences continue to be important players in research.

**Keywords** Universities · Research institutes · Higher education · post-Soviet countries · Research output

## Introduction

Universities and non-university research institutes have been recognised as two key sectors producing research globally. Research institutes were conceived as organisations with the sole function of undertaking research. Depending on the historical and geographic contexts, universities have been seen either as primarily educational organisations or as organisations combining educational and research functions. In the seventeenth century France, the creation of the Academy of Sciences led to an organisational separation of teaching and research and their assignment to two different sectors (Schimank & Winnes, 2000). This two-sector system subsequently became characteristic of a number of European countries (Leisyte et al., 2009). A further change in the role of research in universities is linked

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✉ Maia Chankseliani  
maia.chankseliani@education.ox.ac.uk

<sup>1</sup> Center for Institutional Studies, HSE University, 11 Pokrovsky Boulevard, Moscow 109028, Russia

<sup>2</sup> Department of Education, University of Oxford, 15 Norham Gardens, Oxford OX26PY, UK

to Humboldt's idea of academic education. German universities in the second half of the nineteenth century were the first research-oriented universities that recognised research as their fundamental function. The first research-oriented university in Germany followed Humboldt's vision of the unity of education and research.

University-based research has been contributing to the improvement of our understanding of life and supporting sustainable development in different parts of the world (Chankseliani & McCowan, 2021b). Literature identifies the generation of new knowledge as a fundamental function of universities globally, including in selected post-Socialist countries (Chankseliani et al., forthcoming). The two functions of a higher education institution<sup>1</sup>—teaching and research—are often considered inseparable, but the extent to which research and teaching are linked at the level of individual teachers remains debatable (Leisyte et al., 2009).

In some countries, including Germany, research remains organisationally separate from higher education (Dusdal et al., 2020). This group of countries in Europe includes the Czech Republic, France, Hungary, Slovenia, and Poland where non-university public research institutes remain important producers of knowledge. While the experience of American universities gave rise to the popularity of the research university model, in the USA, a research university continues to be an exception rather than the norm; only approximately 200 out of 3500 American universities and colleges are considered knowledge producers (Castells, 2017). In Europe, a number of national research and innovation systems are university-based, such as in Austria, Denmark, Ireland, Sweden and Switzerland (OECD, 2016). The debates whether research is and should be universities' core function continue globally (Dusdal et al., 2020; Marginson, 2021). Recent writing in higher education studies offers a controversial argument on university's research mission. Marginson (2021) supports the idea of organisational separation and argues that top universities globally accumulate vast social power with research being the principle source of their reputation and funding. This Anglo-American multiversity model of comprehensive university, he writes, needs to be disrupted so that education becomes the main source of funding and reputation for top universities. The research function can be separated to research institutes as it is in Germany or France. This model does not prevent research scientists from keeping links with universities, for instance by delivering guest lectures (Marginson, 2021). A relatively larger body of literature recognises the importance of universities' research function (Chankseliani et al., forthcoming; Chankseliani & McCowan, 2021a; Dusdal et al., 2020; Kwiek, 2012; Leisyte et al., 2009; Powell & Dusdal, 2017), to the extent that European systems which rely on strong university sectors are found to be more productive in terms of research output than systems which rely on research institutes (Powell & Dusdal, 2017). Powell and Dusdal (2017) also note that institutional and organizational antecedents affect scientific productivity.

The Soviet system was similar to the pre-Humboldt model of the organisational separation of higher education and research (Leisyte et al., 2009). A salient organisational form in the Soviet research system was research institute which originates from Germany. The Soviet Union's and the former Soviet countries' research institutes replicate the German research institute (Dusdal et al., 2020). Both publicly funded, one major difference between the Soviet research institute and the German research institute is that the latter 'operates

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<sup>1</sup> Considering a very small number of publications (only 20 in 2017–19) and also extremely limited knowledge available about Turkmenistan's university and research sectors, we excluded Turkmenistan from the analysis.

independently from the government' (Boychev, 2019, p. S34). Following the collapse of the Soviet Union, higher education and research systems in fifteen post-Soviet countries have seen significant changes, both under market and governmental pressures.

There is a growing body of academic literature that looks at the transformation of higher education and research in post-Soviet countries. This literature predominantly focuses on the educational mission of universities and how universities as educational institutions have changed in the years following the dissolution of the Soviet Union (Chankseliani et al., 2021a, b, c; Chankseliani, 2016, 2021b; Heyneman, 2008, 2010; Huisman et al., 2018; Lovakov et al., 2021; Sparks et al., 2015). While there exist studies on research universities and research capacity in selected former Soviet countries (Abramova & Krashe-ninnikov, 2017; Chankseliani et al., forthcoming; Hladchenko, 2020; Jonbekova, 2018; Kataeva & DeYoung, 2018; Lee & Kuzhabekova, 2019; Lovakov et al., 2021), this is a much smaller body of literature which points to the fact that the research mission of universities has been relatively neglected. Universities in this region and elsewhere have been seen as, first and foremost, educational institutions. However, over the past decades, many post-Soviet countries have significantly transformed their academic systems and made considerable efforts to develop scientific research in the university sector. Some countries abolished their national academies of sciences and merged research institutes with universities. Other countries retained powerful structures of academies of science. There are also reputable universities in all countries. Thus, we are observing an institutional transformation that may have affected scientific productivity. The present study offers the first large-scale sectoral analysis of the research output of universities and research institutes in the light of policy choices pertaining to the organisational integration of higher education and research. This study contributes to the debate about the research mission of universities, as well as about the organization of the academic system. In order to position the research output from this region in the global context, the study is limited to the analysis of what we refer to as the global domain of research output, namely publications in journals indexed in the Web of Science database.

## **Soviet legacy of higher education and research and subsequent reforms**

The Soviet model of research organisation included a large network of research institutes at the core. The bulk of research activity took place at the institutes of the USSR Academy of Sciences and republican academies, as well as industry research institutes affiliated with sectoral ministries. The institutes within the Academies of Sciences engaged in fundamental research and the research institutes of industrial ministries and other government agencies conducted mostly applied studies (Frankel & Cave, 1997). In the late 1980s, 2722 research institutes were affiliated with 20 Academies of Sciences. At the same time, there were over 5307 research institutes in the industrial and defence ministerial system (Graham, 1992).

The Soviet higher education system consisted of comprehensive and specialised higher education institutions. Altogether, at the time of the dissolution of the Soviet Union in 1989 there were 973 higher education institutions and 69 of these were comprehensive higher education institutions, called universities. Only approximately one-third of 69 universities were research-intensive. There also existed approximately 50 specialised higher education institutions that were research-intensive (CC of the CPSU & Committee of Ministers of USSR, 1978; USSR, 1989). Many researchers from academies of sciences routinely held part-time academic jobs at universities. All in all, universities played only a minor role in

**Table 1** The numbers of universities and non-university research institutes in post-soviet countries

	Number of universities (state and non-state) 2019–20	Number of non-university research institutes 2019–20
Armenia	57	63
Azerbaijan	52	88
Belarus	51	111
Estonia	19	14
Georgia	64	3
Kazakhstan	128	125
Kyrgyzstan	73	60
Latvia	54	10
Lithuania	41	13
Moldova	24	34
Russia	724	1577
Tajikistan	39	45
Ukraine	281	161
Uzbekistan	131	32
Total	1738	2336

Sourced from respective government web-sites

the development of the Soviet science. Universities were mostly seen as educational institutions. Looking at the public spending can give an idea of the relative share of each of these sectors in the Soviet research. In 1990, 87% of the Soviet research and development (R&D) budget was allocated to research institutes in the industrial and defence system. Only 7% of the R&D budget went to universities and 6% to the academy of science system (David-Fox & Péteri, 2000).

