Translation

The following report by a Russian AI think tank provides an overview of Russia's AI landscape as of the end of 2020. The authors argue that the Russian AI industry is lagging relative to other countries, and recommend a three- to five-fold increase in Russian AI research funding.

Title
Artificial Intelligence Almanac: 2020 Index Report
ИСКУССТВЕННЫЙ ИНТЕЛЛЕКТ АЛЬМАНАХ Индекс 2020 года

Author
National Technology Initiative (NTI) Competence Center for Artificial Intelligence at the Moscow Institute of Physics and Technology (MIPT)

The Russian source text is available online at: https://www.aireport.ru/ai_index_2020
U.S. $1 ≈ 74 Russian rubles (RUB), as of December 6, 2021.

Translation Date	Translator	Editor
December 6, 2021	Etcetera Language Group, Inc.	Ben Murphy, CSET Translation Manager

ALMANAC

ARTIFICIAL INTELLIGENCE

2020 Index Report

Analytical Digest No. 8

APRIL 2021

This year, we have also posted the baseline data for the report that we collected from various sources. You can view the data at: www.dropbox.com/sh/qtztcyw1sfvuqqv/AAA5UoaU40Uu7nZaLt1qwA3Ha?dl=0.

Electronic Version

www.AIreport.ru

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ARTIFICIAL INTELLIGENCE

2020 Index Report

Analytical Digest

Moscow / No. 8 / April 2021

The NTI Competence Center for Artificial Intelligence

MINISTRY OF ECONOMIC DEVELOPMENT OF THE RUSSIAN FEDERATION

Igor Pivovarov

Chief Analyst at the NTI Center for Artificial Intelligence at the MIPT, a member of the NTI Neuronet Working Group, a member of the Expert Council for Innovative Development under the Ministry of Economic Development of the Russian Federation (AI Team), a member of the Expert Council for Research and Technology Development and Intellectual Property under the State Duma Research and Training Committee of the Federal Assembly of the Russian Federation, General Director of IP Laboratory LLC, host of the Open Conference on Artificial Intelligence OpenTalks.AI.

From our Editor-in-Chief:

A year has passed since our first publication, the Almanac 2019 Index Report. In that issue, for the first time, we tried to put together all the information about the AI industry that we could find so that we could analyze it and publicly share our findings. Now, a year later, relying on that information, we are able to evaluate the past year.

The year has not been an easy one: We have all been affected by the global COVID-19 pandemic. Much of our regular life and work has been disrupted, many people lost their jobs, and many companies suffered losses. Some industries have found themselves in crisis, whereas others have been on the rise.

As for the global AI industry, it has been barely affected by the pandemic. In fact, the pandemic has been nothing short of a boon for tech companies. Not so much in Russia, though, where no such AI growth has been reported. The reason is, primarily, that we have been too slow to act. And we've got to be proactive!

We, analysts, are like physicians: We collect evidence and statistics, diagnose conditions, and recommend remedies. We do not worry about whether our clients will like our reports or not. All we want is to continue providing accurate and objective reporting and commentary on the industry.

In the last report, we provided many recommendations. Unfortunately, almost all of them are still valid, and we have had to include them in this report as well.

We hope that, with the adoption of the Federal Artificial Intelligence Project, things will start changing and moving faster. We look forward to hearing our researchers speak annually at conferences and to seeing our new startups dazzle us with their new technologies, which will, hopefully, attract large companies!

We welcome your comments and suggestions, and we look forward to discussions on any platforms. For it is through the forum of discussion that we can find ways to move faster and more efficiently!

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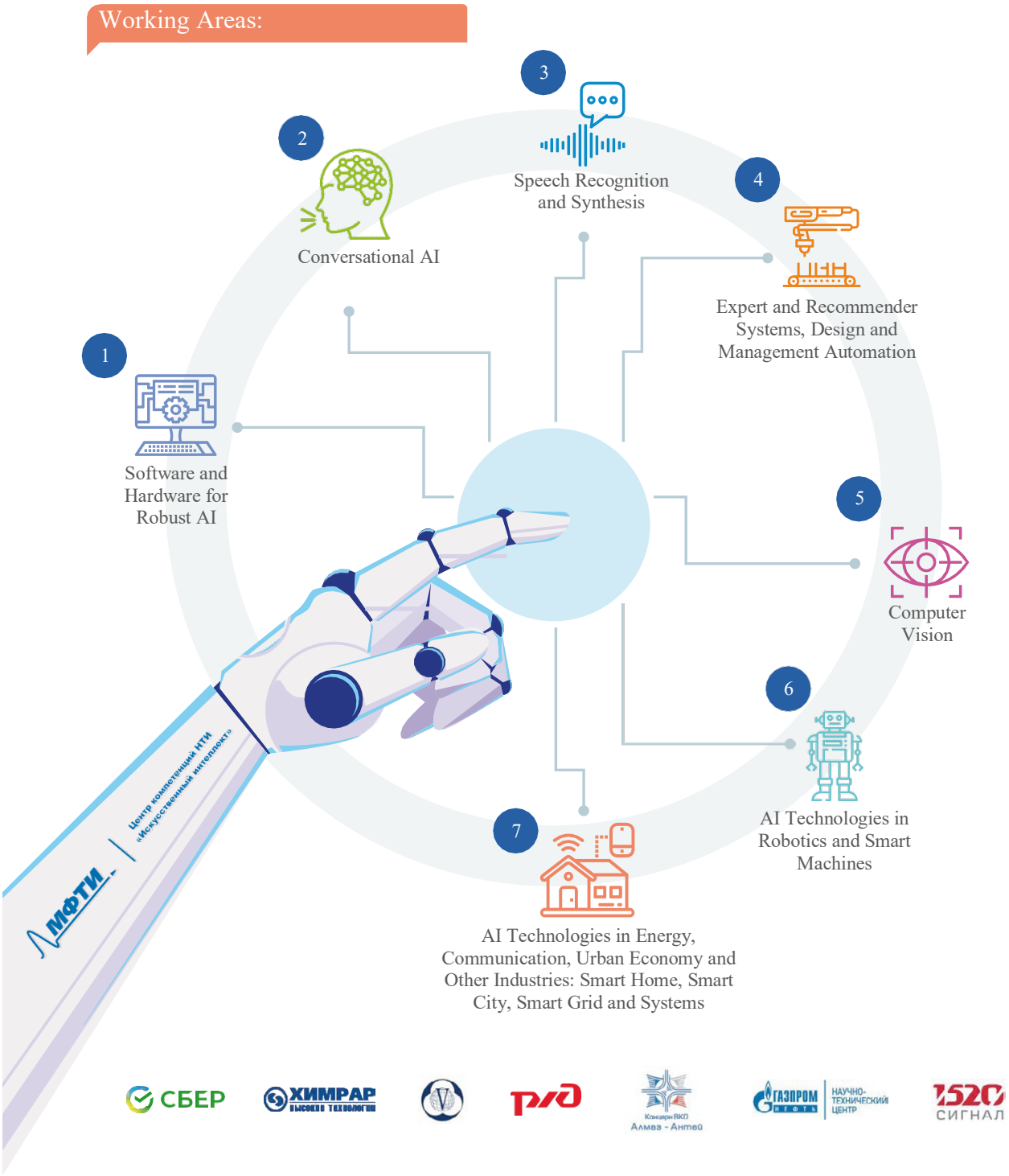
The National Technology Initiative Competence Center for Artificial Intelligence at the MIPT

The Center's operations include R&D, marketing, development, and implementation of undergraduate, graduate, and continuing education programs in the fields of AI and IT Business. The Center is also involved in developing information infrastructure and industry analytics.


Working Areas:
1
Software and Hardware for Robust AI
2
Conversational AI
3
Speech Recognition and Synthesis
4
Expert and Recommender Systems, Design and Management Automation
5
Computer Vision
6
AI Technologies in Robotics and Smart Machines
7
AI Technologies in Energy, Communication, Urban Economy and Other Industries: Smart Home, Smart City, Smart Grid and Systems
МФТИ
Центр компетенций НТИ «Искусственный интеллект»
СБЕР
ХИМРАР
Концерн ВКО Алмаз - Антей
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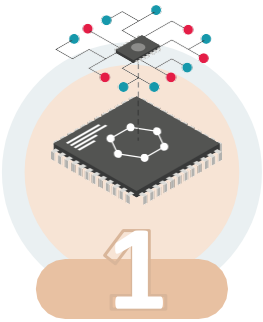
1520 СИГНАЛ

Profile Departments

Laboratories

R&D Centers

Engineering Centers



Microprocessor Technology

Completed 8 projects in 2019–2020; **14 ongoing projects** as of 2021.

We have been involved in creating **49 objects** of intellectual property.

In addition to **12 license agreements.**

Our educational efforts:

In **2018–2020,** we developed:

- The Center's Educational Programs – more than 300 specialists.
- Continuing Education Programs – more than 650 specialists.

+

- **5** new master's programs
- **2** undergraduate and graduate academic disciplines
- **4** afterschool programs for children and continuing education programs for adults
- **3** educational organizations for students (school/afterschool programs)
- **3** professional training/retraining programs
- **10** advanced training programs

Key Highlights of 2020

In this section, we provide the main figures discussed in this Report and the key AI trends in Russia and worldwide.

Science

No. 23
is Russia's global ranking for AI conference publications.[14]

1,120
papers published in peer-reviewed journals in 2020.[14]

We have assessed the status of R&D activities based on the citation data for the top conference publications and peer-reviewed journals, in addition to the number of articles on arXiv.org and in open-source repositories on GitHub.

Russia has risen to No. 23 in the global ranking of AI conference publications. However, in other categories, its rankings have somewhat dropped.

Business

RUB 291.5 billion
is the estimated size of the Russian AI market.*[21, 22]

×7.5
is a factor by which the 2019 growth rate of the Russian AI market exceeded that of the national GDP.[21, 22]

We have estimated the total number of companies whose business models and revenues have been significantly influenced by AI technologies.

We have found that there are about 480 such companies in Russia. We have estimated the size of the AI market in Russia based on the total corporate revenues for 2019. Compared to the growth of the entire economy, the AI market has grown 7.5 times faster!

Startups & Investment

-63%
is the drop in VC in 2020.[23]

USD 84 million
of VC investments in 2020.[23]

Startup investments in 2020 shrank by 46% in terms of the number of deals and by 61% in investment volume. This is largely due to the COVID-19 pandemic. However, there may be some deeper trends here as well. In 2020, there was only one startup exit (acquisition) totaling U.S. $2.5 million.

Conclusion: 2020 became almost disastrous for the Russian venture capital (VC) sector.

Government

RUB 8.7 billion
was spent by the government on AI in 2018–2020.

×35
is a factor by which the Russian government's AI-related spending is less than that of China, in % of GDP.

Government AI spending in Russia over the past three years has amounted to about RUB 8.7 billion. Russia's spending is about 350 times lower than that of China and, as % of its national GDP, it is 35 times lower, even though Russia's GDP is only about 10 times lower than that of China.

Government spending also includes any AI-related government procurement regulated under Federal Laws (FL) No. 44 and No. 223. Over the past three years, the total government spending has come to be on par with direct investments in the AI industry, which is about RUB 2.4 billion.

Education

~3,500
students graduated with B.A. and M.A. diplomas from the top 6 universities in 2020.[32]

No. 1
is Russia's global ranking for AI competence and qualifications.[34]

Despite the 50,000 or so students graduating in Russia each year in specializations related to AI, our country continues to lack IT specialists.

Having examined Russian developer teams and their qualifications, we have concluded that only those who have graduated from the top six universities and have such qualifications would be able to meet the current job requirements. And there are only about 2,000 such graduates each year.

On the other hand, in terms of AI-related skills and qualifications, Russian specialists ranked No. 1 globally in such qualifications.

Job Market

~5,000
Data Scientists was the chronic staff shortage in the Russian market in 2020.[36]

×4
is the factor by which the number of AI jobs available in Russia are less than those available in the U.S.[36, 39]

Having estimated the number of available jobs and created résumés (CVs) in the areas related to artificial intelligence, we have concluded that, despite the annual influx of fresh college graduates, the Russian market continues to experience a chronic staffing shortage of at least 5,000 specialists.

Moreover, interestingly, the U.S. share of available AI jobs is 4 times higher than that of Russia (relative to the total pool of job offers).

Grigory Sapunov

CTO, Intento

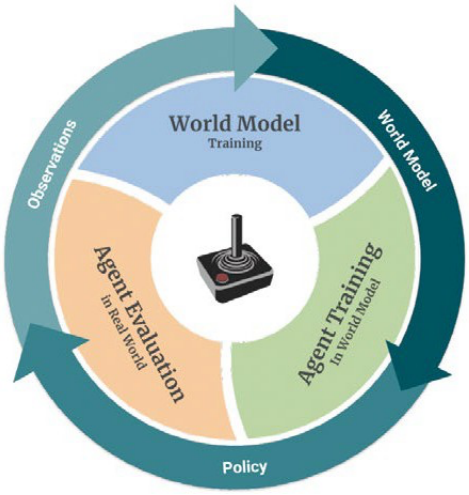
Major AI Events of 2020

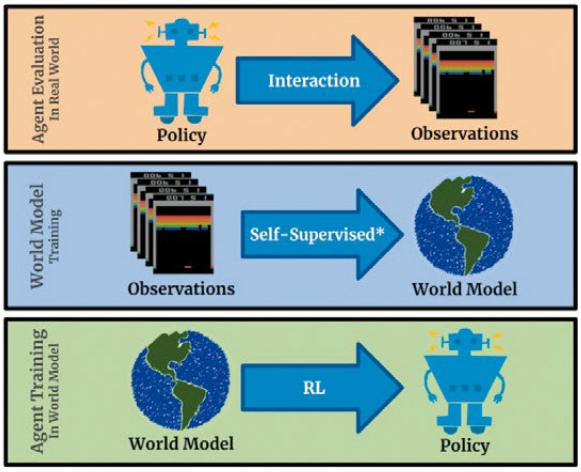
2020 saw the Cambrian explosion in the transformer camp and the unveiling of huge neural network models. Many architectural innovations, combined with the constantly evolving hardware, have ensured enhanced results on numerous benchmarks and tasks, many of which have practical applications. Moreover, in some cases, these models are so large and require so much computing power that only large companies are able to reproduce them. This means an increased inequality in the area. Competition among the national leaders has also been escalating.

Scientifically speaking, the most notable progress has been shown in the field of NLP: namely, computer vision, as an area of application and product development, and reinforcement learning, as a hugely promising model. Particularly noteworthy is the growing application of machine learning and artificial intelligence in the sciences, especially in biology and medicine.

WORLD MODELS

The recent outcomes of using model-based reinforcement learning (SimPLe, Dreamer V1/V2) have demonstrated its ability to yield the best results and its strong prospects. When compared to more traditional approaches without environmental models, such systems can learn using their own "imagination," while requiring significantly less real data.

