THE POST-SOVIET SOUTH: OIL, INNOVATION, AND SCIENCE

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ABSTRACT

The paper discusses the relationship between the development of the economy, the oil industry, science and innovation in the countries of the post-Soviet South (Central Caucaso-Asia, or Central Caucasasia).

The oil industry makes the oil-producing countries of Central Caucasasia relatively richer than those where oil is not produced (or produced in small amounts), but the development level of science in these countries is clearly insufficient for the sustainable development of the oil industry and these countries as a whole. This is demonstrated by the author based on economic and scientometric data for both oil-producing Azerbaijan, Kazakhstan, Uzbekistan and Turkmenistan and non-oil-producing Georgia, Armenia, Kyrgyzstan and Tajikistan. It is shown that scientific collaboration with Russia is probably more promising for the economy.

KEYWORDS: ***Central Caucaso-Asia/Central Caucasasia, GDP per capita, oil production, science, articles, patents, Scopus.***

Introduction

The early 21st century was a time of hope for rapid catch-up growth in the emerging countries of Asia. Following Japan, Singapore, Taiwan and South Korea, the economies of China, India, Malaysia and Thailand surged ahead, with Indonesia and Vietnam joining them in recent years. South of the post-Soviet Caucasus lies the Persian Gulf Basin, one of the main oil-and-gas-producing regions in the world. The Caspian Sea, which for a long time was an almost entirely (80-90%) internal Soviet sea, is itself traditionally rich in oil. The economic successes of the oil-producing countries of the Persian Gulf in recent decades are well known. As for the oil-producing countries of Central Caucasasia,[1] they have also "put their stakes on oil," and not without success. Do these stakes help to develop science in the countries of Central Caucasasia, and does science help to solve the problems of their oil industries?

The post-Soviet countries of the Central Caucasus[2] and Central Asia had a significant scientific and education potential after the breakup of the U.S.S.R. In the last years of its existence, Kazakhstan, Uzbekistan, Turkmenistan and, of course, Azerbaijan produced about 10% of Soviet oil,[3] while in the final year of Soviet rule they had a total population of 65 million, or about 22% of the U.S.S.R. population in 1991.

The Oil Economy of Central Caucasasia: Strong Ties

In 2016, the total population of Central Caucasasia was 84 million. How much has the economy of these countries grown since 1990 at constant prices?

Figure 1 shows that after the breakup of the U.S.S.R. all Central Caucasasian countries (except perhaps Uzbekistan) experienced a kind of economic shock, but by the early 2000s all of them gradually recovered from that shock. By 2016, their economies had grown compared to 1990, but not in all countries: growth in Tajikistan and Kyrgyzstan was minimal, while the Georgian economy never actually managed to reach the level of the Soviet period (in nominal terms).

Of course, it is difficult to determine how much richer a country has really become, because it is necessary to take into account population change over a long period. Figure 2 shows the data of Figure 1 correlated with population growth (GDP at 1990 prices, US dollars per capita).

The data of Figure 2 show that only Kyrgyzstan and Tajikistan still remain trapped in the "cycle of poverty" caused by the disruption of the very strong ties that existed in the Soviet economic system, on the one hand, and rapid population growth, on the other. Georgia has exceeded the Soviet level of GDP per capita partly due to a lower denominator: population size. Kazakhstan, Azerbaijan, Uzbekistan, Turkmenistan and Armenia have significantly improved their performance. Among them, only Armenia is not an oil-producing country.

For comparison, Russia's GDP at constant 1990 prices increased from $570.4 billion in 1990 to $649 billion in 2015.[4] This means growth was around 14%. Compared to 1990, Russia's population

[1] See: V. Papava, "'Central Caucasasia' instead of 'Central Eurasia'," *Central Asia and the Caucasus*, No. 2 (50), 2008, pp. 30-42.

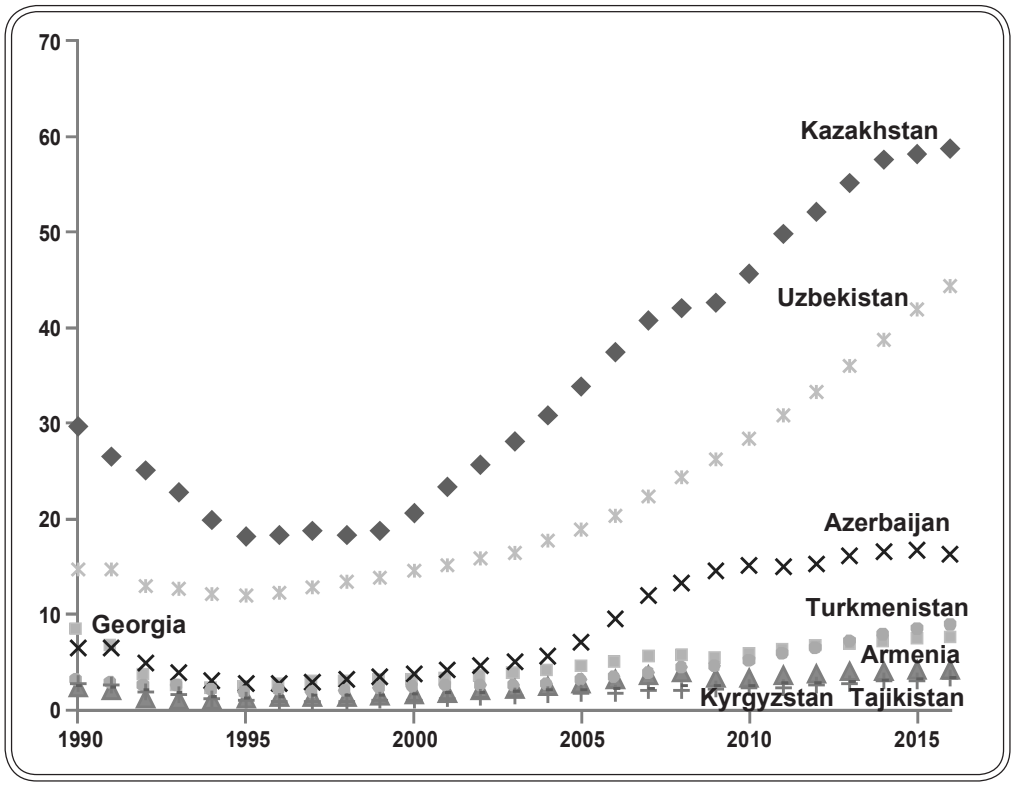
[2] See: E. Ismailov, V. Papava, "A New Concept for the Caucasus," *Southeast European and Black Sea Studies*, Vol. 8, No. 3, 2008, pp. 283-298.