Following the dissolution of the Soviet Union, formerly Soviet countries chose heterogeneous paths of political, economic, and social development (Chankseliani, 2018; Chankseliani & Silova, 2018). Market economy took place of planned economy. Higher education and research sectors which suffered from brain drain and insufficient funding, had to adapt to new, market-oriented realities and open up to global influences. Non-state higher education institutions have emerged, and state higher education institutions have started to offer fee-paying education. The number of higher education institutions increased in all countries with the overall increase across the region from 973 in 1989 to 1738 in 2019/20 (USSR, 1989). Table 1 shows the most recent distribution of higher education institutions by country. The increase in the number of institutions has been driven by the market need to meet the expanding demand for higher education and contributed to the universal access to higher education in the majority of these countries (Chankseliani, forthcoming). At the same time, selected governments and universities in the region have started to recognise the importance of university-based research for building knowledge-based economies, keeping their regional influence, and developing global reputation.

These countries have approached the organisational development of higher education and research differently. While in some countries academies of sciences were abolished and their institutes merged with universities, in others the integration of institutes and universities took milder forms or never happened. The following countries are in the group of radical reformers that abolished their national academies of sciences and

merged research institutes with universities: Estonia, Latvia, Lithuania, Georgia, and Kazakhstan. As academies were transformed into learned societies, institutes integrated with universities or became independent. The Estonian, Latvian, and Lithuanian Academies of Sciences were reformed in the early 1990s. In Kazakhstan and Georgia similar changes happened in the early to mid-2000s. Academies in these countries turned into collective bodies of academics that perform one or more of the following functions: promote research, elect research professors, support early career scholars, offer advice and recognition, prepare annual reports on the development of research nationally. Academies have lost their research governance and financing powers. These processes of reorganisation, together with other reforms in higher education, were driven by the goal of establishing the knowledge economy through research-based knowledge production and increasing global competitiveness by connecting research and education at higher education institutions (Tamtik & Sabzalieva, 2018). While these five countries retain a number of non-university research institutes (Table 1), the disintegration of academies of sciences and the merger of the majority of research institutes with universities led to the strengthening of research capacity of universities as will be shown below.

In contrast, the following countries have not implemented major policies directed at the organisational integration of higher education and research sectors and retain powerful structures of academies of science: Armenia, Azerbaijan, Belarus, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Uzbekistan, and Ukraine. These countries continue to support large numbers of non-university research institutes (Table 1). To give an illustration, the National Academy of Sciences of Ukraine (NASU) has retained its central position in the national research system. The organisation was externally evaluated in 2018. An external reviewer described the Academy as outdated and suggested that ‘the Academy’s competitive labs should be merged with Ukrainian universities to create European-style research universities and to link research and teaching’ (Schiermeier, 2019, p. 163). While a number of research departments at the NASU were closed down following the evaluation, the NASU still enjoys a strong political position and reports to the Cabinet of Ministers directly. Universities in Ukraine are under the Ministry of Education and Science. The status of the Academy of Sciences is somewhat different in neighbouring Moldova where the Academy of Sciences is less powerful and there are ongoing debates about shifting the research funding from the Academy to universities (Campbell & Gherasimov, forthcoming). Kyrgyzstan is another country which has witnessed discussions between two opposing camps regarding the organisation of research. The working group that was set up to radically restructure the National Academy of Sciences in Kyrgyzstan was not successful because of the overrepresentation of conservative scholars who opposed changes to the academy model (Jalil & Shamatov, forthcoming).

The Russian Academy of Sciences (RAS) continues to maintain its status as the largest player in research and development, despite the Russian government’s attempts to reform the Academy (Panova & Yudkevich, 2021). In 2013, the Russian government implemented reforms that targeted the entire higher education and research sector, not just the institutes of the Academy of Sciences. The aim of the reforms was to increase the global competitiveness of Russian research, improve efficiency, and introduce performance monitoring to increase accountability and transparency. However, unlike reforms in higher education, these reforms have not been considered successful (Karaulova et al., 2017; Panova & Yudkevich, 2021). These reforms have caused considerable resistance from the research sector, and especially the RAS, as the largest player. The RAS is now actively involved in the new excellence initiative Priority-2030 which could contribute to the development of closer

connections between the research and higher education sectors in Russia and significantly change the role of research in the university sector.

In both groups of countries, there are reputable universities. The analysis of the 2021 rankings of global universities by Times Higher Education (THE) and Quacquarelli Symonds (QS) demonstrates that all countries from the first group have between one and four universities included in these global rankings. From the first group of countries, Kazakhstan has the largest number of universities featuring in the rankings – three in THE and ten in QS. In contrast, the majority of countries that retain powerful structures of academies, such as Armenia, Azerbaijan, Kyrgyzstan, Moldova, Tajikistan, and Uzbekistan, do not have a single university included in these global rankings. From the second group, Russia has the largest number of universities (48 in THE and 28 in QS) included in the rankings, followed by Ukraine (nine in THE and six in QS), and Belarus (one in THE and two in QS).

Higher education institutions in this region, like elsewhere, operate under the constraints imposed by their respective nation-states which ‘have designs on them’ (Kerr, 1994, p. 6). Adopting different temporal paths, almost all countries have put in place various quasi-market research policies. Such policies include but are not limited to competitive, performance-based mechanisms to distribute research funding; evaluation of research output on the basis of quantifiable indicators; using research productivity to determine faculty pay; offering financial incentives to researchers for producing research output; and supporting selected universities to develop research capacity and become visible in global university rankings. Universities themselves have begun to encourage research activity by including publication requirements for recruitment and promotion and awarding academic titles. Most valued publications are those in journals indexed in international databases such as Scopus or Web of Science. The ‘publish or perish’ principle has been actively implemented in a number of countries, although practices vary by institution. In Lithuania, for example, universities appear to value publications in Lithuanian WoS-indexed journals less than publications in foreign WoS-indexed journals (Grančay et al., 2017). In Latvia, WoS or Scopus-indexed journal publications are required for obtaining professorship (Grančay et al., 2017). Yet, in Belarus, Turkmenistan, or Tajikistan, there are few requirements to publish in journals indexed in international databases (Hladchenko & Moed, 2021).

## Data and methods

The present study uses the Web of Science (WoS) database as the source of the bibliometric data. We analysed publications in journals indexed in three widely used journal citation indexes: Science Citation Index Expanded, Social Sciences Citation Index, and Arts & Humanities Citation Index. The composition of journals indexed in WoS is selective and relatively stable over time which makes it possible to analyse the dynamics of output and impact reliably (Moed et al., 2018). At the same time, many local journals in national languages are not indexed in these three indices, so some publications from post-Soviet countries were not included in our analysis. However, the WoS database brings together publications of comparable quality makes it possible to compare different countries and periods. The WoS database was accessed from the HSE University and last updated in February 2020.

We extracted the full record of meta-data for all publications ('article' and 'review' types) affiliated with 14 post-Soviet countries and published in 2017–19.<sup>2</sup> We also downloaded the full record of meta-data for all publications in 1993, 1998, 2003, 2008, and 2013 to demonstrate dynamics of the contributions of different sectors. Overall, we analysed 319410 publications. If the country of at least one organisational affiliation of the publication's authors was X, then the publication was considered to be from country X. For each publication, we extracted data on several variables, including the number of authors, countries of affiliation, and international co-authorship.