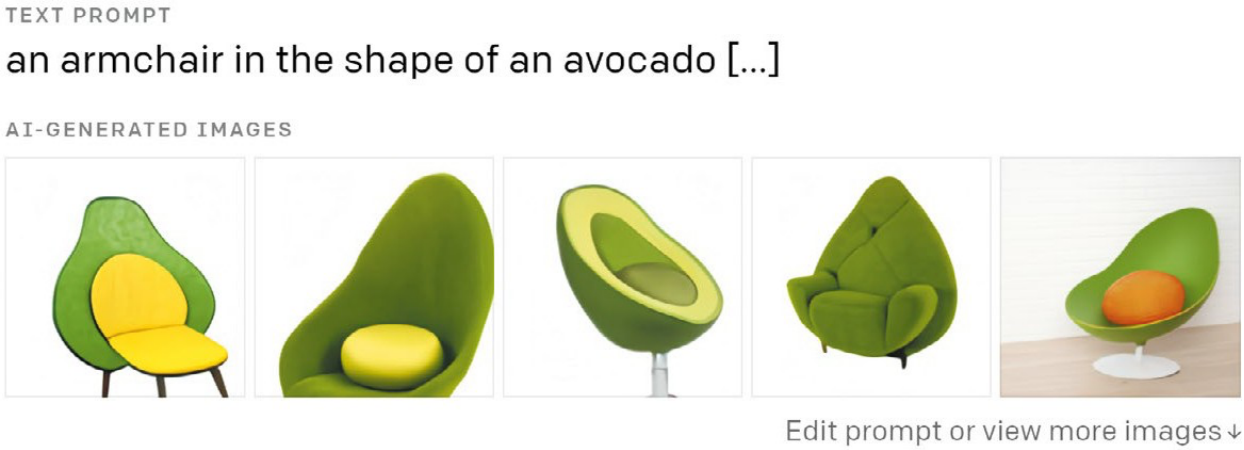




TRANSFORMERS EVERYWHERE

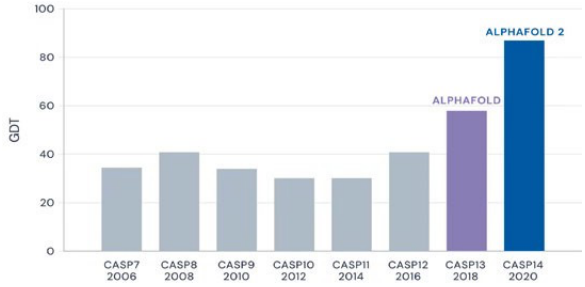
Transformers are expanding from text to other fields. This year, we have had many interesting results for images (DALL·E, ImageGPT, Vision Transformer (ViT), etc.) and other types of data,

including, it seems, the story with AlphaFold 2. Moreover, thanks to the numerous architectural improvements, transformers can be even more computationally efficient (Big Bird, Linformer, Longformer, etc.), capable of handling larger data sets.

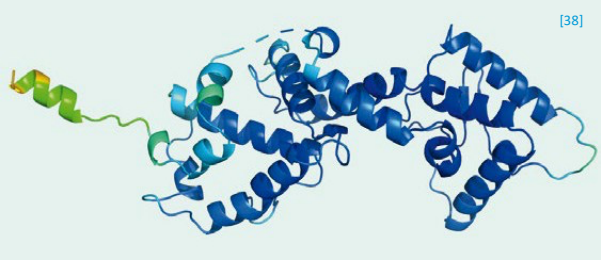


IMAGENET MOMENT IN BIOLOGY

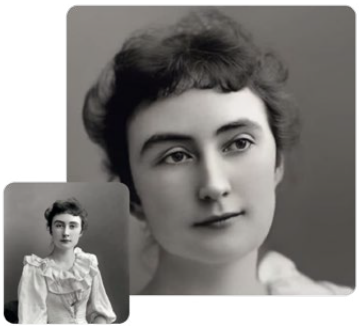
Median Free-Modeling Accuracy[1]



One of the most striking achievements has been that of DeepMind, which confidently prevailed in the so-called “scientific world championship” for the assessment of protein structure prediction (CASP). In addition, a substantial number of studies on predicting drug properties, analyzing genomic data, and processing and analyzing biomedical images have been published in the past year.



CONTENT GENERATION


[2]

The technologies for creating more realistic fakes continue to evolve. Deep Nostalgia from MyHeritage lets you animate the faces of your deceased relatives. Deepfakes are gradually coming to television: The fake Queen of Great Britain congratulated viewers during Christmas, and a news release with a generated presenter was published in Korea. The fake Tom Cruise has appeared on TikTok, and services for removing women's clothes periodically appear online.

GPT-3 AND HUGE MODELS

The last year also saw the shattering performances by many huge language models, most famously by GPT-3 from OpenAI. Nowadays, scaling may vacillate from models with tens (easy-peasy!) to hundreds of billions of parameters (at times, even trillions, although such comparisons may not be exactly appropriate, as with the Switch Transformer).

The paradigm of working with such models has also been changing. They need neither to be trained (there won't be enough resources!), nor to be fine-tuned (since loading them may not always be feasible). These days, the model needs to be "persuaded" to produce the results you need. Some call it, albeit half-jokingly, Software 3.0.

One-shot [3]

In addition to the task description, the model sees a single example of the task. No gradient updates are performed.

```
1  Translate English to French:      <-- task description
2  sea otter => loutre de mer        <-- example
3  cheese =>                         <-- prompt
```

MULTI-LANGUAGE

NLP has finally ceased to be an Anglocentric field when all the major advances support only English. Nowadays, we have many multilingual models that support tens, even hundreds of languages (mT5, mBERT, mBART, M2M-100, XLM/XLM-R, T-ULRv2, etc.), versions of large models for other languages (ruGPT-3, Chinese CPM), and non-English multilingual benchmarks (Russian SuperGLUE, XGLUE, XTREME).

SUPERGLUE

In the beginning of 2021, two models at once crossed the human quality threshold in the SuperGLUE benchmark. Only two years earlier, SuperGLUE had replaced GLUE, which had become too simple for many models. Seems like SuperGLUE itself will be soon replaced with the next new thing.

Rank	Name	Model	URL	Score	BoolQ	CB	COPA	MultiRC	ReCoRD	RTE	WiC	WSC	AX-b	AX-g
1	DeBERTa Team - Microsoft	DeBERTa / TuringNLRv4		90.3	90.4	95.7/97.6	98.4	88.2/63.7	94.5/94.1	93.2	77.5	95.9	66.7	93.3/93.8
2	Zirui Wang	T5 + Meena, Single Model (Meena Team - Google Brain)		90.2	91.3	95.8/97.6	97.4	88.3/63.0	94.2/93.5	92.7	77.9	95.9	66.5	88.8/89.9
3	SuperGLUE Human Baselines	SuperGLUE Human Baselines		89.8	89.0	95.8/98.9	100.0	81.8/51.9	91.7/91.3	93.6	80.0	100.0	76.6	99.3/99.7
4	T5 Team - Google	T5		89.3	91.2	93.9/96.8	94.8	88.1/63.3	94.1/93.4	92.5	76.9	93.8	65.6	92.7/91.9
5	Huawei Noah's Ark Lab	NEZHA-Plus		86.7	87.8	94.4/96.0	93.6	84.6/55.1	90.1/89.6	89.1	74.6	93.2	58.0	87.1/74.4
6	Alibaba PAI&ICBU	PAI Albert		86.1	88.1	92.4/96.4	91.8	84.6/54.7	89.0/88.3	88.8	74.1	93.2	75.6	98.3/99.2
7	Tencent Jarvis Lab	RoBERTa (ensemble)		85.9	88.2	92.5/95.6	90.8	84.4/53.4	91.5/91.0	87.9	74.1	91.8	57.6	89.3/75.6
8	Zhuiyi Technology	RoBERTa-mtl-adv		85.7	87.1	92.4/95.6	91.2	85.1/54.3	91.7/91.3	88.1	72.1	91.8	58.5	91.0/78.1
9	Infosys : DAWN : AI Research	RoBERTa-iCETS		85.0	86.2	93.2/95.2	91.2	84.6/53.4	89.9/89.3	88.5	72.1	89.0	35.2	93.8/68.8
10	Facebook AI	RoBERTa		84.6	87.1	90.5/95.2	90.6	84.4/52.5	90.6/90.0	88.2	69.9	89.0	57.9	91.0/78.1

HARDWARE INNOVATIONS


[7]

More specialized processors for AI have already been marketed, with more to come. Mostly, but not always, these are ASICs used for accelerating matrix operations. Google TPU already exists in the fourth generation (yet to be officially announced). In addition to Google, the players include Intel (Habana), Amazon, Graphcore, Cerebras, Groq, Alibaba, Baidu, Huawei, and others. Another, more exotic and breakthrough area of intense research has been neuromorphic chips: Chinese Tianjic, Intel Loihi, IBM TrueNorth, and Russian Altai. Besides, the good old GPUs are still keeping pace: NVIDIA has released its Ampere Architecture, Intel has new GPUs, and AMD seems to have some interesting solutions.

ETHICAL ISSUES

On the Dangers of Stochastic Parrots: Can Language Models Be Too Big?

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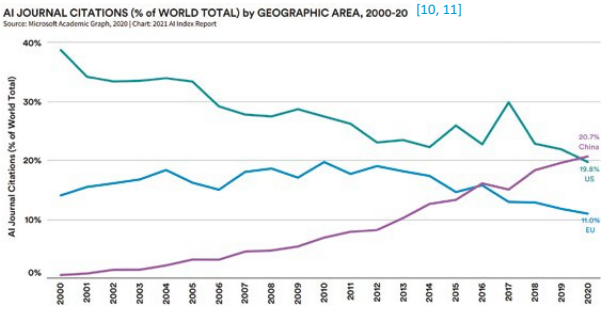
The Aether

The potential ethical issues have been increasingly discussed. The firing of Timnit Gebru from Google's Ethical AI Team last year generated a lot of buzz, raising all kinds of questions regarding large language models. The image dataset TinyImages was permanently removed due to some racist and misogynistic content. Biometrics and facial recognition continue to raise many unique ethical concerns.

AI ARMS RACE BETWEEN THE U.S. & CHINA



[10, 11]

Tensions between the U.S. and China continue threatening the relationship between the two AI powerhouses.

According to the AI Index 2021 Report, Chinese researchers have significantly increased the quantity and quality of their research studies and have now taken the lead in journal citations. In the total number of journal publications, Chinese researchers had surpassed even earlier. The U.S. continues to dominate in conference paper citations.

The newly published report from the U.S. National Security Commission on Artificial Intelligence offers some tips on how to win this race.

+ AI INEQUALITIES

Large-scale AI is turning into a club for the elite. Training heavy models may cost up to hundreds of thousands, even millions of dollars. The learning hardware focuses on supercomputer systems and data center-scale systems, which only very large companies can afford. Not everyone can reproduce the latest scientific results.

01. Science

We have assessed the status of R&D activities based on the citation data for the top conference publications and peer-reviewed journals, in addition to the number of articles on arXiv.org and in open-source repositories on GitHub.

Russia has risen to No. 23 in the global ranking of AI conference publications. However, in other categories, its rankings have somewhat dropped.

No. 23

is Russia's global ranking for AI conference publications.[14]

1,120

papers published in peer-reviewed journals in 2020.[14]

This Chapter was prepared in collaboration with

Skoltech
Skolkovo Institute of Science and Technology

1.1 Conference Publications

In this section, we discuss trends in Russian researchers' publications at leading world conferences for 2015–2020.

The most important papers in the field of machine learning have now been published not in peer-reviewed journals but at leading conferences. Selected papers are published as reports and/or posters at the conferences themselves and, most importantly, as part of conference paper digests. Such papers tend to be cited several times more often than those published in journals.

Figure 1 shows publication trends among Russian researchers for all AI conferences over the years, in absolute terms and as a percentage of world publications.

As we can see, Russian researchers' publication output had been growing for several years. However, about 4 years ago, the growth stopped, and, since then, their publication output has remained somewhat the same.

416
publications at AI conferences in 2020.[14]

30
publications at A* conferences in 2020.[15]

The ranking of the conferences has been established by the Australian Computer Research Association (CORE). All conferences are ranked from A* to C:

A* An industry-leading flagship conference.

A An excellent conference, highly respected in its industry.

B A good conference, with a good reputation in its industry.

C Other conferences that meet the minimum requirements.

Figure 1. Number of Russian publications at all AI conferences [14]

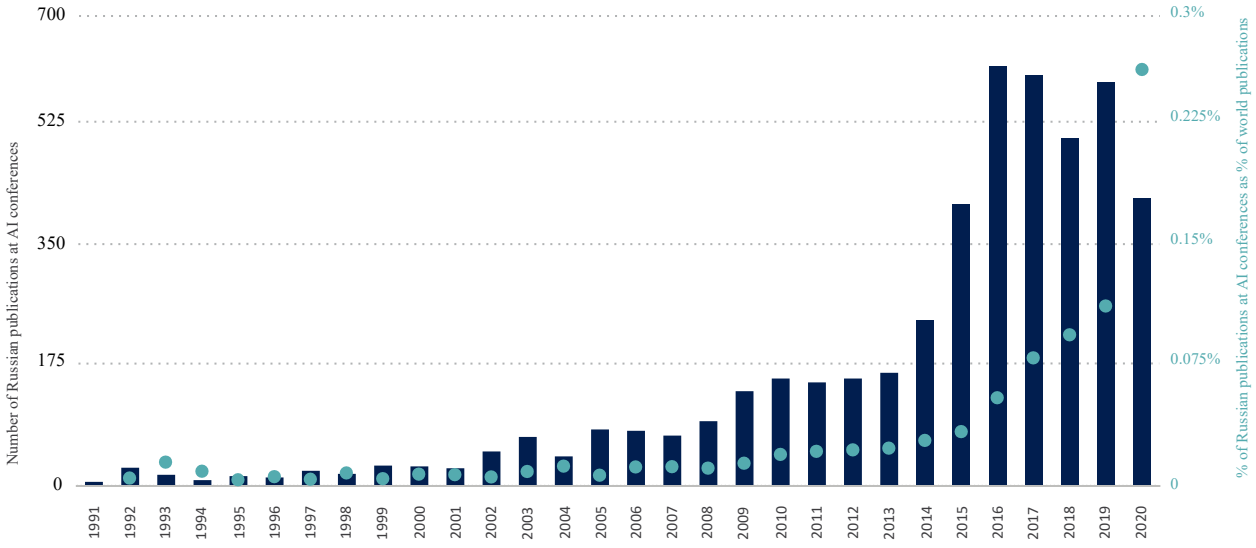


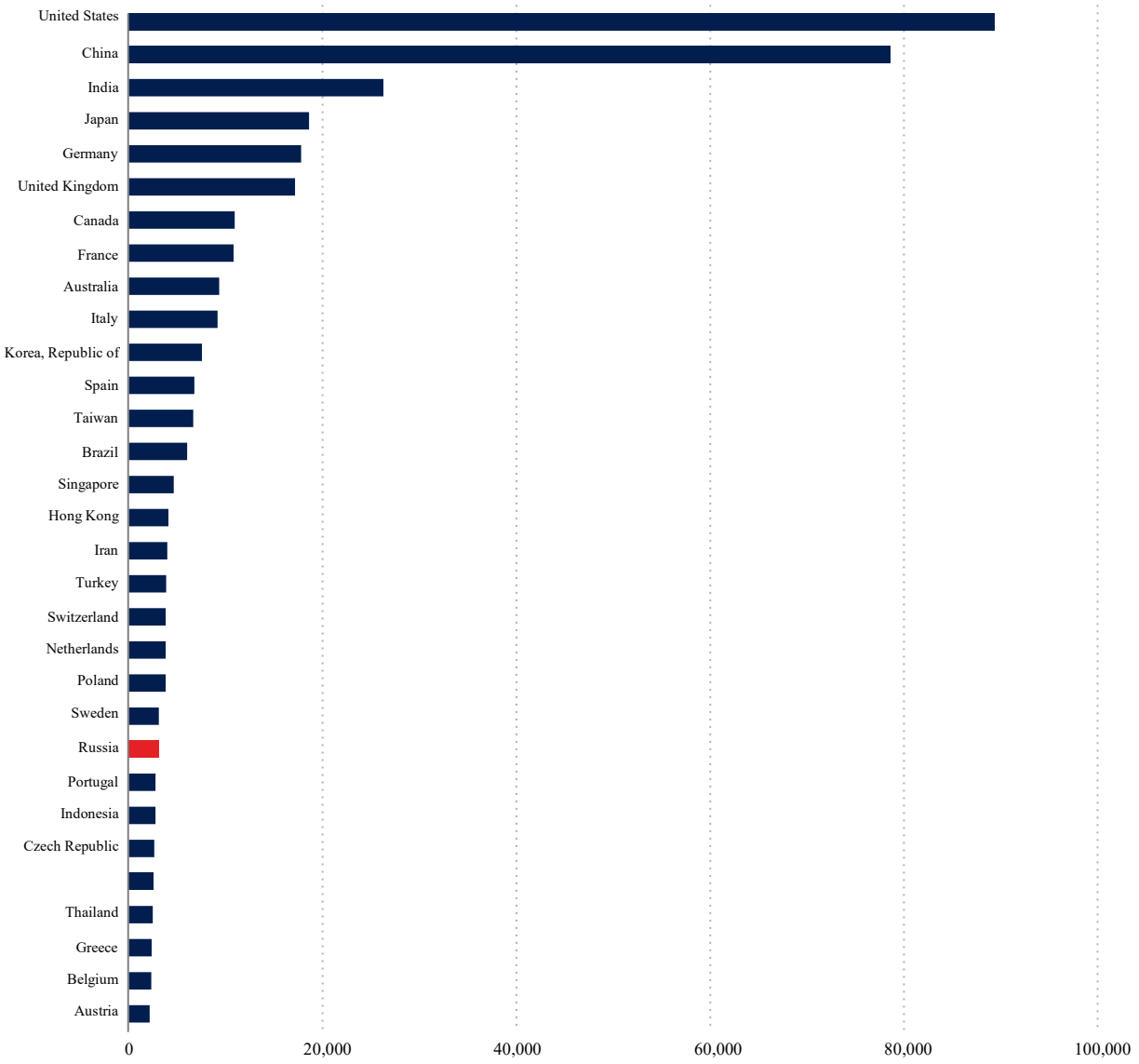
Figure 2 shows the distribution of articles by the researchers who have contributed the most to the conferences from 25 countries. This year, the U.S. has submitted the largest number of conference papers on AI, followed by China, India, Japan, and Germany.