[3] See: *Toplivno-energeticheskiy kompleks SSSR 1990 g.*, VNIIKTEP, Moscow, 1991.

[4] See: International Monetary Fund Database, available at [http://www.imf.org/external/pubs/ft/weo/2015/01/weodata/index.aspx], 1 February, 2018.

Figure 1

Economic Growth in the Countries of Central Caucasasia from 1990 to 2016
(GDP in billions of constant 1990 US dollars)



has slightly declined. In other words, the overall relative change in the economy of Russia is closest to that of Georgia.

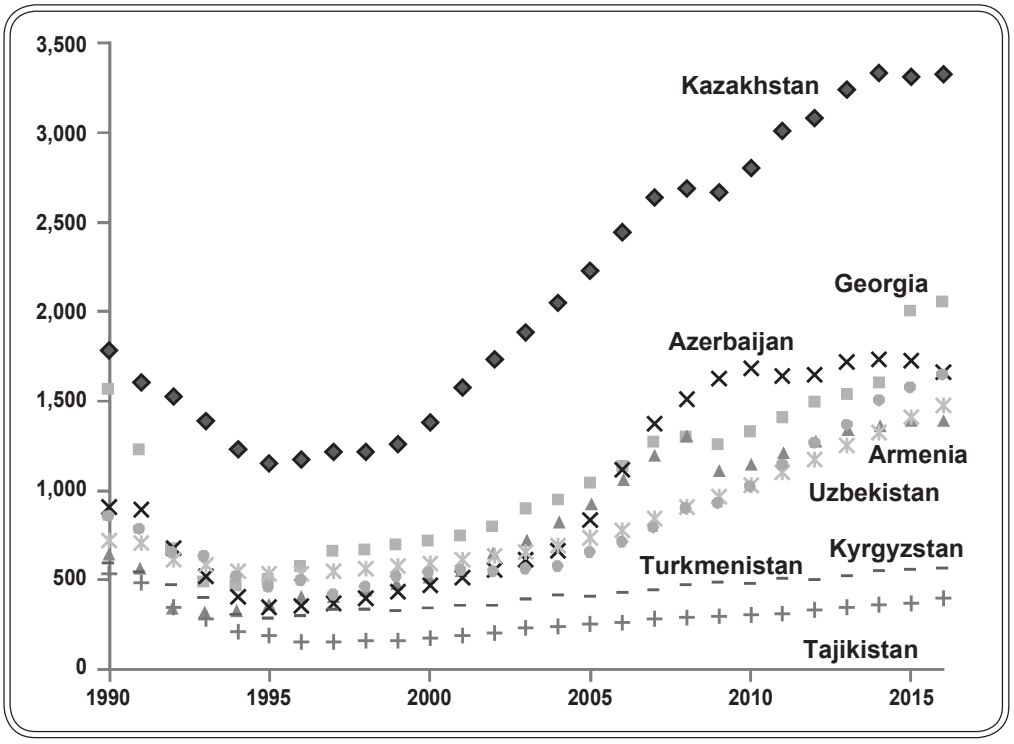
The post-Soviet improvement in the relative per capita wealth of Kazakhstan, Azerbaijan, Uzbekistan and Turkmenistan (as well as, incidentally, of Armenia) is much more significant than in Russia. Of course, these countries started from different levels. In 1990, GDP per capita in Russia ~~was almost $4 thousand, while in Kazakhstan~~ and G~~eorgia it was $1.8 thousand and $1.6 thousand,~~ respectively, and in each of the remaining countries in this group it was less than $1 thousand.

How successfully and effectively have the Central Caucasasian countries developed their oil industries?