Organisational affiliations were categorised into sectors to create the main variable of interest. We applied the following algorithm. For each publication from country X, we identified all organisational affiliations with country X and assigned each of them to one of the following six sectors:

*University*—universities and higher education institutions, including university hospitals;

*research institutes*—research institutes inside and outside National Academies of sciences, e.g. institutes of the Russian Academy of Sciences, National Academy of Sciences of the Republic of Kazakhstan;

*industry*—private business companies (e.g. Lukoil, Cybernetica), partly or wholly state-owned business companies or state corporations (e.g. Gazprom, Rosneft Oil, Minsk Tractor Works, Roscosmos),

*government*—government ministries and agencies, e.g. Ministry of Health of the Russian Federation, Ministry of Health of Kyrgyzstan, National Center for Disease Control & Public Health of Georgia, Rospotrebnadzor, Latvijas Banka;

*hospital*—state and municipal hospitals, medical research centres and institutes, which combine the provision of medical services and research;

*other*—national parks, botanical gardens, libraries, and local offices of the international organisations (World Bank, WWF).

Each affiliation was assigned to only one sector. If the paper had two affiliations, for instance one affiliation assigned to the university sector and another assigned to the research sector, then the paper was considered to contribute to both – the university and research sectors.

To assign each publication to relevant sectoral affiliations, a library of variants of organisational affiliations was created. For each country, we extracted the lists of all organisations in these countries contained in InCites database, an analytical tool that contains a number of bibliometric indicators aggregated from WoS data for countries, organisations, and researchers. As a result, a list of 1508 organisations was created. Each organisation from this list was assigned to one of the six sectors listed above. For each organisation on this list, we extracted all its spelling variations from their WoS profiles. We used the resulting library of over 48000 affiliation variants to classify affiliations into sectors. However, some of the affiliations were not classified at this stage. First, the WoS profiles of organisations did not contain all of the spelling variations found in publications. Second, not all organisations with which the publications were affiliated had their own WoS profiles. Therefore, we had to identify the affiliations unclassified in the first step and manually assigned them

<sup>2</sup> Considering a very small number of publications (only 20 in 2017–19) and also extremely limited knowledge available about Turkmenistan's university and research sectors, we excluded Turkmenistan from the analysis.



to one of the six sectors. The extended library of affiliation variants contained over 62000 variants. We tried to identify and assign all affiliations to a sector, but some of the affiliations remained unidentified and unclassified. The share of unclassified affiliations varied by country and did not exceed 5% for each country. Thus, the margin of error does not exceed 6% (some unclassified affiliations appeared more than once). However, in some countries where individual organisations have moved from one sector to another (Estonia, Latvia, Lithuania, Georgia, and Kazakhstan), the margin of error for earlier years may be higher. This is because early publications from these countries were assigned to the sector to which organisations belong today, and not to the sector to which they belonged at the time of publication.

To analyse the contribution of each sector to the country's research output, we calculated the number of publications affiliated with each sector, as a proportion of the total number of publications in the country.

We compared the quality and impact of output from university and research sectors by country. To measure the quality of journals, we analysed the distribution of publications in each sector by the quartile of journal based on the impact factor. The impact factor of a journal is a very rough estimate of the quality of articles published in it, which may not be valid for individual articles. However, in this study, we are comparing groups of hundreds to thousands of articles, so individual cases will not make a significant difference to the conclusions. We used the highest quartile of the journal in which the paper is published, based on Journal Citation Reports from 2018, as the indicator of quality.<sup>3</sup>

As the indicator of impact, we used the percentile of the publication in the citation frequency distribution for all publications in the same year, subject category, and document type. The citation percentile values were downloaded from InCites database in September 2021. Each publication included in WoS database indicates a number of times it was cited. The percentile of a publication was determined by creating a citation frequency distribution for all publications in the same year, subject category, and document type, and determining the percentage of papers at each level of citation. When all publications were sorted from the smallest citation count to the largest, each article received a percentile value from 0 to 100. This percentile value of publication X can be interpreted as the proportion of publications in the WoS database, which this publication overtakes on citation count. The higher the percentile value, the higher the publication is in the ordered row of all publications in the WoS database. Average percentile was calculated as the arithmetic mean of all the percentiles of all the papers affiliated with university or research sector of the country.

To assess the co-authorship and collaboration patterns and each sector's role in collaborations, we calculated four indicators: (1) the percentage of publications affiliated with the sector which has international co-authorship (affiliated with two or more countries); (2) the percentage of sectors' publications with international co-authorship where the sector is mentioned in the corresponding address; (3) the percentage of each sector's publications with international co-authorship and more than 50 co-authors<sup>4</sup>; and (4) the percentage of

<sup>3</sup> Journals are divided into quartiles within WoS categories. Some journals are classified into more than one categories. These journals have more than one quartile (the number of quartiles is equal to the number of categories) and these quartiles can be different (the journals can be in Q1 in the first category and in Q2 in the second category). In these cases, we used the highest quartile.

<sup>4</sup> For mega-collaborations, this paper uses a stricter inclusion criterion of 51 or more authors than another paper (Chankseliani, Lovakov, et al., 2021a, b, c) which used 21+ author as the criterion for mega-collaborations.



each sector's publications with international co-authorship where authors are affiliated with more than 10 countries.

## Results

### Contribution of different sectors in countries' output

Publications included in the WoS are produced by authors with different sectoral affiliations: universities, research institutes, industry, government, hospitals, as well as national parks, botanical gardens, and libraries. The contributions of each of these sectors to the total research output differs by country (Table 2). We present data on the contributions of each sector as a percentage of the country's total research output. However, there is a great variation in the size of the research output of by country. This should be taken into account when interpreting the findings of the study. The bulk of the research output of post-Soviet countries is produced by university and the research sectors. Besides these two sectors, research output is also produced by industry, government, and hospitals. The contributions of industry-affiliated papers to research output range between 3% in Estonia, Kazakhstan, Latvia, and Russia to less than 1% in Moldova and Tajikistan. In most countries, industry produces between 1 and 3% of WoS publications. Between 9 and 1% of national research output is attributed to government ministries and agencies. Government sectors in Azerbaijan and Tajikistan produce 9 and 6% of research output, respectively. The lowest share of research output is produced by governments in Belarus and Lithuania – only one in hundred papers. Finally, non-university hospitals also produce some research. Kyrgyzstan is a clear outlier with 16% of its WoS output produced by hospitals. This is followed by Moldova with 8% and Georgia and Latvia with 7% each. A very small proportion of research output is produced by national parks, botanical gardens, and libraries, coded as 'other' (Table 2).