Russia in this category in 2020 has slightly risen from the 25th to the 23rd place.

No. 23 ⬆ +2

is Russia's global ranking for AI conference publications.[14]

Figure 2. Total number of articles on AI conferences in 2015–2020 [14]



We should note that it was the number of type A* conference publications that was deemed the main indicator of AI-related research, as approved by the Federal Artificial Intelligence Project (by Decree of the President of the Russian Federation on Development of Artificial Intelligence in the Russian Federation No. 490 dated October 10, 2019).

RUSSIAN ORGANIZATIONS AT CONFERENCES

This year, we have decided to separate the data on Russian organizations' conference publications. Traditionally, both public research institutions (research institutes and universities) and commercial research companies submit publications in this field. Figure 3 presents the data on publications by Russian academic institutions.

As we can see, in Russia, researchers from Skoltech University are responsible for the largest number of AI-related publications at A* conferences.

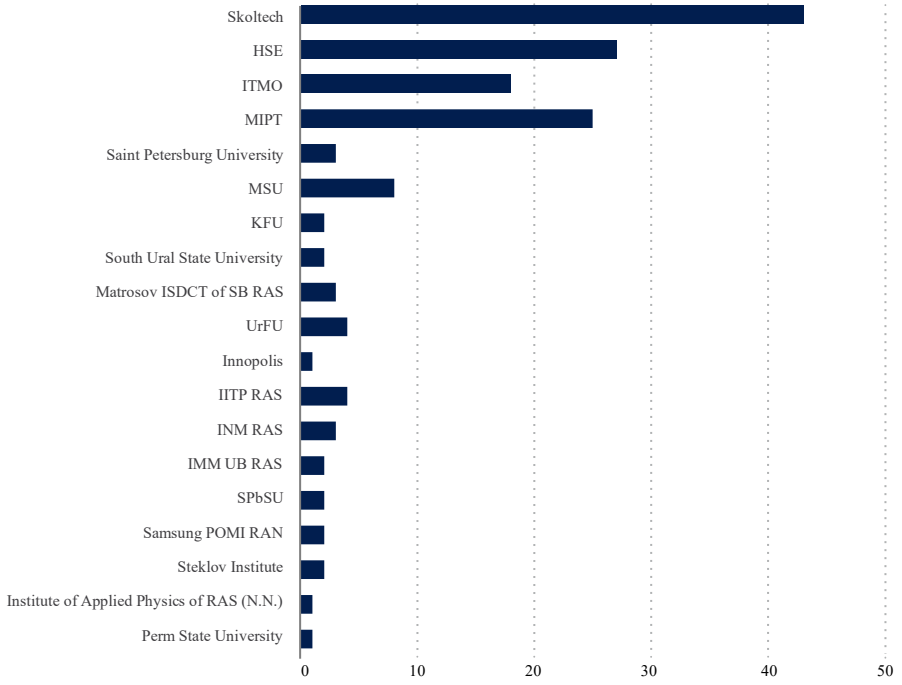


Figure 3. Distribution among Russian academic institutions of publications at top AI conferences [15]

Figure 4 presents data on publications of Russian commercial companies.

As we can see, Yandex is the undisputed leader in publications. Yandex is followed by the Russian Research Center Samsung AI, which we consider a Russian company as it was founded and operates in Moscow, with all its researchers based in Moscow as well. Moreover, we believe that Samsung could serve as a prototype of a successful research site based in Russia to attract other global companies that may want to open research centers in Russia.

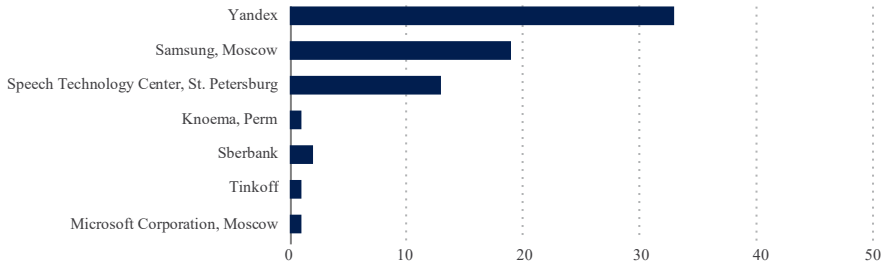
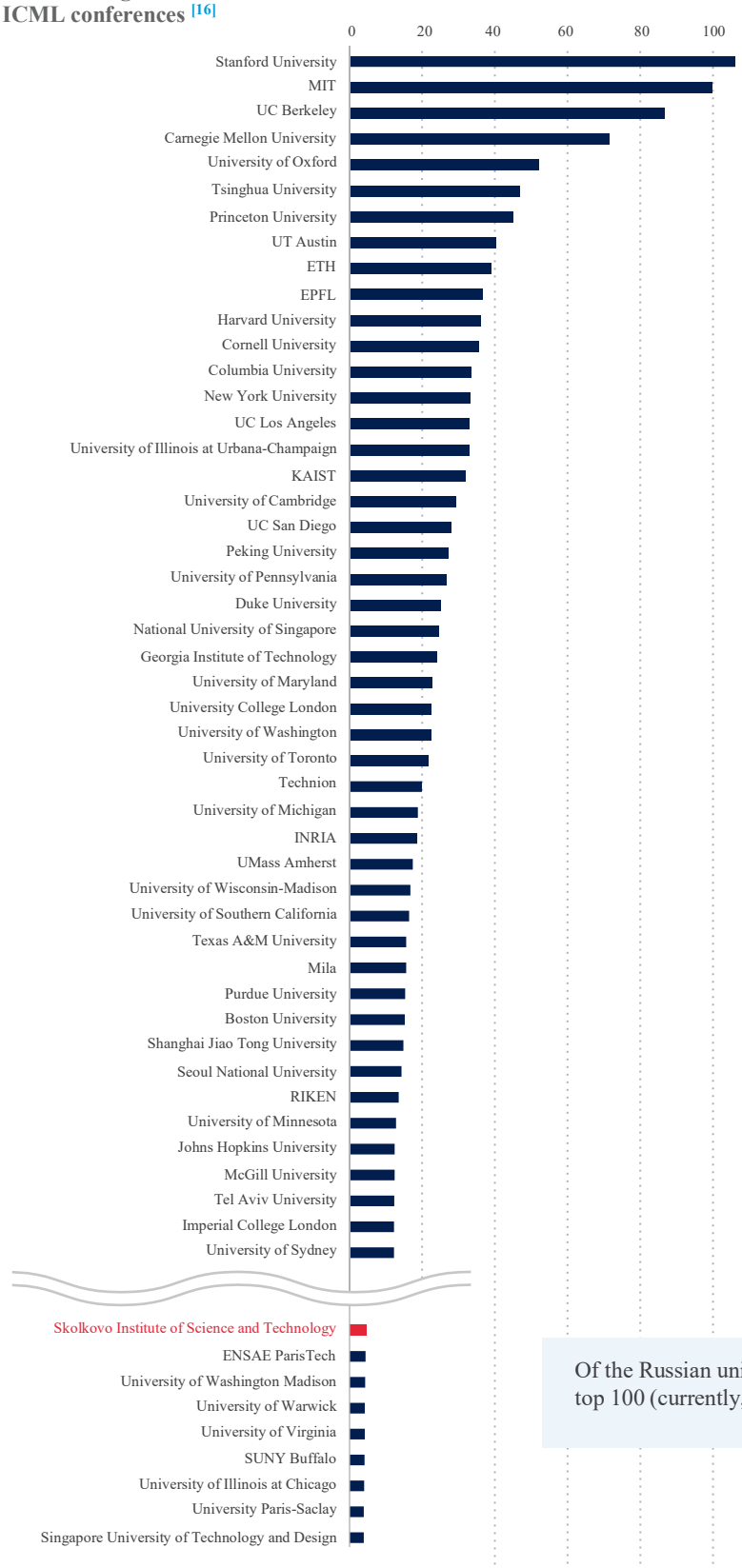


Figure 4. Distribution among Russian companies of publications at top AI conferences [15]

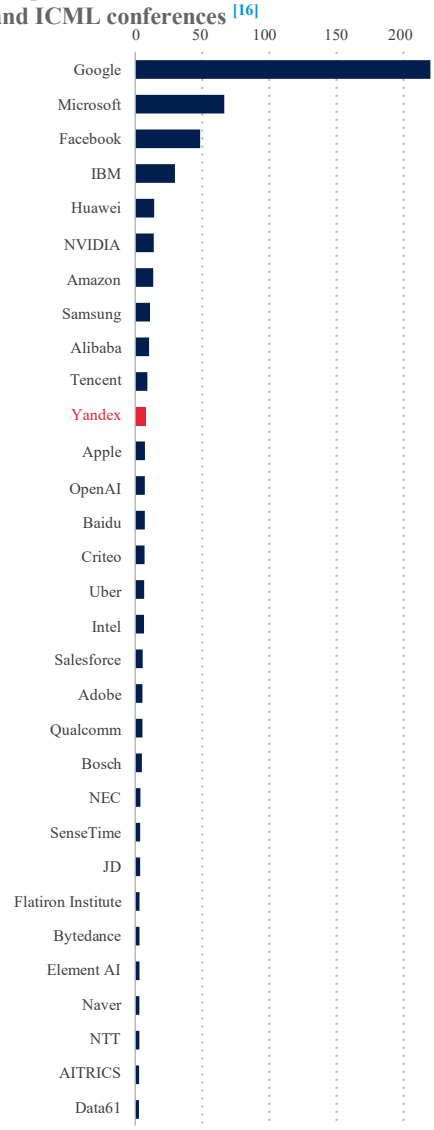
RUSSIAN ORGANIZATIONS AT NEURIPS AND ICML 2020 CONFERENCES

We have separated the 2020 data for the two largest AI conferences: NeurIPS and ICML. Both conferences are classified as class A* conference. The figures below clearly show that Russian universities and companies are globally competitive.

Research organizations that attended the 2020 NeurIPS and ICML conferences [16]



Corporations that attended the 2020 NeurIPS and ICML conferences [16]



Among the Russian companies, only Yandex is internationally visible. In 2020, it reached the 11th place in the world in terms of publications at these two largest conferences.

Of the Russian universities, only Skoltech University entered the top 100 (currently, ranking 98th).

1.2 Publications in Peer-Reviewed Journals

In this section, we discuss the trends in publications by Russian researchers in peer-reviewed scientific journals in 2015–2020.

For many years, Russian researchers lagged behind in publications in world peer-reviewed journals. This was partly due to the fact that Russian researchers tended to publish in Russian journals and in the Russian language. However, in recent years, especially after the introduction of the Five in Top 100 Programs for universities, the number of publications has grown dramatically.

Nevertheless, despite a twofold increase in the number of publications over the past 7 years, we can see that Russian publications continue to account for less than 1% of world publications, which means that the number of world publications in this area has grown significantly.

We believe that additional funding should be allocated for the researchers who publish in Q1 journals, as it has been done, let's say, by the NRU HSE.

Figure 1 shows publication trends for peer-reviewed journals among Russian researchers over the years, in absolute terms and as a percentage of world publications.

1,120 papers published in peer-reviewed journals in 2020.[14]