Figure 3 shows the changes in oil production in Russia and the oil-producing countries of Central Caucasasia. Let us note the obvious fact that Russia's oil industry was practically the only one to experience a post-Soviet shock: from 1991 to 1996, oil production in the country fell by about a third, whereas in the post-Soviet South there was no significant decline in production, and Uzbekistan even increased its production until 1998 (though later it began to decline). Oil output in the remaining countries fluctuated around the Soviet level and then began to grow—in the late 1990s and early 2000s. The surge in production was particularly impressive in Azerbaijan: oil output more than tripled from 2004 to 2010.

Figure 2

GDP per Capita in the Countries of Central Caucasasia from 1990 to 2016
(in constant 1990 US dollars)



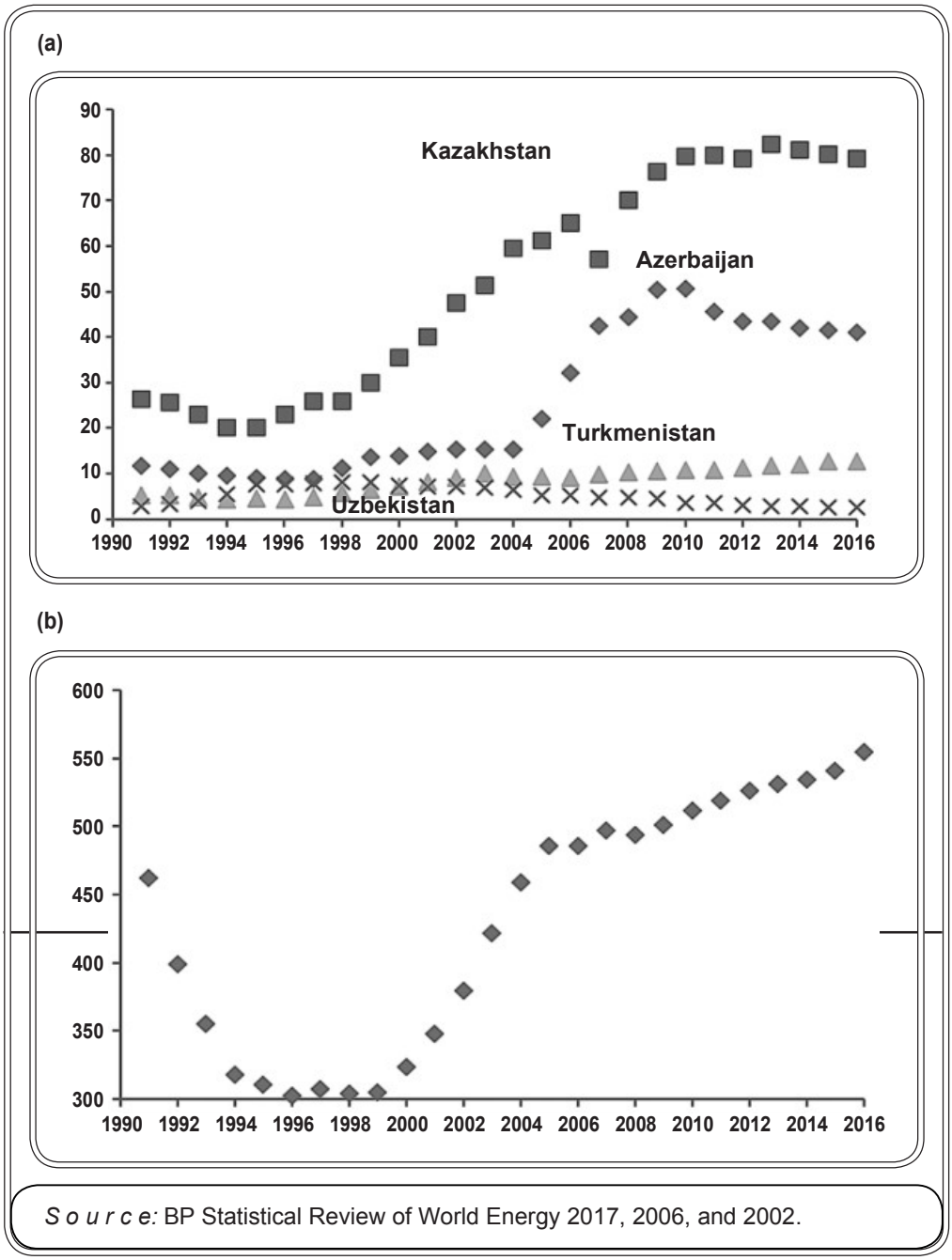
By 2016, oil production in the countries of Central Caucasasia reached a total of nearly 135 million tons, which amounts to at least 20% of all oil produced in the post-Soviet space. In the final years of the USSR, they produced 10% of the Soviet total. This means that in 26 years the oil dependence of these countries has doubled, although considering the total population of the Central Caucasasian countries it has not yet reached the Russian level: since 1990, the population of Russia has not increased, while the population of Central Caucasasia has increased very significantly. It is a different matter when we take into account only the main oil-producing countries: Kazakhstan, Azerbaijan and Turkmenistan. In 2016 Russia produced 3.7 tons per person, Kazakhstan 4.4 tons, Azerbaijan 4.3 tons, and Turkmenistan less than 2 tons. In other words, the economies of Kazakhstan and Azerbaijan are now more dependent on oil (oil-oriented) than the Russian economy. For comparison, in Angola, whose GDP in 2012 was 66% dependent on oil exports, this ratio in 2016 was only 3 tons per person, while in Saudi Arabia, the absolute champion in oil production in 2016, it was 18.6 tons (even though the country's oil industry accounts for only 45% of its gross domestic product—roughly the same as in Azerbaijan[5]). Saudi Arabia's proven oil reserves amount to about 267 billion barrels (15.7% of the world total[6]). Iran, a neighboring country of Central Caucasasia, produced about 2.7 tons per person in 2016.