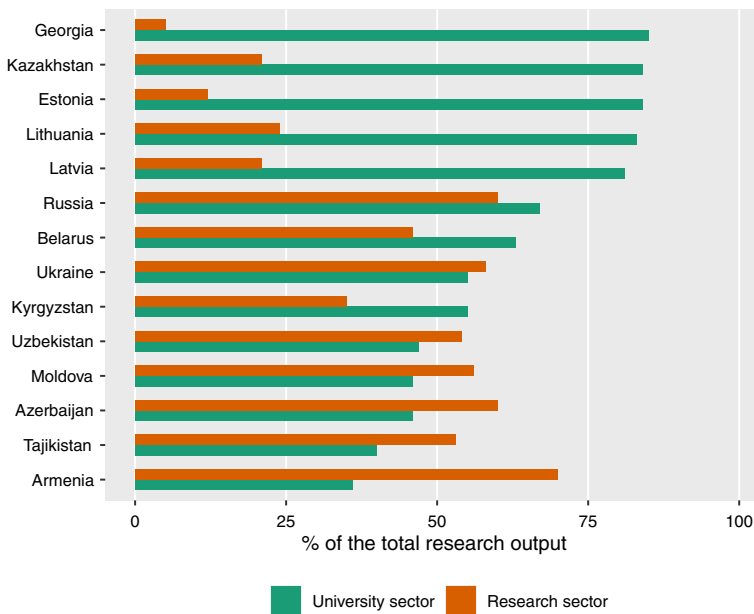
A proportion of WoS publications from each country represents collaborations of authors based in different sectors within the same country. The most extensive cross-sectoral collaborations take place between universities and research institutes. The proportion of publications affiliated with both university and research sectors differs by country. Russia has the largest share of cross-sectoral collaborations (32% of all Russian output), followed by Azerbaijan, Belarus, and Ukraine. In other countries, the share of publications co-authored by universities and research institutes does not exceed 12% (Table 2).

### Dual pillars: university and research sectors

The bulk of the research output of post-Soviet countries is produced by two sectors – university sector and research sector. The relative contributions of the two main sectors differ by country (Fig. 1). Three groups of countries can be distinguished. The first group includes Estonia, Georgia, Kazakhstan, Latvia, and Lithuania (top five in Fig. 1), where a great majority of publications is affiliated with universities, while research sector makes a small contribution. The differences between two sectors in this group includes range between 60 and 80 percentage points. The second group includes Armenia, Tajikistan, and Azerbaijan (the bottom three in Fig. 1) where research institutes produce significantly larger share of output than universities, with more than 20 percentage point differences between two sectors. The rest of the countries are in-between two groups, with university

**Table 2** Contribution of different sectors to the total research output, by country (2017–19)

Country	Number of papers	% produced by universities	% produced by research institutes	% produced by research institutes (co-authorship)	% produced by industry	% produced by government	% produced by hospitals	% produced by other
Armenia	2780	36	70	10	1	2	3	2
Azerbaijan	2297	46	60	17	1	9	1	0
Belarus	3931	63	46	15	1	1	4	0
Estonia	6887	84	12	3	3	5	4	1
Georgia	2405	85	5	4	1	4	7	4
Kazakhstan	3979	84	21	11	3	5	4	3
Kyrgyzstan	527	55	35	5	1	4	16	7
Latvia	2895	81	21	9	3	3	7	2
Lithuania	8519	83	24	9	1	1	2	1
Moldova	763	46	56	12	0	2	8	3
Russia	124062	67	60	32	3	2	5	1
Tajikistan	315	40	53	7	0	6	2	7
Ukraine	14280	55	58	17	2	2	2	1
Uzbekistan	1101	47	54	9	1	3	4	3



**Fig. 1** Contributions of university and research institute sectors to the total research output, by country (2017–19)

and research sectors producing approximately similar shares of research output, accounting for 6% margin of error explained earlier.

Across the region, university research capacity appears to be concentrated in singular institutions. In six countries, more than half of the output of the entire university sector is affiliated with one university. Belarusian State University produces 68% of the total number of publications of the Belarusian university sector, the University of Tartu in Estonia—66%, Yerevan State University in Armenia—64%, Ivane Javakhishvili Tbilisi State University in Georgia—61%, the University of Latvia—58%, Baku State University in Azerbaijan accounts for 51% of Azerbaijani publications affiliated with universities.

There are fewer cases of concentration of research capacity in singular research institutes. Two most prominent examples are the National Institute of Chemical Physics and Biophysics which produces almost 80% of the research output affiliated with Estonian research institutes, and A.I. Alikhanyan National Science Laboratory<sup>5</sup> which produces more than half—almost 60%—of the output of the Armenian research sector.

The sectoral shares of contributions to research output have been changing in the last three decades. Figure 2 shows the dynamics of sectoral contributions to the total output, by country. In the early 1990s, the research sector was the main producer of output in all countries except Lithuania where universities produced the bulk of research output. At that time, Latvia and Estonia had almost identical shares of output originating from research and university sectors. Almost immediately after the collapse of the Soviet Union, university sector began to dominate in Latvia and Estonia. Towards the end of the first decade of independence, university sectors in Georgia and Kyrgyzstan produced larger shares of

<sup>5</sup> formerly known as Yerevan Physics Institute.



**Fig. 2** Dynamics of sectoral contributions to the total output, by country and by year

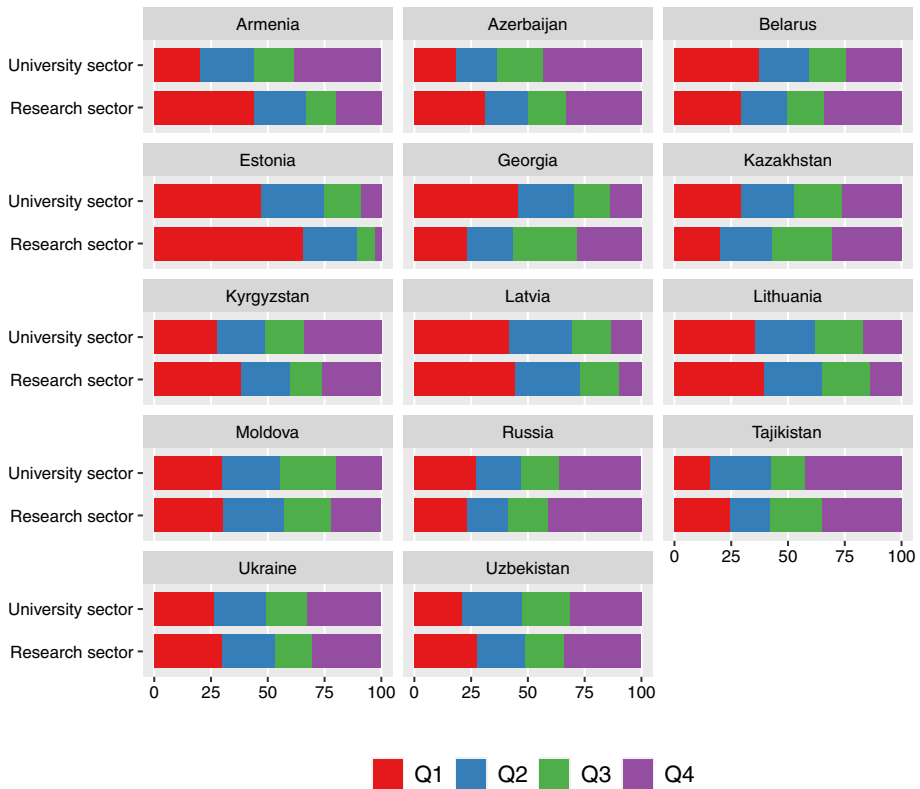
research output than research institutes. Yet, differences between university and research sectors in these two countries were smaller than in the Baltic states.

In the last two decades, Georgia and Kazakhstan saw consistent increases in the contributions of their dominant university sectors and significant drops in the contributions of their research sectors (Fig. 2). In the five countries with currently dominant university sectors, in 2017–19, research institutes produced much smaller share of the output in Georgia and Estonia, than in Latvia, Kazakhstan, and Lithuania.