Figure 1. Number of Russian publications at AI conferences

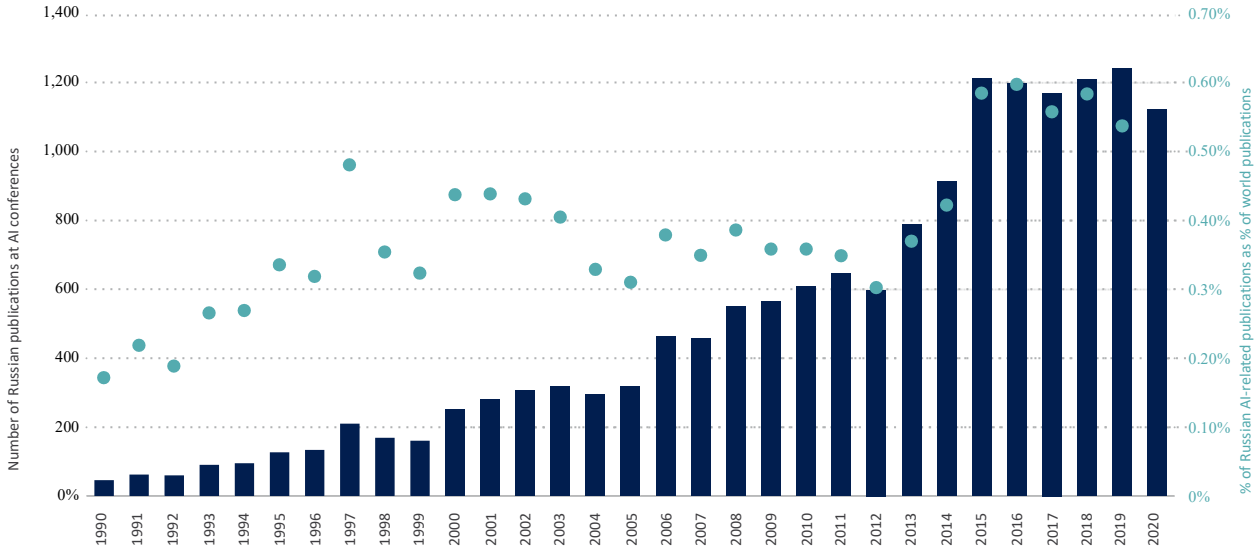


Figure 9. Total number of AI-related articles in 2015–2020

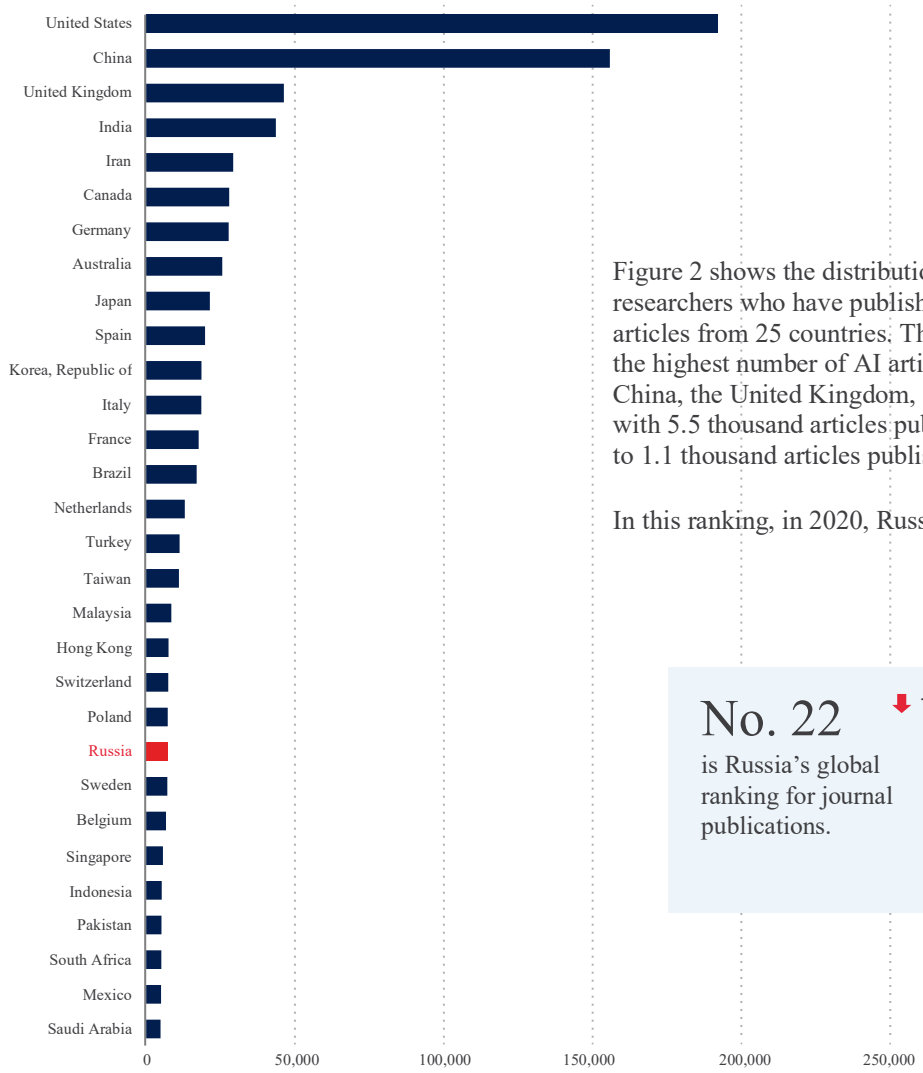


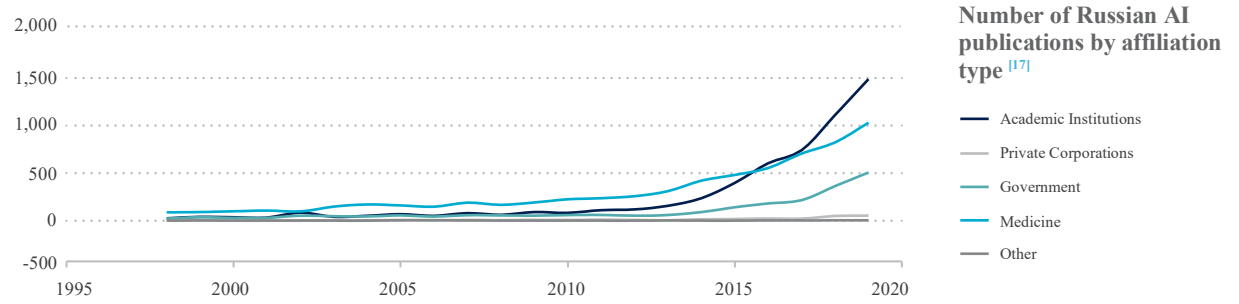
Figure 2 shows the distribution of articles by the researchers who have published the highest numbers of articles from 25 countries. This year, the United States had the highest number of AI articles published, followed by China, the United Kingdom, India, and especially Iran, with 5.5 thousand articles published in 2020 (as opposed to 1.1 thousand articles published by Russia).

In this ranking, in 2020, Russia fell from No. 20 to No. 22.

No. 22 -2
is Russia's global ranking for journal publications.

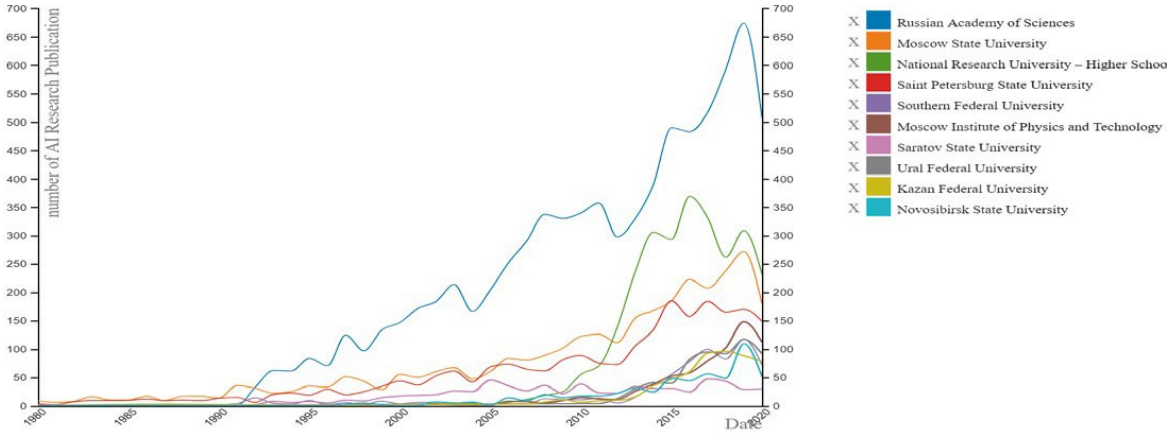
Russia reveals certain patterns in its publications. Most publications in Russia come from public academic researchers (research institutes and universities), whereas the United States tends to have more of its publications come from researchers employed by private companies. In Russia, very few publications come from commercial companies, even though their budgets are much higher. We have already mentioned this fact before, and we believe that the corporate culture and norms in Russian private companies are not conducive to performing open-source research. Therefore, companies should allocate more resources on collaborating with universities.

The number of affiliations on the graph does not match the total number of publications because many publications are submitted by two or more affiliations.



RUSSIA IN JOURNAL PUBLICATIONS [18]

Figure 4 shows the trends in journal publications by Russian organizations. Academic research institutes, which are part of the Russian Academy of Sciences, are responsible for the greatest contribution to publications. Among universities, the Higher School of Economics has the highest share of publications.



TOP 20 RUSSIAN AI RESEARCHERS BY PUBLICATIONS [19]

Name	Tags	H	Citations
Andrzej Chychocki	Biomedical Signal Processing, Brain Machine Interface, Tensor Decomposition, Tensors, Tensor Networks	103	48,343
Artem Oganov	Crystallography	69	22,492
Yuri Nesterov	Optimization, Computer Science, Economics	63	36,310
Alexander Fradkov	Control Theory, Nonlinear Control, Adaptive Control, Chaos Control, Cybernetics	58	17,048
Andrey Khrennikov	Quantum Systems	55	16,528
Victor Lempitsky	Computer Vision, Deep Learning	49	22,079
Alexander Khramov	Nonlinear Dynamics, Neuroscience, Wavelets, Intelligent Systems, Synchronization	46	7,427
Sergey Kuznetsov	Knowledge Discovery, Formal Concept Analysis, Data Mining, Discrete Mathematics, Algorithms and Complexity	41	6,032
Ivan Oseledets	Tensors, Deep Learning, Machine Learning	38	7,059
Maxim Fedorov	HPC, AI, Computer Science, Chemoinformatic	32	4,383
Alexander Tulupiev	Bayesian Network	30	4,388
Sergey Nikolenko	Machine Learning	29	15,476
Yuri Popov	Mathematics, Computer Science, Engineering, Artificial Intelligence, Bioinformatics	26	1,979
Nadezhda Yarushkina	Artificial Intellect, Fuzzy Logic, Fuzzy Time Series	25	3,286

Vladimir Mokshin	Simulation Modeling, Genetic Algorithms, Pattern Recognition, Machine Learning	24	1,789
Evgeny Burnaev	Kernel Methods, Surrogate Modeling, Anomaly Detection, Online Learning, 3D/4D Deep Learning	24	2,125
Dmitry Vetrov	Deep Learning, Bayesian Inference, Graphical Models	22	3,395
Oleg Granichin	Adaptive Control, Optimization, Randomized Algorithms, Multiagent Systems, Artificial Intelligence	20	1,445
Anton Konushin	Computer Vision, Deep Learning, Computer Graphics	19	1,282
Konstantin Vorontsov	Machine Learning, Optimization, Combinatorics, Statistics, Topic Modeling	18	1,100

RUSSIA IN JOURNAL PUBLICATIONS [18]

Figure 5 shows the structure of collaborations in publications of Russian organizations. More often, collaborations take place domestically with other Russian organizations, followed by the European Union, the United States, and the United Kingdom.

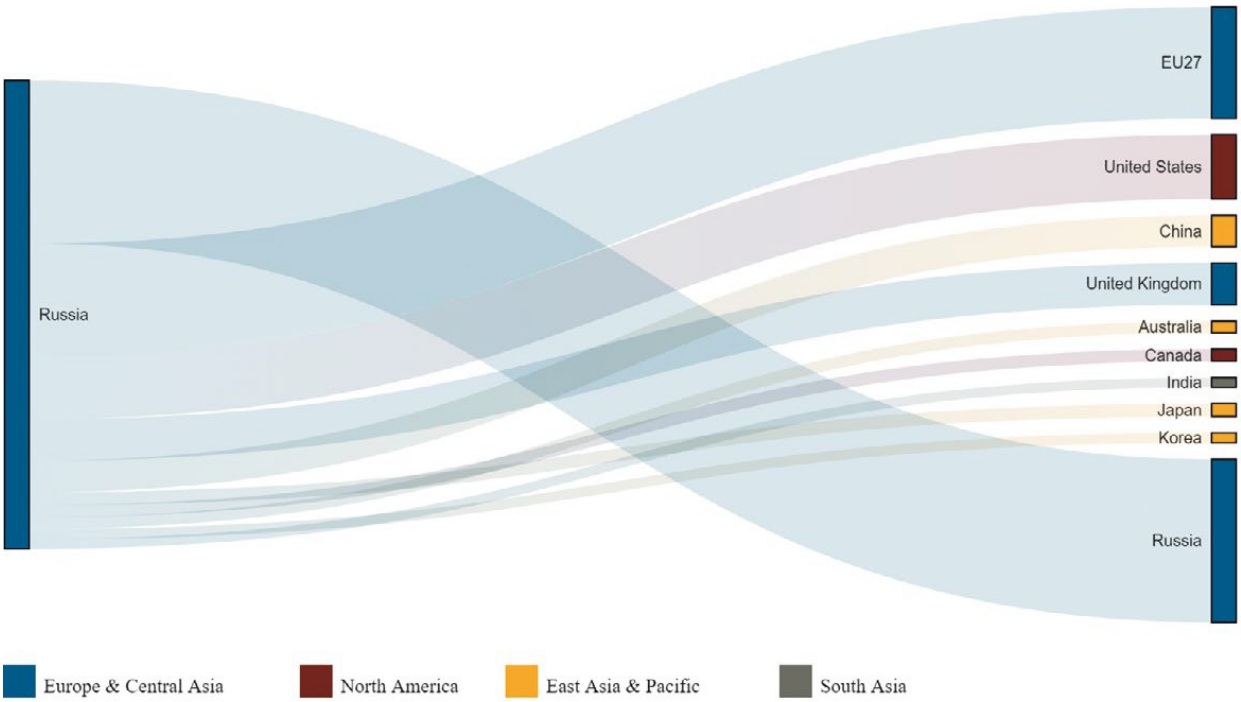
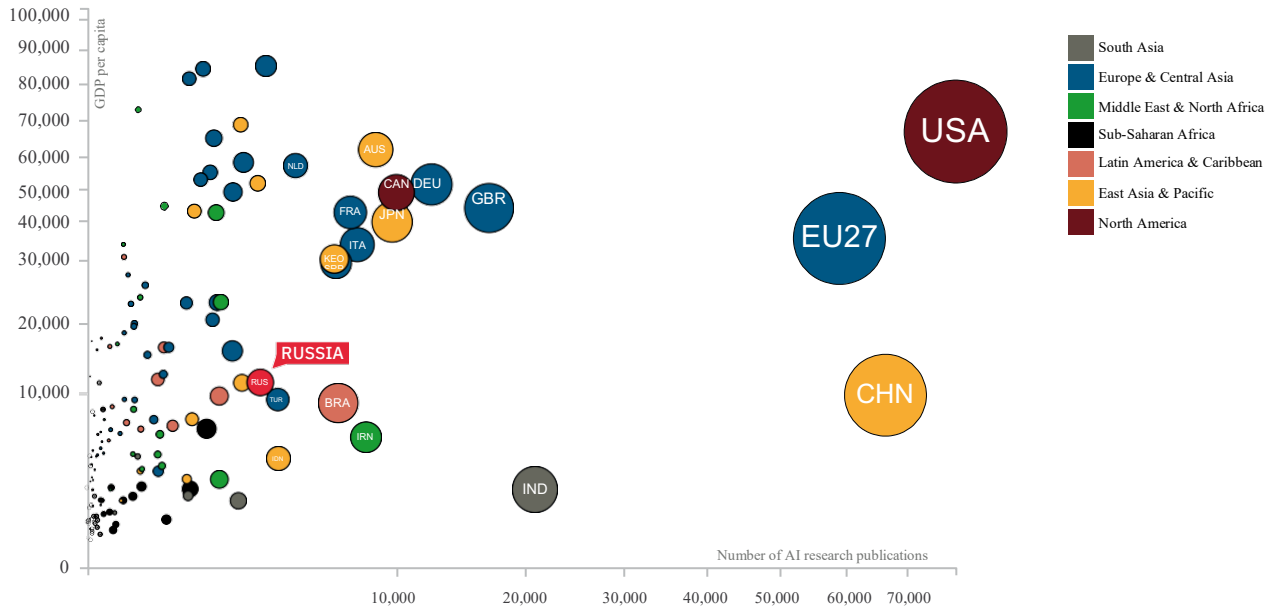


Figure 7 shows the data on publications from different countries. The total number of publications for 5 years from 2015 to 2020 is shown horizontally, and the size of GDP per capita, vertically. The size of the circle is proportional to the number of publications in 2020. As we can see, the United States, China, and the European Union are leading by a wide margin.



1.3 ArXiv Publications

In this section, we discuss the trends of publications by Russian researchers on arXiv on the subjects related to deep learning in 2015–2020.

In recent years, AI researchers have embraced the practice of publishing their work (often pre–peer review) on arXiv, an online repository of electronic preprints. In some way, this resource has become even more important than publications in journals because it allows researchers to promote and prioritize specific topics. The number of AI articles on arXiv has increased in main topic categories and subcategories, reflecting the significant growth of AI researchers using this avenue for publishing their papers. Between 2010 and 2019, the number of AI articles on arXiv increased more than 20-fold.