[5] See: M. Efendiev, "Azerbaidzhan ne smog zabyt neft," Haqqin.az—information, analytical and monitoring portal, 30 September, 2015, available at [https://haqqin.az/news/54007], 1 February, 2018.

[6] According to BP Statistical Review of World Energy 2015.

Figure 3

Oil Production in the Countries of Central Caucasasia (a) and in Russia (b) *(million tons)*



Source: BP Statistical Review of World Energy 2017, 2006, and 2002.

Scientific Knowledge and New Technologies in the Oil Industry

With the development of shallow oil reserves, oil-producing companies have to drill deeper wells, which requires a constant influx of new and ever more sophisticated technologies based on scientific knowledge.

Even if current extraction technologies are still sufficient and accessible oil reserves are still abundant and can ensure an extensive increase in production for a long time to come, it is necessary to develop and upgrade innovative technologies in areas such as actual exploration and drilling, as well as in transportation, refining, storage, logistics, etc.

In the above case of abundant reserves and sufficient extraction technologies, it is nevertheless necessary to automate oil production to the utmost so as to reduce the labor intensity of these fairly hazardous processes (and this can be done endlessly, even to the point of creating cyber-physical systems for oil extraction and subsequent transportation, refining, storage and logistics).

Among the oil-producing countries of the Caspian (Central Caucasasia and Russia)—Russia, Kazakhstan, Azerbaijan, Turkmenistan and Uzbekistan—only the latter three have experienced population growth. For Russia and Kazakhstan, labor-saving technologies are highly relevant. At the same time, the development of automated systems requires a very high level of human potential, education and basic science, which is sometimes impossible to achieve with a high proportion of children and young people in the country. But such a level of human reproduction in turn requires a constant increase in revenue, inducing the oil industry to opt for extensive production. This option, however, poses threats and risks: de-innovatization of life in the country in general, growing dependence on world oil prices, increasing social inequality, and sociopolitical instability.

Today, virtually the entire oil industry is innovation-intensive, but how do the own innovations of Central Caucasasian countries contribute to its development? And does their oil wealth help to develop science? There are some doubts about this. Despite a developed network of scientific organizations in Uzbekistan inherited from Soviet times (in 2011, 317 organizations, including 80 higher education institutions,[7] engaged in research), research activity is relatively low: in 2011, only 556 patent applications were filed in the country (compared to 1,125 applications in 1994).[8] Moreover, about half of these applications were filed by non-residents of Uzbekistan.

The "Soft Power" of Science in the Oil-Producing Economies of the Post-Soviet South

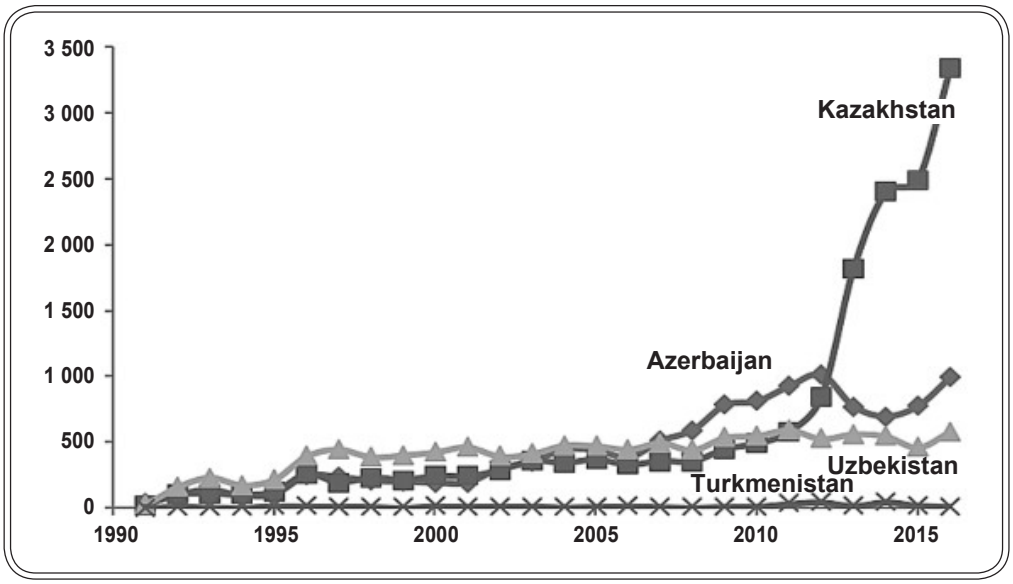
The basis for an analysis of the innovation economy is provided by scientific knowledge recorded in publications. Let us turn to basic science, to articles in journals included in international databases.