Russia, Ukraine, Uzbekistan, and Belarus have also seen a gradual rise in the number of publications from the university sector; in these countries, universities have been catching up with the research sector, having achieved comparable contributions in recent years.

Research sector has remained dominant in Armenia. In Tajikistan, Azerbaijan, and Moldova, research sector has consistently been producing higher proportions of research output than university sector.

The share of publications written jointly by authors from universities and research institutes has grown over time in several countries. In the 1990s, Georgia (18% in 1998),

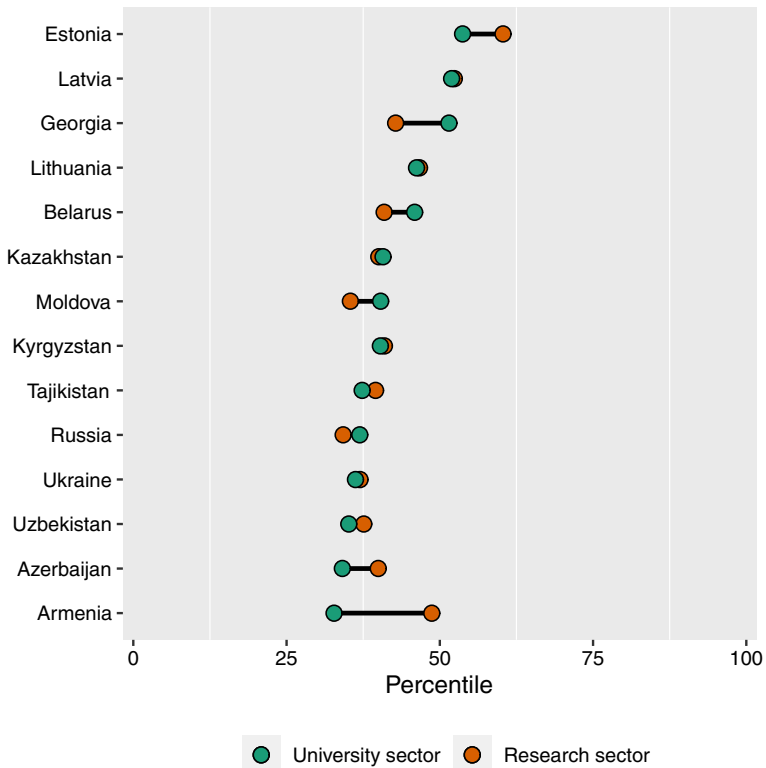


**Fig. 3** Percentage of publications in journals with different quartiles, by sector and by country (2017–19)

Kazakhstan (9% in 1998), Latvia (9% in 1998) had the largest shares of cross-sectoral output. The most noticeable growth in collaborations between university and research sectors is observed in Russia from 4% in 1993 to 32% in 2017–19. The increase is also seen in Azerbaijan and Ukraine (from 3 to 17%) as well as in Belarus (from 2 to 15%).

### Quality of journals and impact

There are variations in the quality and impact of research output produced by sectors and by country. This study used the quartile of the journal in which the publication appeared as the indicator of quality. Figure 3 shows the distribution of publications by journal quartile, sector, and country. Differences in the quality of sectoral output can be observed among three groups of countries. The first group includes Belarus, Georgia, and Kazakhstan where university sector has a larger share of publications in Q1 journals and a smaller share in Q4 journals, when compared to research sector (Fig. 3). In other words, university sector output from these countries appears in relatively better quality journals than research sector output. While Belarus has a powerful structure of Academy research institutes in place, Belarussian universities have been developing their research capacity as seen in Fig. 2. Especially noteworthy is Belarussian State University which produces 68% of the total number of publications of the Belarussian university sector.



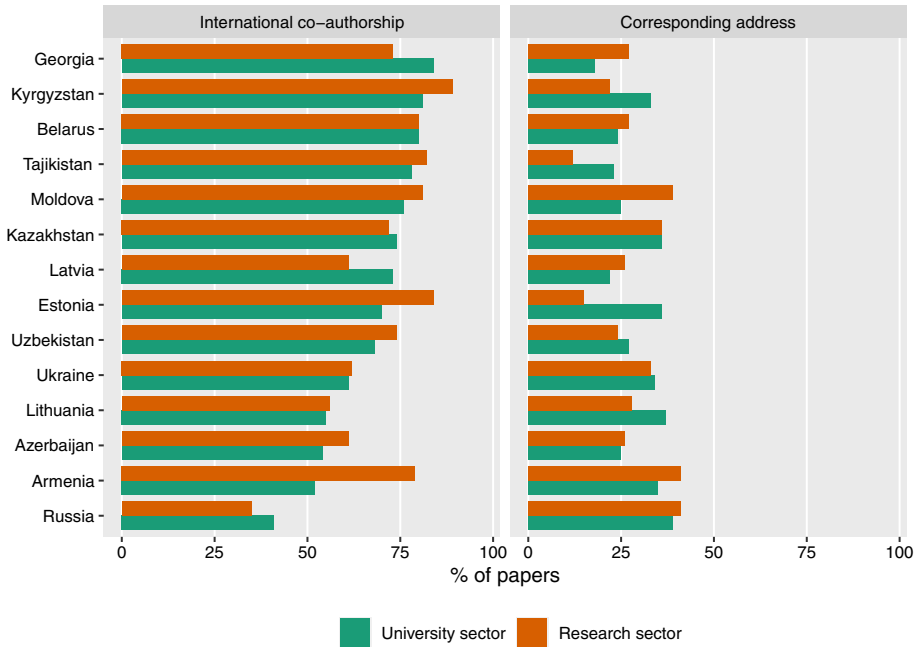
**Fig. 4** Average citation percentile for publications from university and research sectors

The second group includes Armenia, Azerbaijan, Estonia, Kyrgyzstan, and Tajikistan where research sector has a significantly larger share of publications in Q1 journals and a smaller share in Q4 journals, when compared to university sector. In other words, research sector output from these countries appears in relatively better quality journals than university sector output. Even though only 12% of Estonian papers are produced by the research sector (Fig. 1), almost 80% of the output of the Estonian research sector is affiliated with one highly reputable institution—the National Institute of Chemical Physics and Biophysics. This explains the appearance of Estonia in this group.

The third group of countries includes Latvia, Lithuania, Moldova, Russia, Ukraine, and Uzbekistan where publications from both sectors appear in journals of comparable quality (Fig. 3).

These results are broadly consistent with the findings of the citation analysis of publications from different sectors. We used the citation percentile of paper in the subject area as the indicator of impact. Figure 4 presents the average citation percentiles of publications within university and research sectors. The higher the average percentiles, the higher cited the sector average publication is.