Figure 1 shows the trends of publication on aRxiv by Russian researchers, by year, in absolute values (number of publications) and in relative values (% of the total number of AI publications).

290
articles on arXiv in 2020.[20]

Figure 1. Number of Russian AI-related articles on arXiv

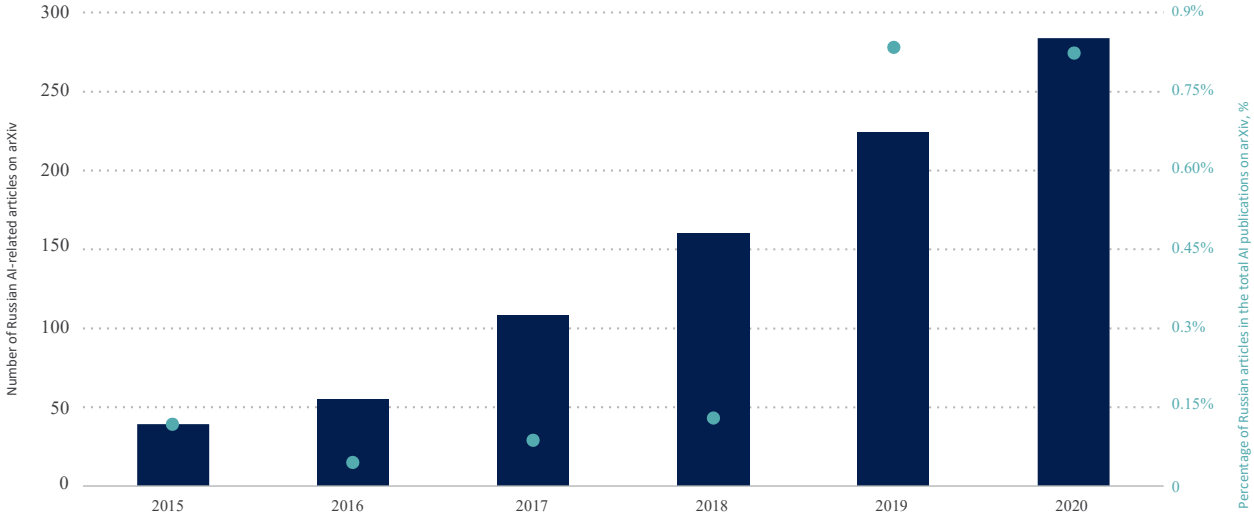
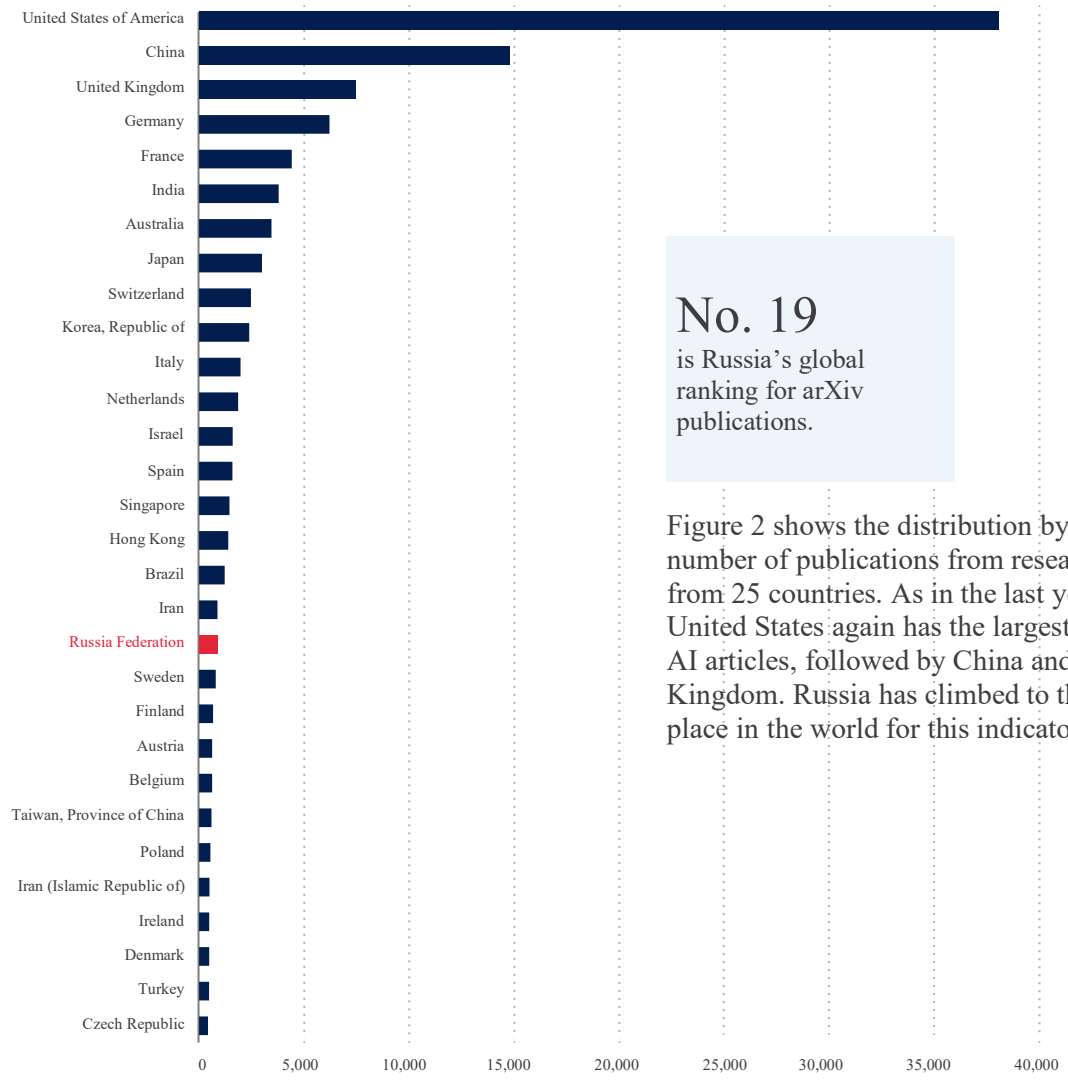


Figure 2. Total number of AI-related articles in 2015–2020

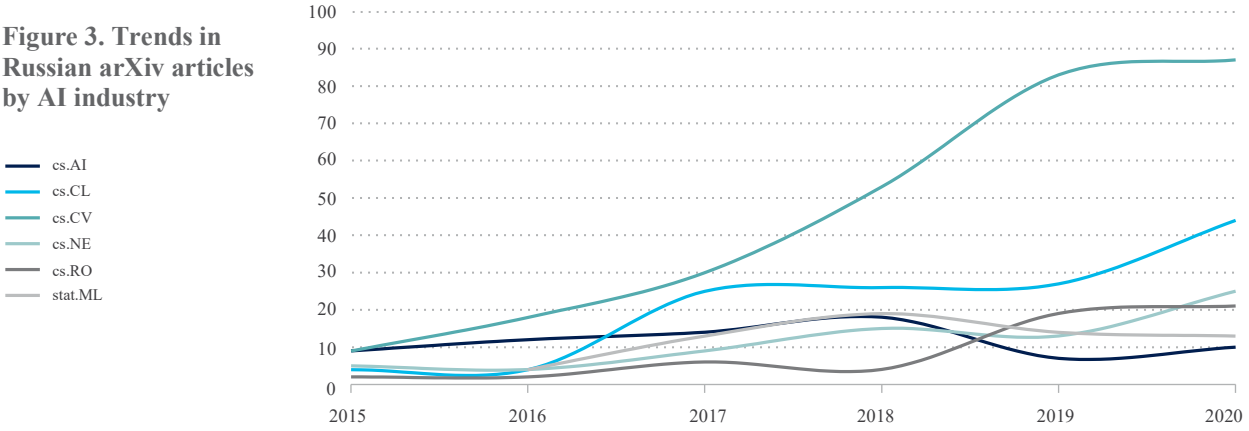


No. 19
is Russia's global ranking for arXiv publications.

Figure 2 shows the distribution by the number of publications from researchers from 25 countries. As in the last year, the United States again has the largest number of AI articles, followed by China and the United Kingdom. Russia has climbed to the 19th place in the world for this indicator in 2020.

Figure 3 shows the trends in arXiv publications in Russia by technology.

Figure 3. Trends in Russian arXiv articles by AI industry



1.4 Patents

In this section, we discuss the statistics on Russian AI patents for 2015–2020.

Even though the usefulness of AI-related patenting remains controversial, AI technologies and products continue being actively patented worldwide. The total number of AI patents has been steadily growing, having grown 4.5 times from 21,806 patents in 2000 to 101,876 patents in 2019. The largest number of patents have been published in the United States. In Russia, AI patenting is much more modest, with 26 patents in 2020.

Figure 1 shows the trends of Russian AI-related patents, in absolute value (patents) and in relative value (% of the total number of patents in the world).

40
patents in 2020.[14]

Figure 1. Number of AI patents

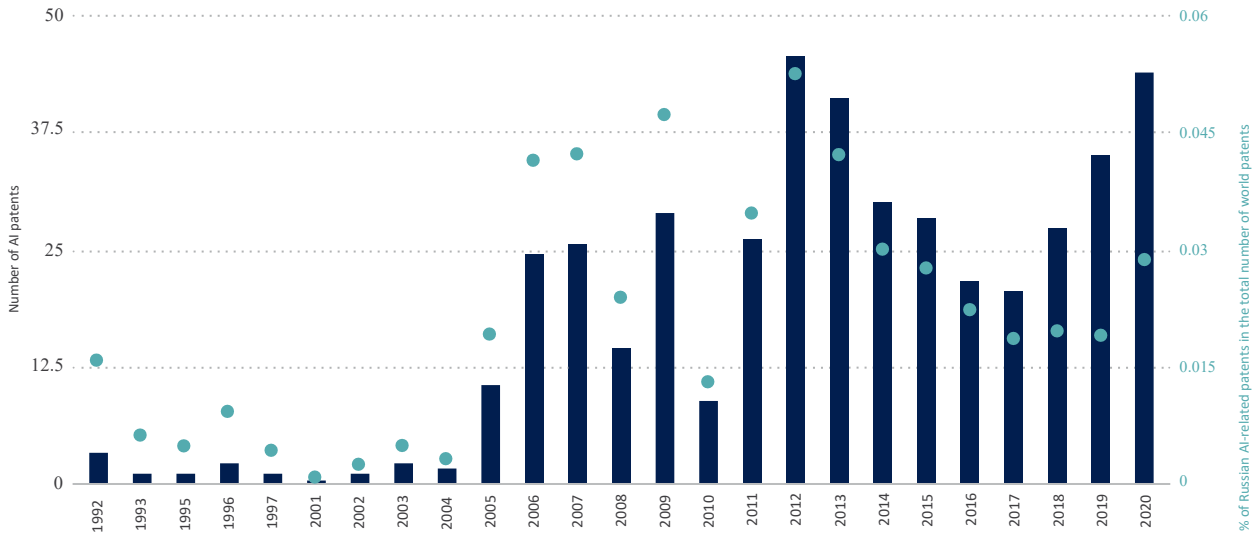
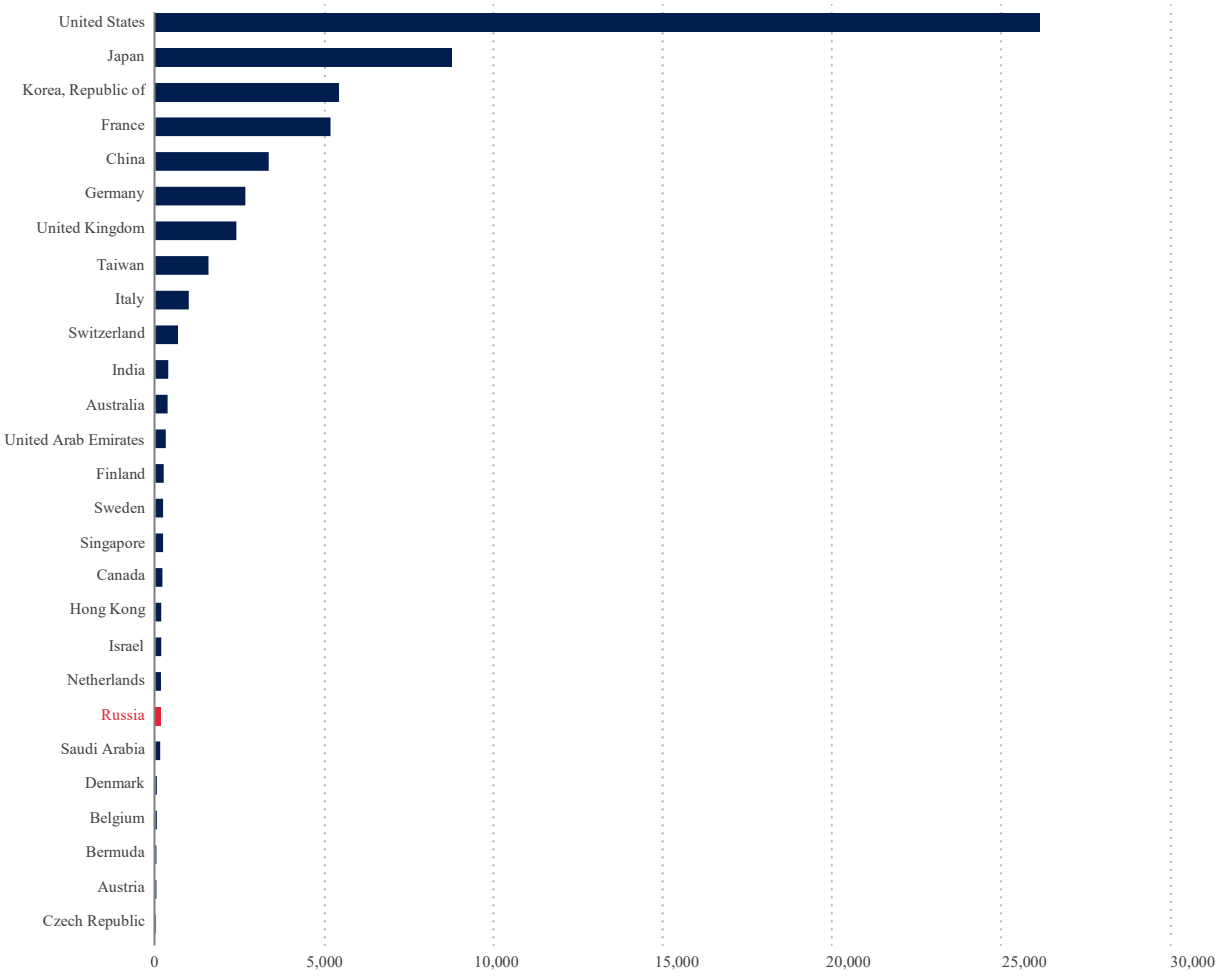


Figure 2 shows the distribution by the number of patents from 25 countries. As in the last year, the United States again has had the largest number of AI-related patents, followed by Japan, Korea, and France. Russia's ranking decreased within the year from 17th to 21st.

No. 21 -4
is Russia's global ranking for AI-related patents.

Figure 2. Total number of AI patents for 2015–2020



1.5 Repositories

In this section, we discuss statistics on Russian AI-related repositories for 1997–2020.

Open libraries are one of the pillars of modern machine learning, thanks to which developers can quickly exchange new algorithms and data processing methods. These libraries are combined into repositories. Each repository represents a complete programming code for working with AI-related methods or data. Most of the code used in today's AI is open-source libraries: e.g., TensorFlow, PyTorch, OpenCV, etc.