[7] See: M.A. Ikramov, A.M. Abdullayev, K.I. Kurpayanidi, "Nekotorye voprosy gosudarstvennogo reglamenta innovatsionnogo protsessa: zarubezhnyi opyt i praktika Uzbekistana," *Innovatsionnaia ekonomika: perspektivy razvitia i sovershenstvovania*, No. 3 (3), 2013, p. 202.

[8] See: L.Sh. Sultanova, M.A. Aidinova, "Znachenie kanalov transfera novykh tekhnologii dlia Uzbekistana," *Aktualnye voprosy sovremennoi nauki*, No. 1 (2, 3), 2014, p. 87.

Figure 4

Number of Articles in the Scopus Database from the Oil-Producing Countries of Central Caucasasia (1991-2016)



As we see, Kazakhstan has significantly increased its presence in Scopus (a global database of scientific publications) since the start of the current decade. True, 3.0-3.5 thousand articles per year cannot be regarded as a high level for a country with a population of 14 million. Russian researchers published 77.2 thousand articles in Scopus in 2016. At the same time, GDP per capita in Kazakhstan is comparable to that of Russia. Considering the difference in population size, a further increase in Kazakhstan publications in the global database to 6-7 thousand per year would be more in line with the country's economic strength.

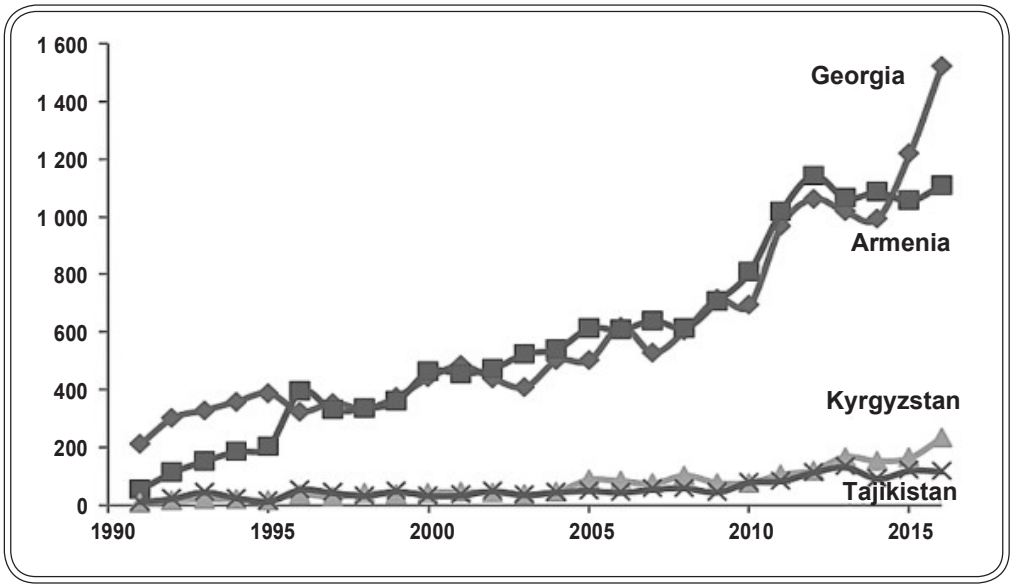
As for the other oil-producing countries of Central Caucasasia, in recent years they have shown only a modest increase in the number of Scopus articles or even a certain stagnation. Let us note that Uzbekistan reached a fairly high level of representation of its science in Scopus earlier than other countries, but this level increased insignificantly in 20 years.

For comparison, Figure 5 shows the dynamics of the number of scientific publications in the other, non-oil-producing countries of Central Caucasasia.

In Tajikistan and Kyrgyzstan, the development of world-class science is quite slow, while Georgia and Armenia demonstrate similar positive dynamics, with more Scopus articles than in Azerbaijan, although the population of each of these countries is only a third of the latter's. The ratio of the number of publications to population size in these countries is even higher than in Kazakhstan, the leader in the number of Scopus publications among the Central Caucasasian countries. Georgia in its international scientific collaboration is oriented towards the United States, and the percentage of articles co-authored by Americans has increased: from 22% in 1991-2000 to 35% in the last decade. Russia had the second largest presence in Georgian science at the end of the 20th century (8% of all joint articles), but today is has dropped out of the top three international collaborators: in the last decade, 22% of articles by Georgian researchers were written in collaboration with German researchers, and 21% with researchers from Britain. Whereas in the 20th century 55% of all articles in post-

Figure 5

Number of Articles in the Scopus Database from the Countries of Central Caucasasia Not Engaged in Active Oil Production (1991-2016)



Soviet Georgia were published independently, in recent years the figure is only 39%. In Armenia, the percentage of articles written in recent years without international collaboration is roughly the same. At the end of the 20th century, the top three countries collaborating with Armenia in this field were Russia (14% of all articles), Germany (12%) and the United States (11%), while 60% of all articles were written by Armenian researchers "on their own," and in the current decade the top three are Russia and the U.S. with 26% each and Germany with 24%. Tajik and Kyrgyz researchers have also actively internationalized their publications in recent years (since the end of the 20th century, the number of "national" publications has declined from 68% to 35% in Tajikistan and from 61% to 27% in Kyrgyzstan). The absolute leader in international scientific collaboration with these countries is Russia (in all periods), whose presence has somewhat declined (from 25% to 17%) in Tajik science and somewhat increased (from 16% to 20%) in Kyrgyz science. The United States and Germany were the second and third largest collaborators, respectively, in both Kyrgyz and Tajik science in the 20th century, but in the current decade the second place is held by Turkey in Kyrgyzstan and by Pakistan in Tajikistan (each with 15% of all publications).