Three groups of countries can be identified in terms of the impact of publications produced by university and research sectors (Fig. 4). The first group includes Georgia, Belarus, and Moldova, average publication of the university sector is cited higher compared to the average publication of the research sector. It means that an average publication with



**Fig. 5** Proportions of papers with international co-authors and local corresponding authors, by sector (2017–19) international co-authorship – percentage of sectors’ publications with international co-authorship, Corresponding address – percentage of sectors’ publications with international co-authorship where the sector is mentioned in corresponding address

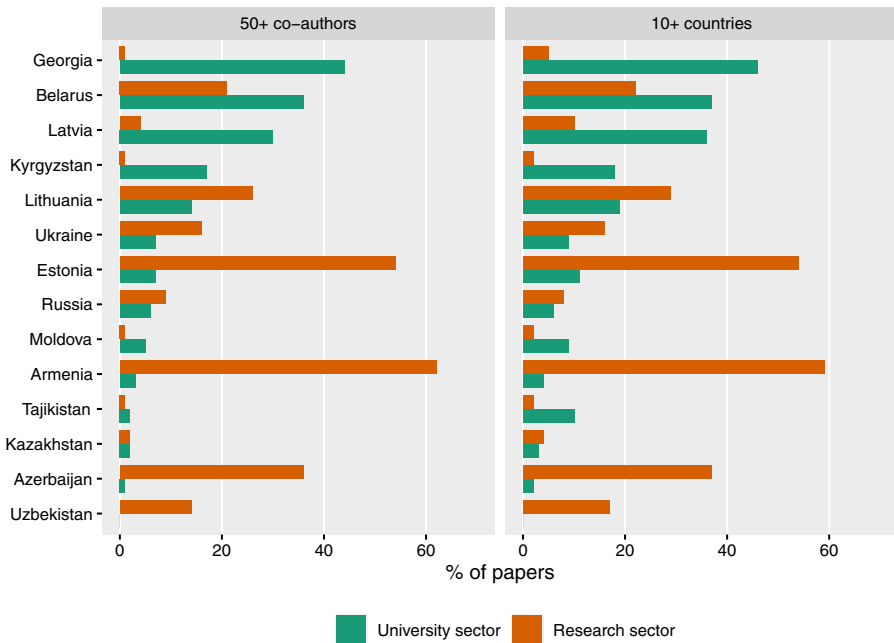
an author affiliated with university sector in these countries has a higher number of citations than an average publication with an author affiliated with research sector. In contrast, research sector in Armenia, Azerbaijan, and Estonia produces higher impact publications when compared to university sector. Finally, in Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Russia, Tajikistan, Ukraine, and Uzbekistan average citation percentiles of publications within both sectors are about the same.

The average citation percentile is a value that is normalized across the whole WoS database. This allows a cross-country comparison against the median publication in the WoS database. In Fig. 4, countries are sorted by the average citation percentile of publications from university sectors. As we move from top to bottom, the citation rate of an average publication from university sector decreases. An average publication of the university sector in Estonia, Latvia, and Georgia are the most cited among all post-Soviet countries. The average citation percentile for publications of the universities in these countries also exceed value 50. This means that an average publication of universities in these countries is more frequently cited than the median publication in the entire WoS database.

**Co-authorship and collaboration patterns**

Researchers from post-Soviet countries tap into international collaborative networks actively, resulting in an exceptionally large proportion of publications from this region being internationally co-authored. As reported in another paper, in 1993–2019, every





**Fig. 6** Proportions of mega-collaborations in internationally co-authored papers, by Sector (2017–19), 50+ co-authors – percentage of sectors’ publications with international co-authorship and more than 50 co-authors, 10+ countries – percentage of sectors’ publications with international co-authorship where authors are affiliated with more than 10 countries

post-Soviet country had a higher proportion of internationally co-authored publications than the world average of 20%. Three in ten publications produced by researchers from this region were internationally co-authored but there is a large country-level variation (). The analysis of the 2017–19 data showed that in all countries, except Russia, more than half of the output of both university and research sectors consisted of publications with international co-authorship. In Russia, the percentage of such publications was slightly less than 50%.

While there are differences in international co-authorship by country, the sectoral differences in the proportions of internationally co-authored papers within each country are not large (Fig. 5). Across most countries, comparable proportions of papers produced by university and research sectors are internationally co-authored. There are four countries where differences between sectors are more prominent. In Armenia and Estonia, research sector has a larger proportion of internationally co-authored output than the university sector. In Latvia and Georgia, university-based academics appear to be more engaged in international collaborations than academics based at research institutes.

Approximately one-third of internationally co-authored publications from these countries have a local corresponding author. This study takes corresponding authorship as an indicator of the role of local authors in international co-authorships. In Armenia and Russia, the proportion of internationally co-authored publications with a local corresponding author is more than 40% (Fig. 5). Differences by sector are considerable. In Estonia, Kyrgyzstan, Tajikistan and Lithuania, university-based authors are much more likely to

be corresponding authors in international collaborations, than authors based at research institutes. In contrast, in Moldova and Georgia, larger proportions of internationally co-authored papers from the research sector have a local corresponding author, when compared to the international collaborative output of the university sector.

In a number of post-Soviet countries, mega-collaborations drive research output, including internationally co-authored output. We define an international collaboration involving more than 50 authors or authors from more than ten countries as a mega-collaboration. There is a strong, positive correlation between these two measures. The sectoral and country differences in terms of mega-collaborations are large (Fig. 6).

There are large differences by sector. As seen in Fig. 6, there are three groups of countries in terms of the role of mega-collaborations in driving internationally collaborative research output from two sectors. Research sector has much higher share of publication prepared by mega-collaborations than university sector in Armenia, Estonia, Azerbaijan, and Lithuania where more than a half to more than a quarter of all internationally co-authored publications from research sector are mega-collaborations (Fig. 5). In contrast, in Georgia, Belarus, and Latvia, the bulk of university research output is produced by mega-collaborations.

## Discussion and conclusion

If knowledge is power, which institutions are considered legitimate to produce knowledge and, thus, hold power? In the Soviet Union, research institutes used to be main producers of knowledge. Soviet higher education institutions were seen primarily as educational institutions. The organisation of research has changed in the last three decades. There have been radical changes in some countries and less radical changes in others.

At present, universities and research institutions are two main producers of research output measured by publications from post-Soviet countries. Five former Soviet countries have ended the Soviet tradition of organisational separation of higher education and research in the first two decades of independence. Estonia, Latvia, Lithuania, Georgia, and Kazakhstan dissolved their Academies of Sciences and merged the bulk of their research institutes with universities. Yet, in the majority of post-Soviet countries academies of sciences continue to be important organisational players in research. These countries are: Armenia, Azerbaijan, Belarus, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Uzbekistan, and Ukraine.

As we have shown, in the group of radical reformers (Estonia, Latvia, Lithuania, Georgia, and Kazakhstan), vast majority of papers are affiliated with the university sector. Two groups of countries can be distinguished among the rest that have not implemented major reforms of organisational integration of higher education and research sectors. In Armenia, Tajikistan, and Azerbaijan, research institutes produce significantly larger share of output than universities. In the rest of the countries (Belarus, Kyrgyzstan, Moldova, Russia, Uzbekistan, and Ukraine), universities produce research output comparable to the output of research institutes. However, this group is not homogeneous. In Russia the comparability of the sectoral output might have been driven by large-scale investment in university research capacity development. In other contexts, relative balance in sectoral output might be a mixture of underinvestment in research sector and reforms of university sector.

Across this diverse region, universities remain to be perceived largely as educational institutions. At the same time, a number of universities became important producers of research and some have been producing cutting edge research. For example, in July

2021, the University of Tartu showcased the world's first autonomous hydrogen vehicle which was developed in collaboration with the Estonian enterprise Auve Tech (University of Tartu, 2021). The development of university research capacity in post-Soviet countries might have been facilitated by expanding international collaborations of individual researchers, policies to encourage research activity in universities and, in some countries, by radical reforms of academies of sciences – historically major players in research sector – to support organisational integration of higher education and research. The latter has undoubtedly had a positive effect on national research output in Estonia, Latvia, Lithuania, Georgia, and Kazakhstan.