The open-source philosophy requires reconsideration of the business model for private companies. After all, the code has been traditionally closed, and it is only recently that

developers have begun using open-source resources. Russian companies are still struggling to join this movement. Nevertheless, in recent years, there has been a clear trend of the growing number of repositories, and Russian developers have been the leading contributors.

Figure 1 shows the trends in AI-related repositories of Russian origin, both in absolute value (number of repositories) and in relative value (percentage of the total number of repositories in the world).

Perhaps the best-known Russian library is OpenCV, a library for working with images and videos. Originally created by a team of programmers from Nizhny Novgorod as part of X, it was later purchased and is now supported by Intel.

48
repositories in 2020 [14]

Figure 1. Number of AI repositories

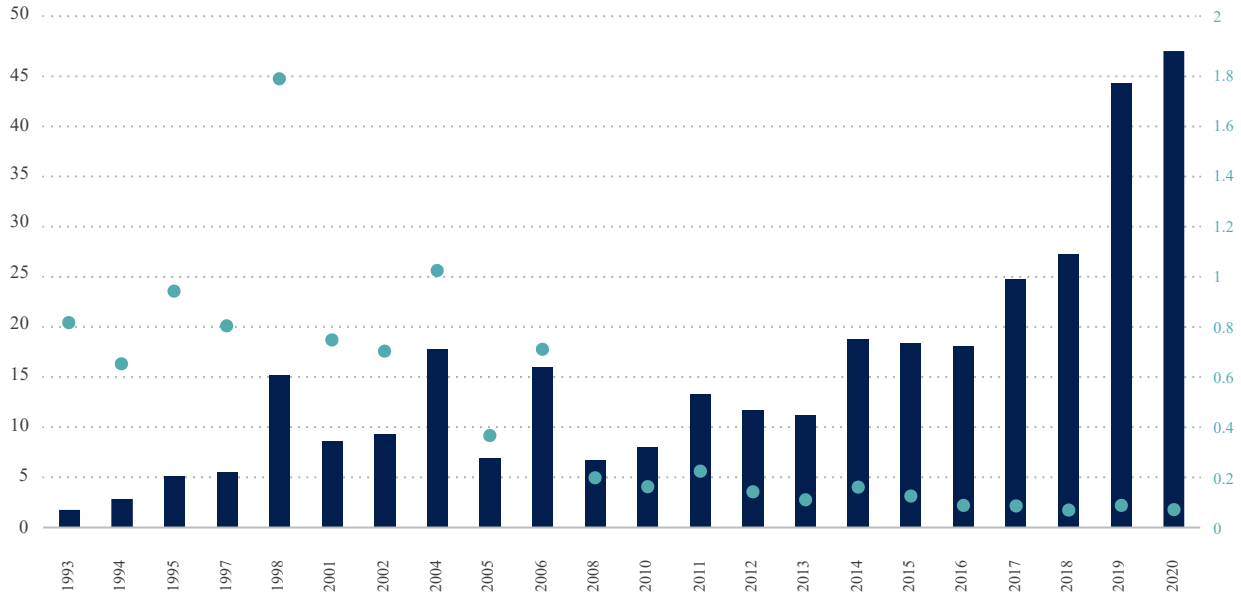


Figure 2. Total number of AI patents for 2015–2020

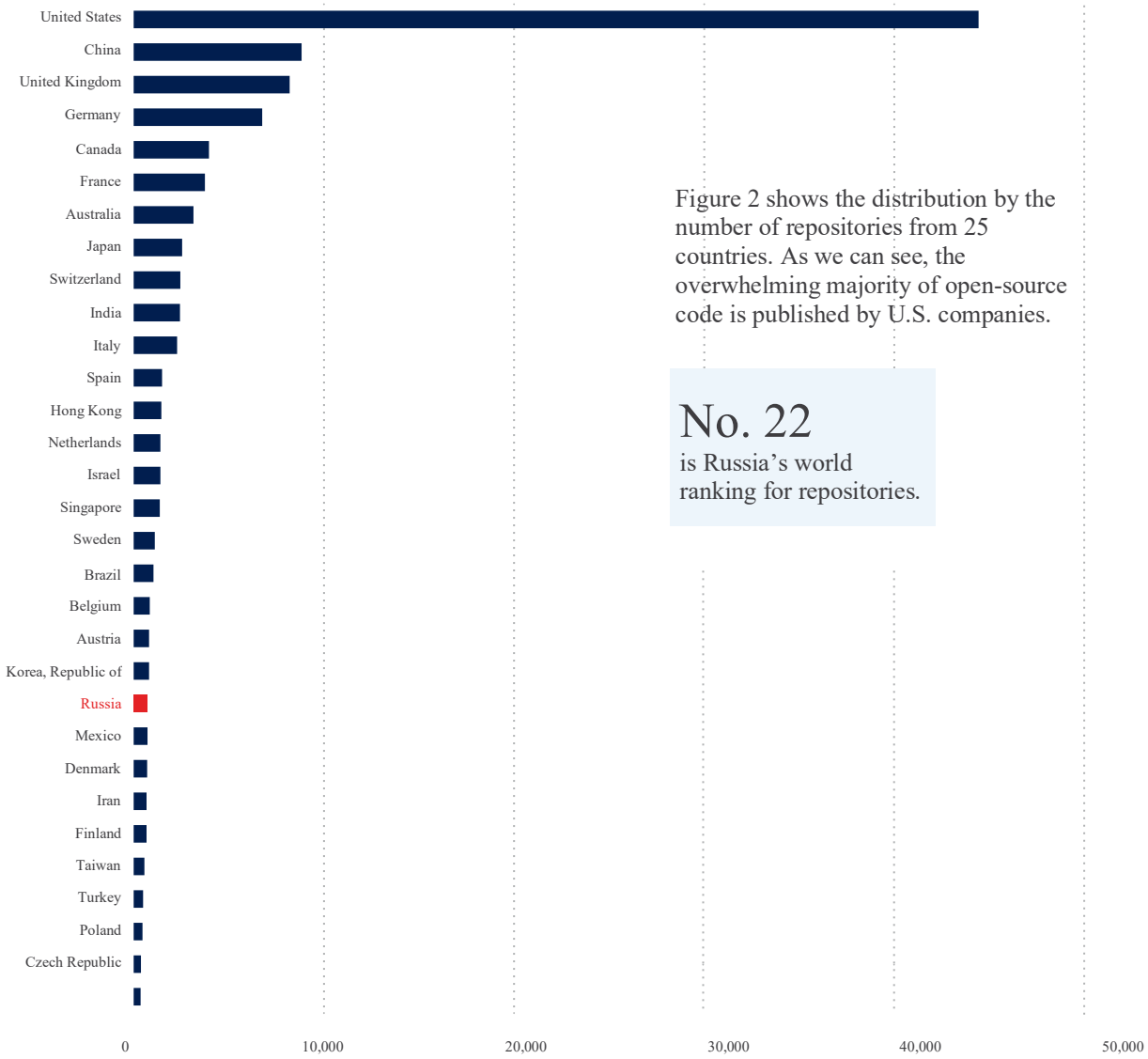


Figure 2 shows the distribution by the number of repositories from 25 countries. As we can see, the overwhelming majority of open-source code is published by U.S. companies.

No. 22
is Russia's world ranking for repositories.

THE MOST POPULAR RUSSIAN OPEN-SOURCE LIBRARIES:

OpenCV	**OpenCV**	☆52.9k	Software for real-time image and video processing, analytics, and machine learning capabilities.
YOLO	**Yolo**	☆15.3k	Neural networks for object detection.
	Deep Image Prior	☆6.5k	A convolutional neural network used to enhance a given image with no prior training data other than the image itself.
Yandex CatBoost	**Catboost**	☆5.8k	A high-performance open-source library for gradient boosting on decision trees.
	DeepPavlov	☆5.1k	DeepPavlov is a framework for conversational artificial open-source intelligence built on TensorFlow, Keras, and PyTorch.
Catalyst	**Catalyst**	☆2.5k	PyTorch framework for research and development in the deep learning field. Focuses on reproducibility, rapid experimentation, and codebase reuse.

1.6 Conclusion

Even though some indicators show a slight growth, R&D activities in Russia have not yet shown explosive growth, as it has been, let's say, in China in recent years. This is mostly due to the government's insufficient funding. We discuss this in more detail in Chapter 4.

02. Business

We have estimated the total number of companies whose business models and revenues have been significantly influenced by AI technologies.

We have established that there are about 480 such companies in Russia. Based on corporate revenue data for 2019, we have estimated the size of the AI market in Russia. Compared to the growth of the entire economy, the AI market has grown 7.5 times faster!

×7.5
is a factor by which the 2019 growth rate of the Russian AI market exceeded that of the national GDP.

RUB 291.5 billion
is the estimated size of the AI market in Russia. [21, 25]

This Chapter was prepared in collaboration with

SELDON

ilabs

Companies

In this section, we discuss the Russian companies and startups that are engaged in developing and designing technologies related to Artificial Intelligence, divided by industry.

Interactive AI Map of Russia
aiRussia.online

As of the beginning of March 2021, there are about 480 companies working in the field of artificial intelligence in Russia. In Figure 1, AI companies on the map are divided according to the technology used and the main type of activity.

The largest segments, comprising 64% of all companies on the market:

CV	79 companies
BI&I	75 companies
Healthcare	55 companies
NLP	52 companies
Data Analysis	45 companies

We have divided all AI technologies into three large groups:

1. Recognition
2. Comprehension
3. Action

Each group includes several specific technologies. The classification tree looks like this:

RECOGNITION

- Speech Recognition
- Computer Vision
- IoT
- Gesture Recognition

THINKING

- NLP
  - LegalTech
- Data Analysis
  - B2B Solutions
  - Retail
  - Cybersecurity
  - Healthcare

ACTION

- Robots
- Fintech
- Logistics
- Advertising
- Industry

Figure 1. Map of Russian AI companies

Source: www.airussia.online

Total: 478

The main parameter according to which the companies are included in the map is whether AI technologies have a significant impact on their business models and revenues. The map contains both large corporations, such as Yandex, CROC, and Mail.Ru Group, and small startups. The sizes of the circles in Figure 1 reflect the sizes of the companies: the circumference of each circle is proportional to a company's revenue for 2019 (i.e., the radius of the circle is proportional to the cube root of the revenue).

Some companies may be included in several segments of the map, depending on their business profile and the AI technologies used.

There is also an Archive section on the map, with about 50 companies that have ceased to operate for various reasons.

AI Market Structure

In this section, we discuss the data on Russian companies operating in an AI-related field and their industry affiliations.

Figure 2 shows the estimated sizes of large companies (annual revenues over RUB 500 million), startups (annual revenues less than RUB 5 million), and medium-sized companies. On the aiRussia.online map, you can see the trends of segment growth in time, from 2010 to 2019.

Compared to 2018, the percentage of startups decreased by 20%, while the share of medium-sized companies and corporations slightly increased.

INDUSTRY AFFILIATION

Figure 3 shows the trends of emerging Russian AI companies from 2000 to 2019 in different industries. The trends are presented by segment. As you can see from the diagram, the fastest growing sectors are Business Intelligence & Analytics CV, Healthcare, and NLP. This includes both large companies and small startups engaged in the development and implementation of various models and algorithms aiming to improve business efficiency, predict market trends, optimize pricing, routine corporate processes, etc.

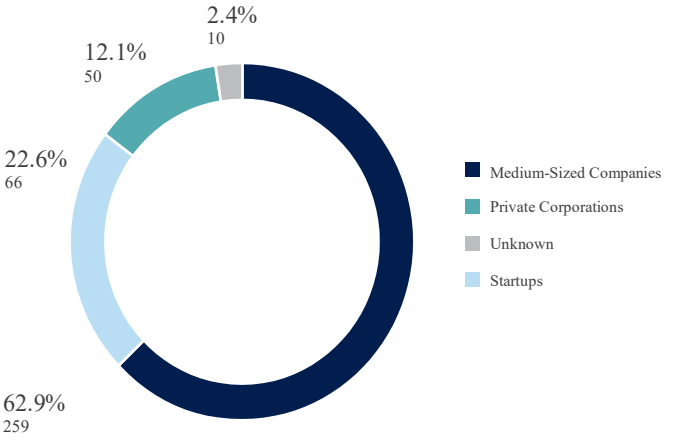


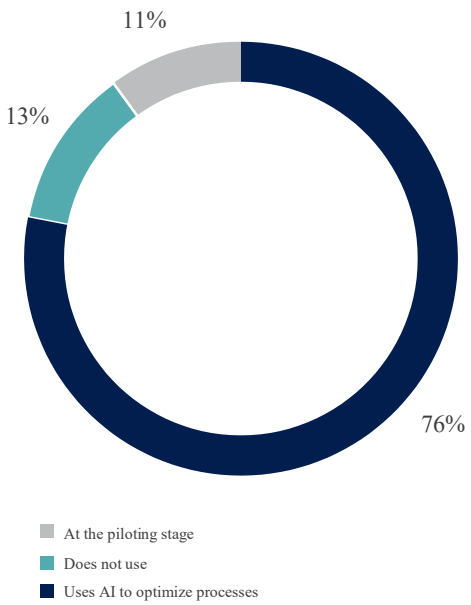
Figure 2. Sizes of AI companies

Figure 3. Growth trends of the Russian AI market by industry

AI Market Assessment

In this section, we provide our assessment of the artificial intelligence market in Russia.

According to TAdviser, as of the end of 2020, more than 85% of large Russian organizations (including foreign enterprises operating in Russia) have been using AI solutions to optimize their internal business processes.[41] These organizations represent mainly the financial sector, telecom, retail, IT, industry, and oil & gas.



According to a joint assessment by IDC and ABBYY, in 2019, the AI market in Russia reached U.S. $139.3 million. IDC estimates the average annual growth rate of the Russian artificial intelligence market at 23.5%. Sberbank has estimated that the artificial intelligence market in Russia will reach RUB 80 billion by 2024. The Ministry of Telecom and Mass Communications estimates that the Russian market of artificial intelligence (AI) solutions will grow 80-fold by 2024, from RUB 2 billion in 2018 to RUB 160 billion.

RUB 291.5 billion
is the estimated size of the AI market in Russia. [21, 22]

Even though it is difficult to come up with an unequivocal assessment of the AI market (see our article "Why Is Assessing Artificial Intelligence Market So Difficult?" in Almanac No. 2), we are going to try, nonetheless. We have built our estimate upon the total revenue of the companies listed in the aiRussia.online map: i.e., the total of 480 companies whose business models and revenue structures significantly depend on using AI technologies.

We had access to the 2019 corporate revenue data, and, based on the data, we have estimated the AI market in Russia to be RUB 291.5 billion or U.S. $3.8 billion. As we can see, corporate turnover in 2019 increased by 9.6%, as compared to 2018, in RUB. Note that the Russian artificial intelligence market has grown 7.4 times faster than the country's GDP: a market growth rate of 9.6% versus the GDP growth rate of 1.3%.

The revenue growth leaders in 2019 were Yandex, with revenue growth of RUB 18 billion, Kaspersky Lab, with an increased revenue of about RUB 11 billion, and AO Jet Infosystems with revenue growth of RUB 5 billion.

Unfortunately, right now, we cannot yet provide an estimated market value for 2020. The revenue data will become available to the public only after May. As soon as the data becomes available, we will update our aiRussia.online map.