In assessing the presence of foreign "soft" scientific power in the national science of the oil-producing countries of Central Caucasasia, we find that Turkey has been ahead of Russia and the United States in Azerbaijan in both the 20th century and today (and the share of joint publications with Turkish researchers has increased from 13% to 24%). The percentage of articles published by Azerbaijani researchers without international collaboration has been around 54% in recent years. Russia's share in the science of Kazakhstan is double that of the United States, its nearest "competitor," and four times higher than that of Germany, remaining at a steady level (16% at the end of the 20th century, and 14% in the current period). The situation in Uzbek science is similar: co-publications with Russia amount to 13% of all publications in recent years, although Germany has moved into second place with 9%.

Tables 1 and 2 show the level of spending on science and its patent productivity in the Central Caucasasian countries based on data from the World Bank, UNESCO and national statistical organizations; data on Turkmenistan not available.

Table 1

Research and Development Expenditure as a Percentage of GDP in the Countries of Central Caucasasia

Year	Kazakhstan	Georgia	Kyrgyzstan	Armenia	Azerbaijan	Tajikistan	Uzbekistan
1995	0.44	0.32	0.16	0.11	0.1	—	—
2000	0.18	0.22	0.16	0.19	0.34	0.11	0.36
2005	0.28	0.18	0.2	0.26	0.22	0.1	0.23
2010	0.15	0.12	0.16	0.24	0.22	0.09	0.2
2015	0.19	0.11	0.1	0.26	0.21	0.13	0.21

Source: Research and Development Expenditure (% of GDP): World Bank; United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics.

Table 2

Resident Patents in the Countries of Central Caucasasia

Year	Kazakhstan	Uzbekistan	Georgia	Azerbaijan	Armenia	Tajikistan	Kyrgyzstan
1993	3,223	2,136	502	221 (1995)	184	5	132
2000	1,399	755	232	165	119	80	80
2005	1,523	264	225	281	206	30	179
2010	1,691	370	183	254	136	7	134
2015	1,271	288	99	184	113	2	122

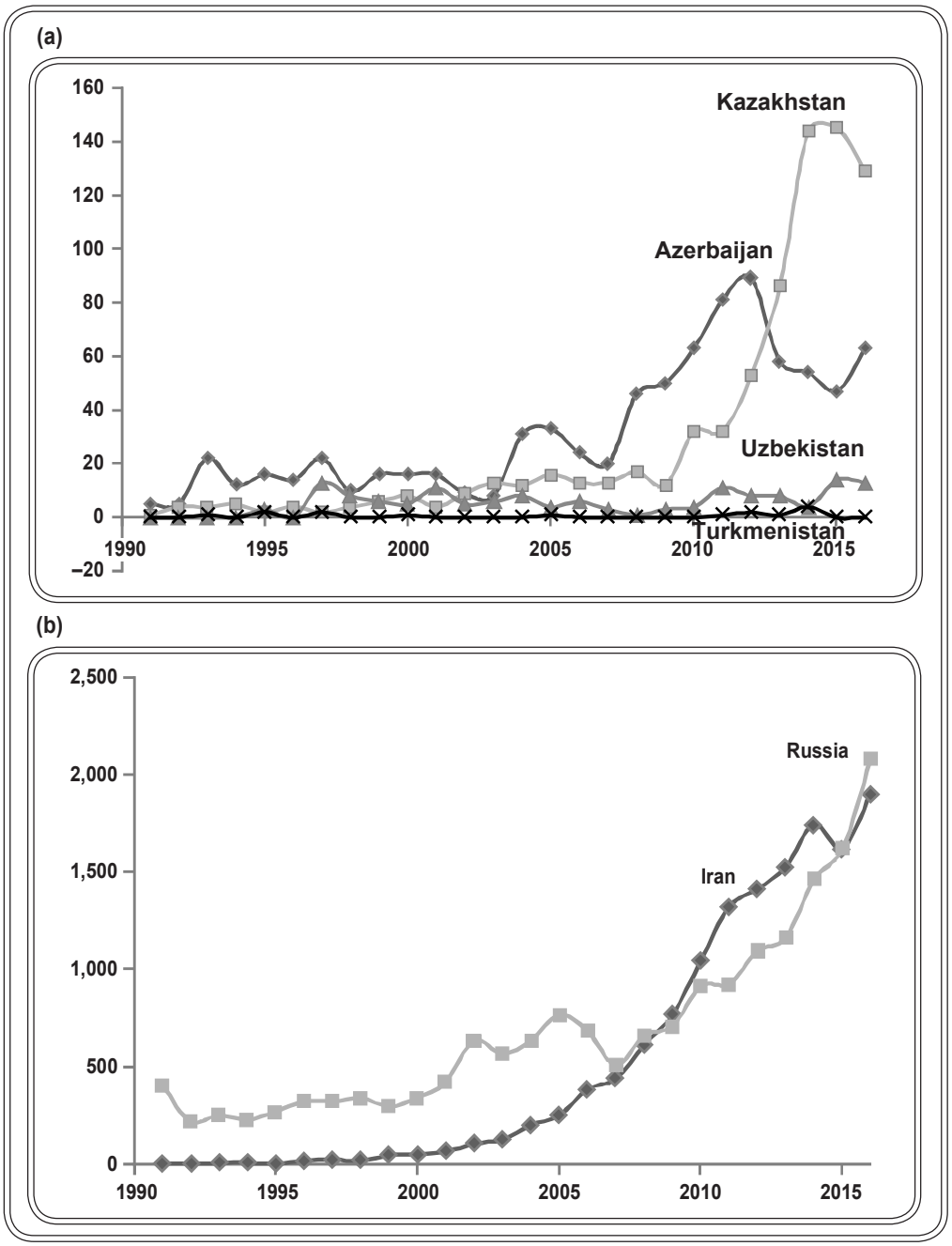
Source: Data of national statistical agencies from the Knoema World Data Atlas, available at [https://knoema.ru/atlas].