As shown in this paper, university sector contribution is often clustered in a small number of universities. The same trend is detected in the research sector in some countries. The concentration of large capacity within singular organisations explains some of the findings pertaining to the quality and impact of sectoral output. While macro changes in the organisational landscape can be linked with the quantity of national research output, such links appear to be weaker when it comes to the quality and impact of the papers analysed.

Research sector in Armenia, Azerbaijan, Estonia, Kyrgyzstan, and Tajikistan produce considerably higher quality output than university sectors. Estonia's presence in this group might be explained by the fact that almost 80% of the output of the Estonian research sector is concentrated at the National Institute of Chemical Physics and Biophysics.

Countries where university sector produces significantly higher quality of output than research sector include Belarus, Georgia, and Kazakhstan. Again, the presence of Belarus, which has a powerful structure of Academy research institutes in place, in this group might be explained by the concentration of 68% of the university output at Belarusian State University. Finally, in Latvia, Lithuania, Moldova, Russia, Ukraine, and Uzbekistan, publications from both sectors appear in journals of comparable quality.

These results are broadly consistent with the findings of the citation analysis of publications from different sectors. In Armenia, Azerbaijan, and Estonia research sector produces on average higher cited publications than university sector. Whereas in Belarus, Georgia, and Moldova, universities produce publications which are on average higher cited compared to publications within research sector. All other countries – Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Russia, Tajikistan, Ukraine, and Uzbekistan – the impact of publications within both sectors are approximately the same.

International collaborations appear to be equally widespread in both sectors. Across most countries, comparable proportions of papers produced by university and research sectors are internationally co-authored. There are four countries where differences between sectors are more prominent. In Armenia and Estonia, larger proportions of papers from research sector are internationally co-authored when compared to the output of university sector. Again, in the case of these two countries, research sector indicators are largely determined by the publications of two dominant research institutions. Approximately 90% of publications of both the A.I. Alikhanyan National Science Laboratory in Armenia and the National Institute of Chemical Physics and Biophysics in Estonia are the result of international collaboration. In contrast, university-based academics appear to be more engaged in international collaborations than academics based at research institutes in Georgia and Latvia.

Approximately one-third of internationally co-authored publications from these countries have a local corresponding author which is taken here as an indicator of a leading role in the production of research output. Considerable differences are detected by sector in terms of the proportion of papers led by local authors. University-based authors are markedly more likely to be corresponding authors in international collaborations, than authors

based at research institutes in Estonia, Kyrgyzstan, Tajikistan, and Lithuania. Contrast this with Moldova and Georgia where larger proportions of internationally co-authored papers from the research sector have a local corresponding author, when compared to the international collaborative output of the university sector.

A high share of international mega-collaborations in the WoS output of post-Soviet countries demonstrates the integration of researchers from these countries into global networks. Such collaborations can lead to major discoveries. At the same time, according to recent estimates, of all publications indexed in the WoS, only 1.7% of publications are affiliated with four or more countries, and only 0.01% of publications are affiliated with 30 or more countries (Adams et al., 2021; Potter et al., 2020). Most of the WoS publications with international co-authorship are publications with authors from two or three countries. The excessively high proportion of publications stemming from mega-collaborations in post-Soviet countries, often concentrated in one sector, might be due to the presence of extremely productive researchers at singular institutions, producing a lion's share of country's total output through mega-collaborations. Research sector is much more active in mega-collaborations than university sector in Armenia, Estonia, Azerbaijan, and Lithuania where more than a half to more than a quarter of all internationally co-authored publications from research sector are mega-collaborations. In contrast, in Georgia, Belarus, and Latvia, the bulk of university research output is produced by mega-collaborations.

There have been recent debates globally on whether research is and should be universities' core function (Dusdal et al., 2020; Marginson, 2021). A significant body of literature recognises the importance of universities' research function to the extent that systems which rely on strong university sectors are found to be more productive in terms of research output than systems which rely on research institutes. In the context of former Soviet countries which have limited funding for research, as well as in more generous funding environments such as Germany, universities and research institutes compete for a finite pot of research funding (Dusdal et al., 2020). The organisational separation of higher education and research leads to the dispersion of research funding to two sectors. The dispersion of funding reduces the chances of concentrating research within the higher education sector where the research activity is likely to feed into the educational activity and produce broader public benefits.

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## Declarations

**Conflict of interest** The authors have no conflict of interest to disclose.

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## References

- Abramova, M. A., & Krashennikov, V. V. (2017). Interaction of science and education in soviet and post-Soviet Russia (on the example of the Republic of Sakha, Yakutia). *HERJ Hungarian Educational Research Journal*, 7(4), 12–22.
- Adams, J., Pendlebury, D., Potter, R., & Szomszor, M. (2021). *Global research report multi-authorship and research analytics*. Institute for Scientific Information. [https://clarivate.com/wp-content/uploads/2021/02/ISI\\_-Multiauthorship\\_Global\\_Research\\_Report.pdf](https://clarivate.com/wp-content/uploads/2021/02/ISI_-Multiauthorship_Global_Research_Report.pdf)
- Boychev, H. (2019). An introduction to the complexities of the German research scene. *Nature*, 567(7749), S34–S35.
- Campbell, A., & Gherasimov, C. (forthcoming). Internalizing Research Capacity in Moldovan Universities: An Unfinished and Contested Project. In: M Chankseliani, I Fedyukin, & I Froumin (Eds) *Building Research Capacity at Universities: Insights from Post-Soviet Countries*. Palgrave
- Castells, M. (2017). Universities as Dynamic Systems of Contradictory Functions. In J. Muller, N. Cloete, & F. van Schalkwyk (Eds.), *Castells in Africa: Universities and development* (pp. 1–248). African Books Collective.
- Chankseliani, M. (2016). Escaping homelands with limited employment and tertiary education opportunities: outbound student mobility from post-soviet countries. *Population, Space and Place*, 22(3), 301–316.
- Chankseliani, M. (2018). The politics of student mobility: links between outbound student flows and the democratic development of post-soviet Eurasia. *International Journal of Educational Development*, 62, 281–288.
- Chankseliani, M. (2021). The politics of exporting higher education: Russian university branch campuses in the 'Near Abroad.' *Post-Soviet Affairs*, 37(1), 26–44.
- Chankseliani, M. (2022). *What Happened to the Soviet University? Looking to the Present Looking to the Past*. UK: Oxford University Press.
- Chankseliani, M., & McCowan, T. (2021). Higher education and the sustainable development goals. *Higher Education*, 81(1), 1–8.
- Chankseliani, M., & Silova, I. (2018). *Comparing Post-Socialist Transformations: Purposes, Policies, and Practices in Education*. USA: Symposium Books.
- Chankseliani, M., Lovakov, A., & Pisyakov, V. (2021a). A big picture: bibliometric study of the quantity, quality, and impact of academic publications from post-soviet countries. *Scientometrics*, 126(10), 8701–8730.
- Chankseliani, M., & McCowan, T. (2021b). Special issue higher education and the sustainable development goals. *Higher Education*, 81(1), 1–8.
- Chankseliani, M., Qoraboyev, I., & Gimranova, D. (2021c). Higher education contributing to the local, national, and global development: New empirical and conceptual insights. *Higher Education*, 81(1), 109–127.
- Chankseliani, M., Fedyukin, I., & Froumin, I. (Eds.). (forthcoming). *Building Research Capacity at Universities: Insights from Post-Soviet Countries*. Palgrave.
- CC of the CPSU, & Committee of Ministers of USSR. (1978). *Postanovlenie CK KPSS i Soveta ministrov SSSR ot 6 aprlja 1978 #271 «O povyshenii jeffektivnosti nauchno-issledovatel'skoj raboty v vysshih uchebnyh zavedenijah» [On increasing the efficiency of research work in higher educational institutions]*.
- David-Fox, M., & Péteri, G. (2000). *Academia in Upheaval: Origins, Transfers, and Transformations of the Communist Academic Regime in Russia and East Central Europe*. Connecticut: Bergin & Garvey.
- Dusdal, J., Powell, J. J. W., Baker, D. P., Fu, Y. C., Shamekhi, Y., & Stock, M. (2020). University vs research institute? the dual pillars of german science production, 1950–2010. *Minerva*, 58, 319–343.
- Frankel, M. S., & Cave, J. (1997). Introduction. In M. S. Frankel & J. Cave (Eds.), *Evaluating science and scientists: An East-West dialogue on research evaluation in post-communist Europe* (pp. 1–8). Central European University Press.
- Graham, L. R. (1992). Big science in the last years of the big soviet union. *Osiris*, 7(1), 49–71.
- Grančay, M., Vveinhardt, J., & Šumilo, E. (2017). Publish or perish: How Central and Eastern European economists have dealt with the ever-increasing academic publishing requirements 2000–15. *Scientometrics*, 111(3), 1813–1837.
- Heyneman, S. P. (2008). Three universities in Georgia, Kazakhstan and Kyrgyzstan: The struggle against corruption and for social cohesion. *Prospects*, 37(3), 305–318.
- Heyneman, S. P. (2010). A Comment on the Changes in Higher Education in the Post-Soviet Union. In I. Silova (Ed.), *Globalization on the margins: Education and post-socialist transformations in Central Asia* (pp. 27–40). Information Age Publishing.