Figure 3. Russian AI market structure

Comprehension	78.70%
Recognition	1.40%
Action	20.50%
DataAn	67.10%
NLP	11.00%
CV	1.30%
FinTech	17.50%
Advertising	2.35%
Robotics	0.40%
Industry	0.20%

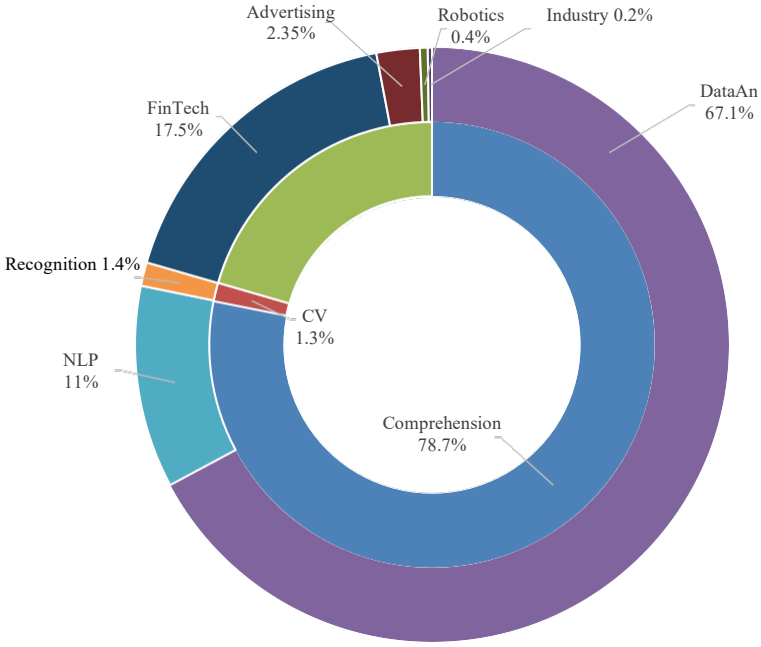


Figure 3 demonstrates the structure of the market. Based on their revenues, the main market players include several large companies (over 50%): Yandex (~ 26%), Tinkoff (~ 15%), Mail.Ru Group (~ 10%), Sberbank Technologies, Croc, Lab, Avito, Yota, etc.

Please note that, even though some companies may specialize in more than one segment, in our diagram we show them as specializing only in one. Thus, Data Analysis turns out to be the largest segment, currently represented by almost all large companies.

You can access the detailed information about each segment and the share of each company using the interactive AI map of Russia aiRussia.online for OpenTalks.AI community members.

Compared to 2018, the FinTech sector grew by 13%, while the Data Analysis sector fell by 11%. Other sectors remained unchanged.

For more information about AI-related Russian companies, please refer to our open interactive map on Artificial Intelligence of Russia:

aiRussia.online

03. Startups & Investment

Startup investments in 2020 fell by 46% in the number of deals and by 61% in investment volume. This is largely due to the COVID-19 pandemic. However, there may be some deeper trends here as well. In 2020, there was only one startup exit (acquisition) totaling U.S. $2.5 million.

Conclusion: 2020 became almost disastrous for the Russian VC sector.

-63%
is the drop in venture capital (VC) in 2020.

USD 84 million
of VC investments in 2020. [23]

Denis Efremov
Fort Ross Ventures

This Chapter was prepared in collaboration with

@proVenture

FORT ROSS VENTURES

DSIGHT

3.1 Venture Transactions

In this section, we discuss the changes in numbers of Russian AI companies, from 2015 to 2020. [23, 24]

We should start with the global market analysis. The Stanford Institute regularly publishes its Artificial Intelligence Index: Annual Reports. The 2021 Report analyzes the 2020 data and provides information on the volume of global investments in artificial intelligence projects.

The authors of the report have significantly restructured the data and reassessed the results for the previous periods. Thus, Figure 1 below shows the data on private investments[1] in AI projects from the previous 2019 Report and the current 2020 Report. This data includes both venture capital investments and other nongovernmental and unincorporated investments.

According to the report, in total, private investors invested U.S. $42.2 billion in 2020, which is 9% higher than in 2019. The growth rates are not exactly breathtaking. However, we should keep in mind that the global economy was in crisis in 2020. Despite that, venture capital investments grew by 15% in the U.S. and 13% in Europe.

Note that the growth rates have been slow in the last two years: 6% and 9%, respectively, whereas the growth rates in 2016, 2017, and 2018, were 65%, 76%, and 56%, respectively.

On the Russian market,[2] investor activity dropped significantly in 2020 (see the figures below).

Figure 1. Total investments in AI-related projects

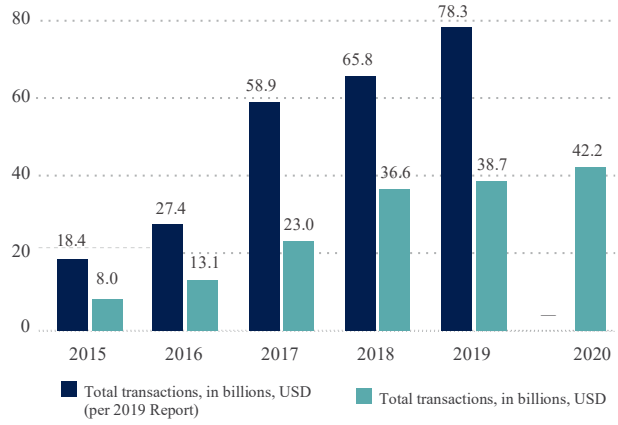
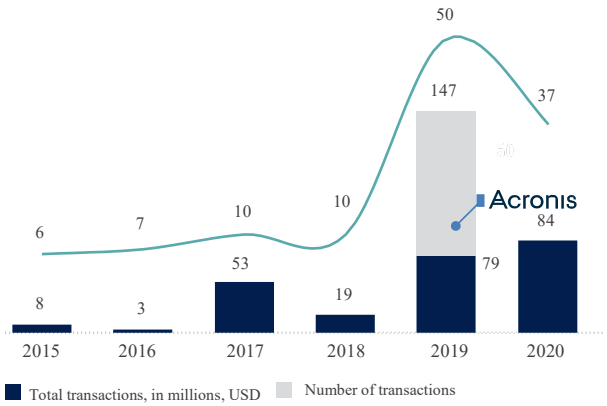


Figure 2. Total investments in AI-related startups and the number of investment transactions with Russian startups



The number of transactions decreased by 26% from 50 to 37 transactions, and volume fell from USD 226 million to USD 84 million, or by 63%. Moreover, if we remove the large Acronis

[1] We should note that Stanford researchers understand the term "investor" quite broadly—as being applicable to many participants. If considered separately, venture investments are better represented in the CB Insights Reports, according to which venture investments in AI companies amounted to just over USD 23 billion in 2019. There is no data for 2020 at the moment. Nonetheless, we intentionally adhere to the Stanford findings to ensure statistical comparability of the remaining data.

[2] Here, by "Russian market," we mean investments in any startup that was founded by Russian-born individuals and operates primarily in Russia. In other words, by participating in the "Russian market," we mean investing in a Russia-based company whose historical business either largely benefits or fully depends on the use and application of artificial intelligence technologies.

transaction,[3] then the volume will show a slight increase from USD 79 million to USD 84 million, or 6%. The entire Russian venture capital market has shrunken down to USD 703 million, a drop of 19%.

-26%
a drop in the number of transactions in 2020.

USD 84 million
of venture capital in 2020. [23]

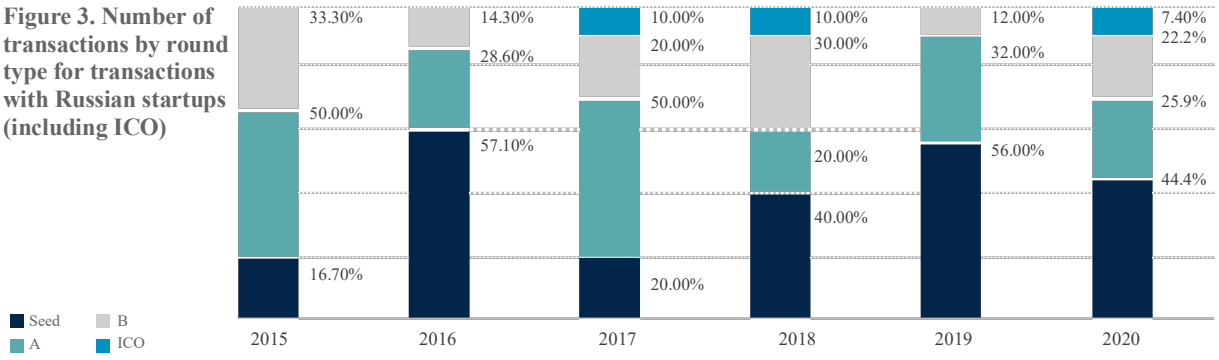
-63.1%
was a drop in investments in 2020.

The share of investments in Russian startups in the global market is 0.2% in 2020. It remained at the level of 2019, excluding the Acronis transaction, or dropped from 0.58% due to Acronis in 2019.

Within the structure of the Russian venture capital market, investments in artificial intelligence projects account for 11.9%.

The startup structure of investing by rounds (series) has significantly changed since 2020 as many companies succeeded in raising large round C funding or higher. This shows that many projects that had managed to raise early round funding in 2018 and 2019 continued to do so well into 2020. However, very few other seed projects received any further investments. The round structure was significantly distorted by the Acronis transaction in 2019 and, before that, by funding raised by startups through the ICO (initial coins offering) procedure in 2017–2018.

Figure 3. Number of transactions by round type for transactions with Russian startups (including ICO)



[3] From the AI Almanac No. 4 of 2020 (for 2019) on a deal with Acronis: "Among the 2019 deals, the particularly noteworthy one was the investment agreement made between Acronis, a cybersecurity company that was founded by Andrey Belousov, and Goldman Sachs, one of the largest global investment banks. The deal was estimated at USD 147 million, which is, on the one hand, an extreme case. On the other hand, it is an exemplary case that demonstrates the overall sampling problem in such assessments: Acronis, for instance, has its headquarters based in Switzerland, while its director Mr. Belousov is a citizen of Singapore."

Figure 4. Investments by round type for transactions with Russian startups (excluding ICOs)

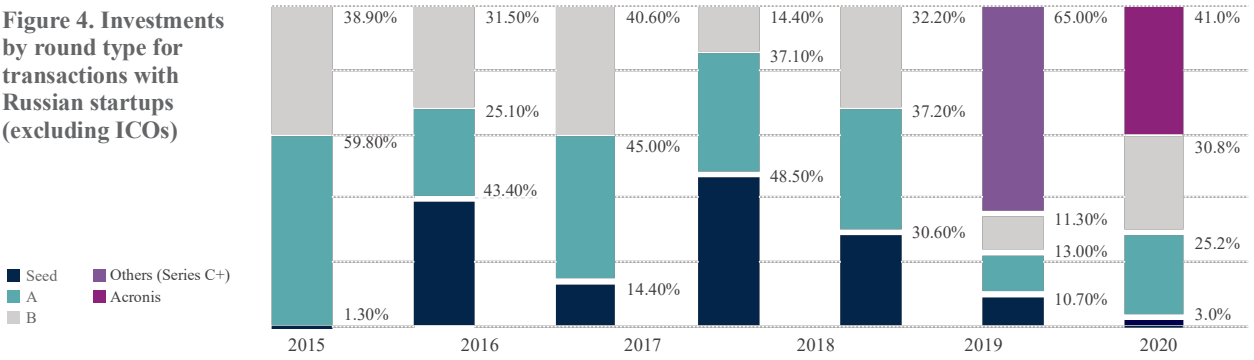
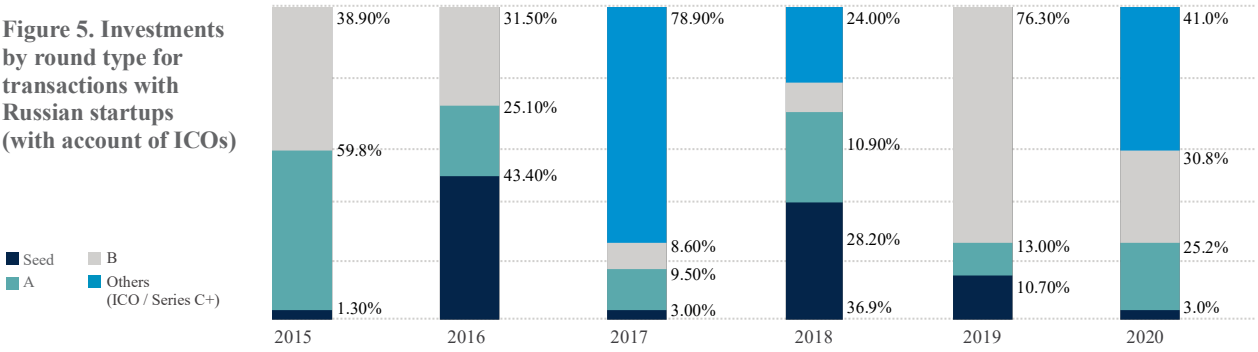


Figure 5. Investments by round type for transactions with Russian startups (with account of ICOs)



If ICO and Acronis are excluded from the analysis, then the volume of seed round transactions in the investment market structure decreases, and this is exactly what we observe. What is more, any transactions that emerge during round C or higher suggest that new rounds get attracted by companies that are already developed (see the Figure below). Series A and B funding have been nearly equivalent in recent years, and they shape up to become the preferred funding rounds for AI startups.

41%
is the seed round percentage within the market, by transaction numbers.

Seed rounds remain the most popular funding stages judging by the number of transactions performed, which was 40.5% in 2020, a considerable drop from 56.0% in 2019. Still, this stage has many more transactions than any other stages. Series A is as high in the volume as it is the most stable: In recent years, its share has fluctuated from 20% to 30%.

The weighted average transaction increased by 40%, from USD 1.6 million to USD 2.3 million, provided that Acronis is not included (with Acronis included, the average transaction size would drop to USD 4.5 million).

The average seed round has significantly decreased: It fell from USD 0.9 million to USD 0.3 million. The same with round B: It decreased from USD 5.1 million to USD 3.5 million. Transactions emerged at the C+ round when the startups attracted on average USD 13.6 million.

USD 2.3 million
is the average transaction amount.

And only at stage A, the average transaction size increased—not by much, though: from USD 1.8 million to USD 2.4 million, or by 13%.