As we see from Tables 1 and 2, most of the countries in question have registered a rapid decline in inventive activity compared to the early post-Soviet years (it has remained at about the same level only in Armenia and Kyrgyzstan). The situation in Kazakhstan appears to be much better than in the other Central Caucasasian countries (in both absolute and relative terms). A similar downward trend is also characteristic of almost all Central Caucasasian countries (except Armenia and Azerbaijan) in R&D expenditure as a percentage of GDP. But research funding at 0.1%-0.3% demonstrated by the Central Caucasasian countries is 10 or more times lower than in the innovative economies of developed countries and 5 times lower than in Russia.

In other words, the recent increase in the number of Scopus publications from the Central Caucasasian countries is a consequence of the general trend towards globalization of national science, which has been particularly pronounced in the entire post-Soviet space in recent years, rather than actual development of science with a high-level basic and a sound applied component.

Figure 6

Number of Articles by Researchers from the Oil-Producing Countries of Central Caucasasia (a), Russia and Iran (b) Whose Titles, Abstracts and Keywords Include the Words "Oil" or "Petroleum"



A fact to be noted is that the curves of publication activity in Azerbaijan and Kazakhstan are similar to those of oil production (the more money, the greater the opportunities for funding science). In this context, let us take a look at Scopus articles on the topic of oil from the main oil-producing countries of Central Caucasasia and, for comparison, similar articles from Russia and Iran, a neighbor of Central Caucasasia in the Caspian region.

Figure 6(a) shows the dynamics of such articles in the countries of Central Caucasasia. Azerbaijan was the leader in the number of "oil" publications until 2012, but in 2013 Kazakhstan forged ahead, while the number of such publications by researchers from Azerbaijan declined.

Evidently, these countries have their own scientific and technological base for the solution of technical problems in the oil industry dating back to the days of the Soviet Union.

International Scientific Collaboration in the Oil Sector

The "orientation" of world science towards oil is around 2% (out of a total of 2.62 million publications in Scopus in 2015, 51 thousand contain the words "oil" or "petroleum" in their titles, abstracts and keywords). Thus, the share of "oil" publications in the science of Azerbaijan and Kazakhstan (5-6% in recent years) is three times higher than in Russia and the world at large, and about twice as high as in Iran. But since R&D expenditure as a percentage of GDP in these countries is less than a fifth of that in Russia, this level is clearly insufficient for the development of their own scientific and technological base, which is indirectly confirmed by the very significant decline in the number of patent applications compared to the early post-Soviet years.

In the post-Soviet period to 2016 (including 1991), a total of 1.75 thousand articles on oil were published by researchers in Azerbaijan, 1.28 thousand in Kazakhstan, 0.24 thousand in Uzbekistan, and only 34 in Turkmenistan (see Fig. 7).

Which foreign countries have been helping the oil-producing countries of Central Caucasasia to engage in "oil-oriented" science?

In 2010-2016, Kazakh researchers published 622 oil-related articles: 12% of these were written in collaboration with Russians, 10% with co-authors from the United States, and 3% with British co-authors, while 54% of all such articles were published without international collaboration.

In that period, Azerbaijanis published 455 "oil" articles: 7% with researchers from the United States, 3.5% with those from Russia, and 3.1% from Germany, while 78% of the total were published without international collaboration.