- Hladchenko, M. (2020). Academic identities in Ukrainian research universities under conditions of means-ends decoupling at the state level. *Journal of Further and Higher Education*, 44(2), 244–257.
- Hladchenko, M., & Moed, H. F. (2021). The effect of publication traditions and requirements in research assessment and funding policies upon the use of national journals in 28 post-socialist countries. *Journal of Informetrics*, 15(4), 101190.
- Huisman, J., Smolentseva, A., & Froumin, I. (2018). *25 Years of Transformations of Higher Education Systems in Post-Soviet Countries—Reform and Continuity*. London: Palgrave Macmillan.
- Jalil, R., & Shamatov, D. (forthcoming). Trajectory of Evolution of Research Capacity at Higher Education Institutions in Kyrgyzstan. In: M. Chankseliani, I. Fedyukin, & I. Froumin (Eds.), *Building Research Capacity at Universities: Insights from Post-Soviet Countries*. Palgrave
- Jonbekova, D. (2018) Educational research in Central Asia: Methodological and ethical dilemmas in Kazakhstan, Kyrgyzstan and Tajikistan. Compare: A Journal of Comparative and International Education. 0(0) 1–19
- Karaulova, M., Shackleton, O., Liu, W., Gök, A., & Shapira, P. (2017). Institutional change and innovation system transformation: A tale of two academies. *Technological Forecasting and Social Change*, 116, 196–207. <https://doi.org/10.1016/j.techfore.2016.10.018>
- Kataeva, Z., & DeYoung, A. J. (2018). Faculty challenges and barriers for research and publication in Tajik higher education. *European Education*, 50(3), 249–265.
- Kerr, C. (1994). *Higher Education Cannot Escape History: Issues for the Twenty-First Century*. New York: State University of New York Press.
- Kwiek, M. (2012). Changing higher education policies: From the deinstitutionalization to the reinstitutionalization of the research mission in polish universities. *Science and Public Policy*, 39(5), 641–654.
- Lee, J. T., & Kuzhabekova, A. (2019). Building local research capacity in higher education: A conceptual model. *Journal of Higher Education Policy and Management*, 41(3), 342–357.
- Leisyte, L., Enders, J., & de Boer, H. (2009). The balance between teaching and research in Dutch and English universities in the context of university governance reforms. *Higher Education*, 58(5), 619–635.
- Lovakov, A., Panova, A., Sterligov, I., & Yudkevich, M. (2021). Does government support of a few leading universities have a broader impact on the higher education system? Evaluation of the Russian University Excellence Initiative. *Research Evaluation*, 30(3), 240–255.
- Marginson, S. (2021). Higher Education at the Core of Human Society. *UNESCO Expert Consultation on the Futures of Higher Education*. <https://www.iesalc.unesco.org/en/futures-of-higher-education/expert-consultations/>
- Moed, H. F., Markusova, V., & Aкоеv, M. (2018). Trends in Russian research output indexed in Scopus and Web of Science. *Scientometrics*, 116(2), 1153–1180. <https://doi.org/10.1007/s11192-018-2769-8>
- OECD. (2016). *OECD Reviews of Innovation Policy: Lithuania 2016*. Berlin: OECD Publishing.
- Panova, A., & Yudkevich, M. (2021). Research and Higher Education in Russia: Moving closer together. In T. Aarrevaara, M. J. Finkelstein, G. A. Jones, & J. Jung (Eds.), *Universities in the Knowledge Society The Nexus of National Systems of Innovation and Higher Education*. Berlin: Springer.
- Potter, R. W. K., Szomszor, M., & Adams, J. (2020). Interpreting CNCIs on a country-scale: The effect of domestic and international collaboration type. *Journal of Informetrics*, 14(4), 101075. <https://doi.org/10.1016/j.joi.2020.101075>
- Powell, J. J. W., & Dusdal, J. (2017). Science production in Germany, France, Belgium, and Luxembourg: comparing the contributions of research universities and institutes to science, technology, engineering, mathematics, and health. *Minerva*, 55(4), 413–434.
- Schiermeier, Q. (2019). Ukraine’s science revolution stumbles five years On. *Nature*, 566(7743), 162–163.
- Schimank, U., & Winnes, M. (2000). Beyond humboldt? The relationship between teaching and research in European university systems. *Science and Public Policy*, 27(6), 397–408.
- Sparks, J., Ashirbekov, A., Li, A., Parmenter, L., Jumakulov, Z., & Sagintayeva, A. (2015). Becoming Bologna Capable: Strategic Cooperation and Capacity Building in International Offices in Kazakhstani HEIs. In A. Curaj, L. Matei, R. Pricopie, J. Salmi, & P. Scott (Eds.), *The European Higher Education Area* (pp. 109–126). Springer International Publishing.
- Tamtik, M., & Sabzalieva, E. (2018). Emerging Global Players? Building International Legitimacy in Universities in Estonia and Kazakhstan. In M. Chankseliani & I. Silova (Eds.), *Comparing Post-Socialist Transformations: Purposes, policies, and practices in education* (pp. 129–148). Symposium Books.
- University of Tartu. (2021, July 5). *The First Autonomous Hydrogen Vehicle in the World Showcased in Tartu*. <https://www.ut.ee/en/news/first-autonomous-hydrogen-vehicle-world-showcased-tartu>
- USSR. (1989). *Narodnoe hozjajstvo SSSR. Statisticheskij ezhegodnik [National Economy of the USSR. Statistical Yearbook]*. <http://listmat.info/node/17055>