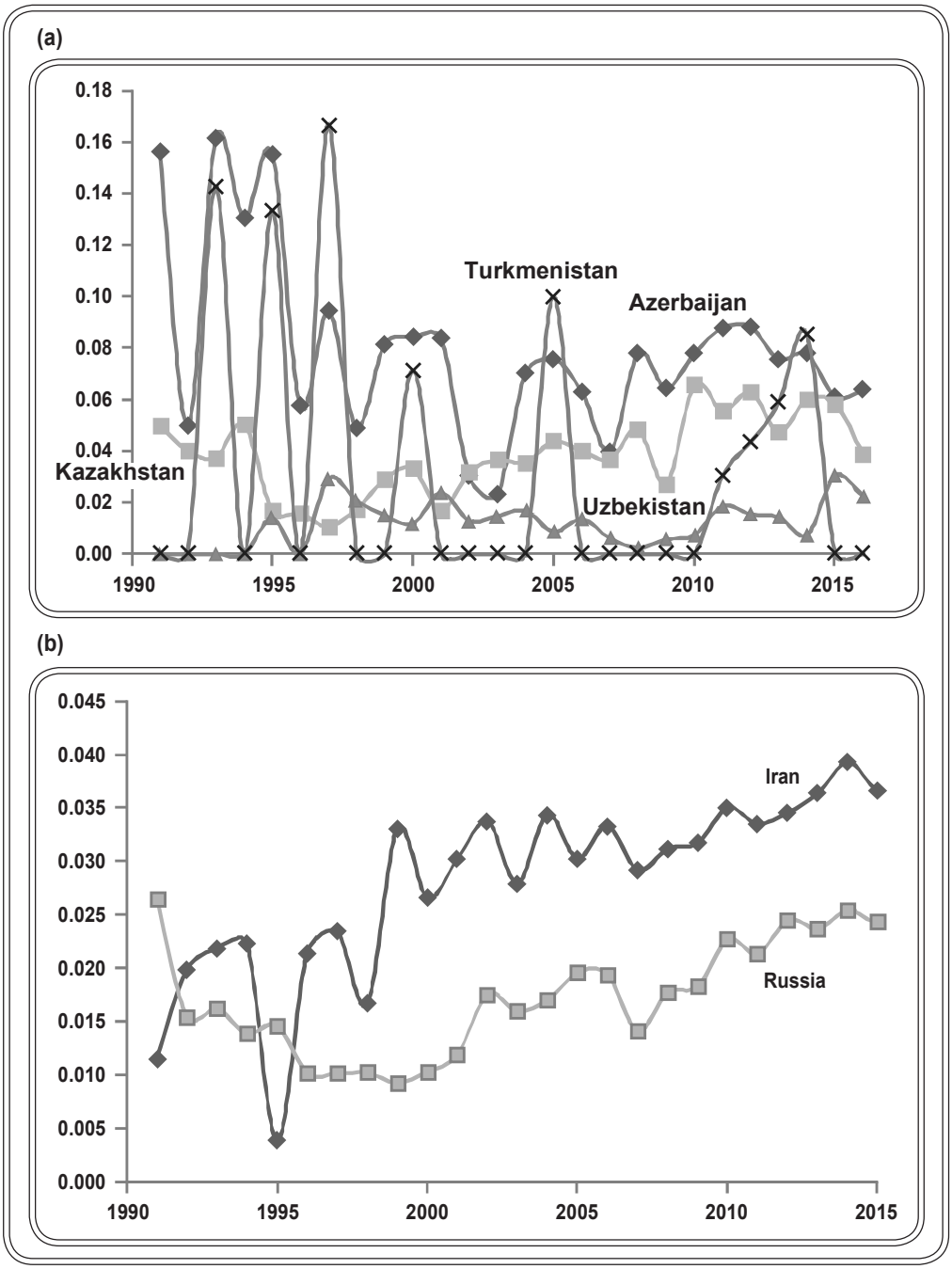
As for Uzbek researchers, they published only 58 articles on oil in that period: researchers from Germany and the United States each co-authored 7% of the total; 3.5% were written in collaboration with Russians, and 3.1% with researchers from Israel; 64% of all such articles were published without international collaboration.

International collaboration in Kazakhstan's oil sector (both production and research) is more active than in the other oil-producing countries of Central Caucasasia and is oriented towards Russia. At the same time, Azerbaijan, whose oil research and production is more Western-oriented, has experienced a decline in oil production in recent years. The contract with an international consortium for the development of three major fields (discovered, incidentally, by Soviet geologists) ends in 2024, and no new large oil fields have been discovered.[9] Western companies come and go without concern for the country's welfare or its future, which is the exclusive responsibility of the state.

[9] See: A. Zyutin, "Bogatoe neftianoe proshloe. Kak uglevodorody dvazhdy izmenili Azerbaijan," *Kommersant*, 11 March, 2017.

Figure 7

Share of Publications on Oil in the Scopus Database from the Countries of Central Caucasasia (a), Russia and Iran (b) in 1991-2016



Conclusion

Oil wealth has undoubtedly helped to improve the welfare of the oil-producing countries of Caucasasia, but insufficient investment in national science (and, let us add, in technology) is a visible threat to the future of this welfare. The situation in Kazakhstan, which is naturally oriented towards Russia and has maintained and developed scientific and technological ties with it, is better in this respect, both currently and from a strategic perspective. The prospects of the oil industry in Azerbaijan are quite worrying, because its oil fields, discovered back in Soviet times, are gradually running out, while the competition for market share in the period of unstable prices is intensifying. Azerbaijan has succeeded in attracting foreign capital and quickly developing its rich oilfields, but the development of its own scientific and technological base for the oil industry seems to be stagnating, whereas the situation calls for innovative solutions directly linked to the country's future welfare, which, in effect, is of little interest to concessionaires from Far Abroad countries. Turkmenistan, which has virtually no world-class science of its own, is also in a strategically dangerous situation.

From a scientific perspective, the countries of Caucasasia have different political leanings similar to those in foreign policy and economic cooperation. Science, including oil research, is in this respect a kind of marker of deep geopolitical affinity. Evidently, in long-term mineral resource development it is better for a country to collaborate with its closest neighbors and traditional partners.