Figure 6. Weighted average round size by type for transactions with Russian startups (excluding ICO and Acronis)

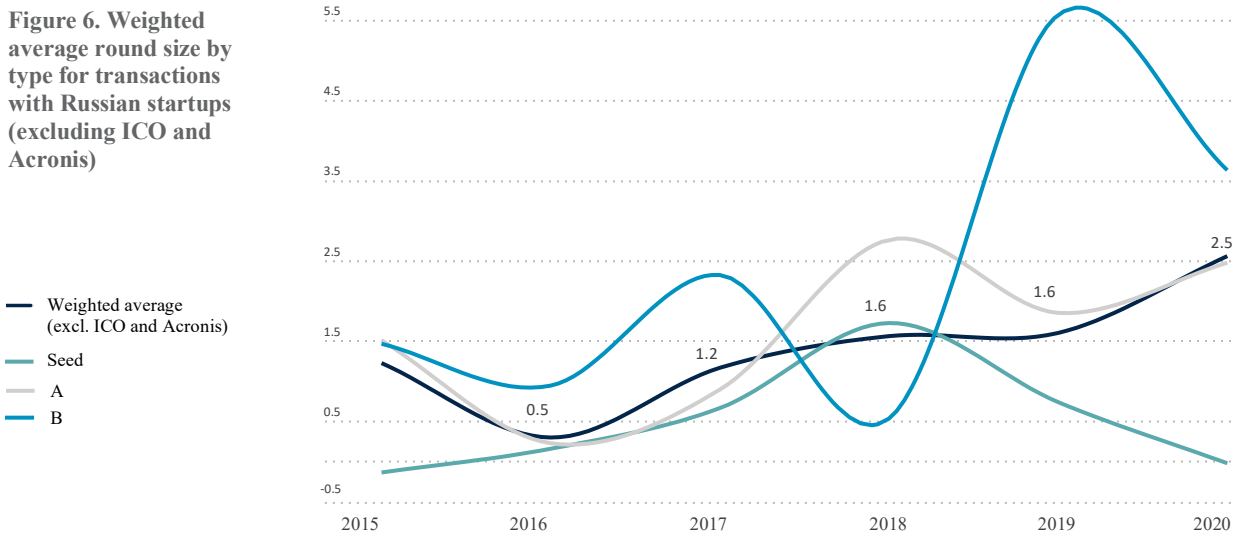


Figure 7. AI startup investment market structure by volume of investments from different types of investors, %

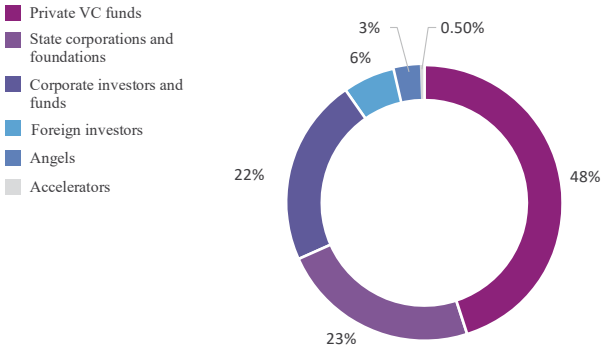
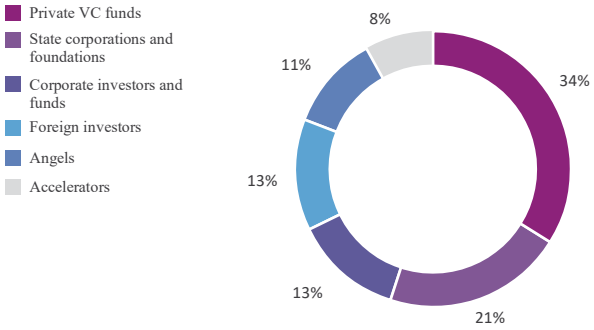


Figure 8. AI startup investment market structure by number of transactions from different types



If we look at the Russian market in terms of the structure of key investor participants, we can see that there is relative unity here. Private venture capital funds rank first in terms of both volume and number of transactions, with shares of 50% and 38%, respectively. This is followed by state investors and foundations with shares of 29% and 19% in terms of volume and quantity, respectively, as well as corporate investors and funds with a share of 15% both in terms of volume and quantity.

Interestingly, 84% by volume and 79% by number are occupied by startups that operate based on the B2B model, whereas the B2C model is content with 16% by volume and 21% by quantity.

Figure 9. AI startup investment market structure by investment volume, %

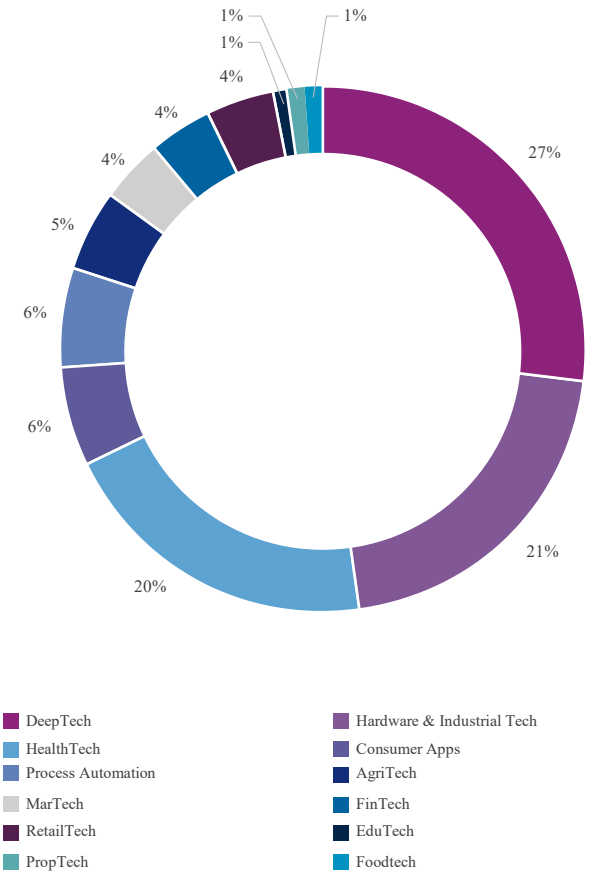
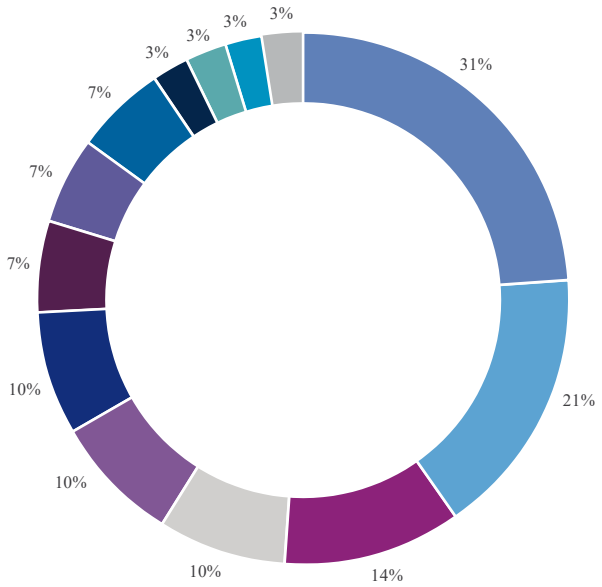


Figure 10. AI startup investment market structure by the number of transactions, %



The industry analysis of transactions in Russia shows that the following types of projects attract the most investments: DeepTech (27%), HealthTech (21%), and Hardware & Industrial Tech (20%). These three categories cover 68% of the market. They are followed by consumer applications, fintech, and process automation solutions.

The latter also lead in the number of transactions with a 19% share, followed by medical projects (15%), DeepTech, and marketing projects (both 12% each).

If we compare this with the global market structure (see the Table below), what's clear is that some popular AI trends, namely, autonomous driving and such open-source solutions as FashionTech and Gaming, are not common for our market. This has an element of future prospects.

Investment in Process Automation and EduTech lags behind the global market trends in terms of volume. However, Agri & FoodTech are relatively more popular in Russia. The FinTech, RetailTech, and PropTech segments are also close to popular.

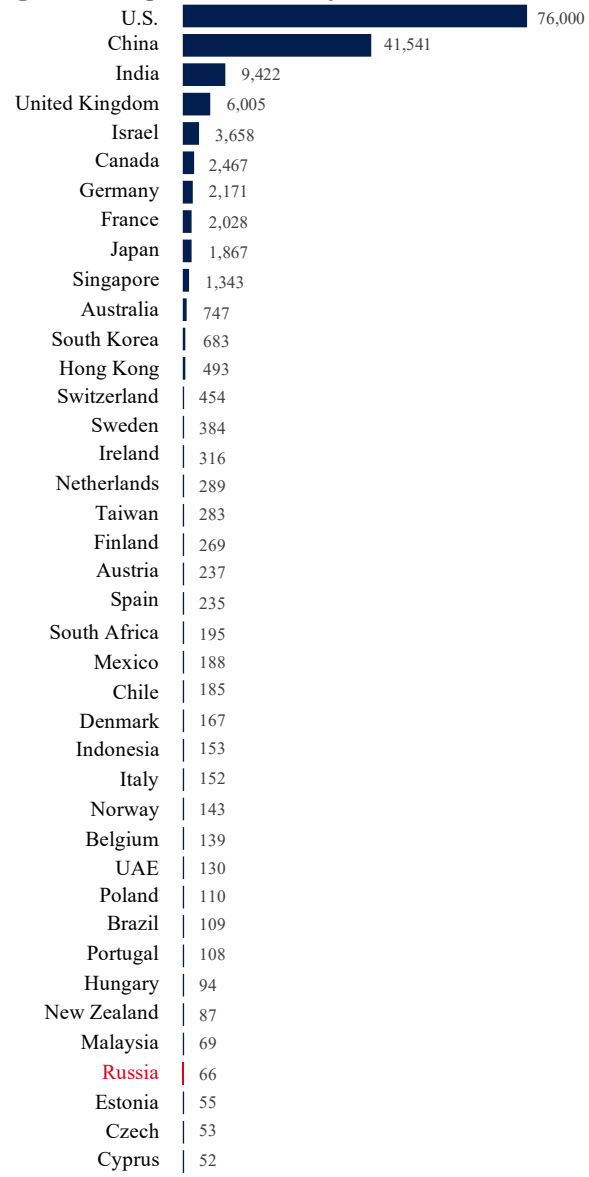
On the other hand, investments in DeepTech and Hardware & Industrial Tech comprise a much larger share in Russia than on average worldwide.

9.4%
is the share of AI investment projects in the total venture capital market in Russia in 2020.

Quarter	Investment structure in the world in 2020, %	Investment structure in Russia in 2020, %
HealthTech	26.50%	21.0%
Process Automation	8.90%	4.6%
DeepTech	8.10%	26.6%
Hardware	6.90%	19.8%
Autonomous Vehicles	6.70%	0.0%
Fintech	6.40%	6.2%
EdTech	6.00%	1.2%
Open source / DevOps	4.70%	0.0%
FashionTech	3.80%	0.0%
MarTech	3.60%	3.8%
Gaming	3.40%	0.0%
RetailTech	3.00%	4.5%
AgriTech	2.10%	5.0%
Wireless Tech	1.80%	0.0%
Cybersecurity	1.40%	0.0%
EnergyTech	1.10%	0.0%
LegalTech	1.00%	0.0%
PropTech	0.70%	0.8%
HR Tech	0.50%	0.0%
VR	0.50%	0.0%
Entertainment	0.40%	0.0%
TravelTech	0.10%	0.0%
Other	2.4%	6.3%

Comparison of the AI project investment structures in Russia and worldwide in 2020, by investment volume, %

Figure 11. Top 40 countries by AI investments in 2020[24]



The United States ranks first in the world for AI investments, with USD 76 billion invested (see Figure 11). China, India, Britain, and Israel round out the top five countries.[24]

0.16%
is Russia's investment share in AI-related projects in 2020.

Let's not forget that the United States is 80% larger than China, while China is more than 4 times larger than India. The concentration is, therefore, very high. Russia ranks 36th among the countries. Out of the top 40, we are only ahead of Malaysia, Estonia, the Czech Republic, and Cyprus.

Unfortunately, in the current version of the report, there was no information on the number of transactions in the global market by country. Therefore, determining the ranking by the number of transactions in 2020 may not be feasible. In 2019, Russia ranked 11th with 50 deals, while, with 27 deals, Russia would have ranked only 13th last year. The fact is that there was a large gap in the number of transactions, which was offset by a drop in the number of transactions in 2020.

3.2 Venture Funds [23]

Venture capital funds closely monitor AI projects.

Fifty-three companies invested in artificial intelligence companies in 2020, which is 42% less than it was a year earlier when 92 investors made at least one transaction in the market.

The concentration of leading investors has also dropped significantly. Last year, the top 9 investors made 90% of the deals, and this year the top 8 investors made 49%.

The average number of investors per transaction decreased by 22% from 1.84 in 2019 to 1.43 in 2020.

The figure below shows the top 8 investment funds that have made 2 or more investments in artificial intelligence projects.

As in the previous year, the top three venture funds that actively invest at the early stages are Starta Ventures, Moscow Seed Fund, and IIDF. Finsight Ventures, ExpoCapital, Far East High Technologies Fund, and Digital Evolution Ventures also made two deals each, while they participated in much larger rounds.

Separately, we should note Y Combinator, the world's most famous accelerator, which involved two Russia-based projects in 2020.

53
investors invested in AI projects in 2020.

49%
is the percentage of transactions made by top 6 investors in the total number of investments.

1.4%
of investors, on average, participated in one transaction.

Figure 12. Rating of the largest venture funds by number of transactions in 2020[4]

3.3 Venture Exits (Acquisitions)[23]

In this section, we provide an analysis of artificial intelligence project exits in 2020.

In 2020, there was only one AI-related startup exit: This was the sale of a stake in a startup SumSub by Flint Capital to an unknown "large IT holding," which could be valued at USD 2.5 million. This happened in Q1 of 2020, before the start of the coronavirus pandemic in Russia.

Eventually, practically all exits this year have been postponed. At least in the context of 2019, they appear like a statistical error because, in 2019, exits earned USD 4.4 billion in 9 transactions to investors and founders of Russia-based startups (see the figure below).

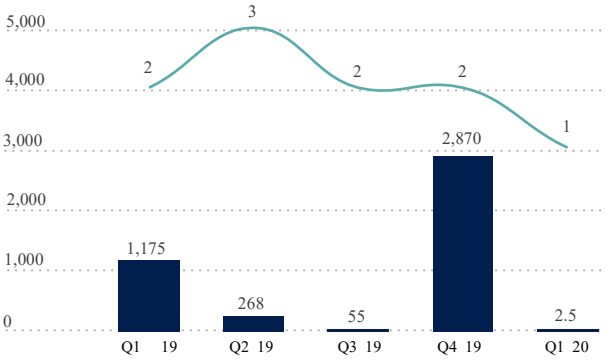
1
AI project exit (acquisition) took place in 2020.

Two big deals, Avito and MagicLab, had a significant impact last year, totaling USD 1.1 billion and USD 2.9 billion, respectively, i.e., USD 4 billion out of USD 4.4 billion.

If we compare the remaining USD 400 million to the USD 2.5 million this year, 2020 clearly falls behind.

[4] In 2020, only 8 investors concluded 2 or more deals. Therefore, we are unable to create a longer list of active investors.

Figure 13. Total AI project exits in 2019–2020



04. Government

Government AI spending in Russia over the past 3 years has amounted to about RUB 8.7 billion. Russia's spending is about 350 times lower than that of China and 35 times lower as % of its national GDP, even though Russia's GDP is only about 10 times lower than that of China.

Government spending also includes any AI-related government procurement regulated under Federal Laws (FL) No. 44 and No. 223. Over the past three years, the total government spending has come to be on par with direct investments in the AI industry, which is about RUB 2.4 billion.

×35
is a factor by which the Russian government's AI-related spending is less than that of China, in % of the GDP.

RUB 8.7 billion
was spent by the government on AI in 2018–2020.[25]

This Chapter was prepared in collaboration with

Ministry of Economic Development of the Russian Federation

ЭКОНОМИКА

SELDON

4.1 AI Funding in the Russian Federation

FUNDING STRUCTURE

According to the National Strategy for the Development of Artificial Intelligence (AI), funding is aimed at supporting scientific research, software development, increasing the availability and quality of data, the availability of hardware, nurturing qualified personnel, informing the population about the capabilities of artificial intelligence, and regulating related public relations.

The main sources of funding, naturally, are the state and the private sector. In this section, we are going to look at government funding.

FUNDING IN 2018–2020[25]

Although the National Artificial Intelligence Project was launched on January 1, 2021, the Russian government has been funding AI projects since 2018.

From 2018 to 2020, funding was provided as part of the Neurotechnologies and Artificial Intelligence Roadmap for the development of end-to-end digital technology and support of commercial projects. The funding was provided on a competitive basis through national development institutions (see Figure 2).

As part of the roadmap, 241 projects were approved. The project distribution by development institutions is shown in Figure 3.

Figure 1. Government funding of AI in the Russian Federation

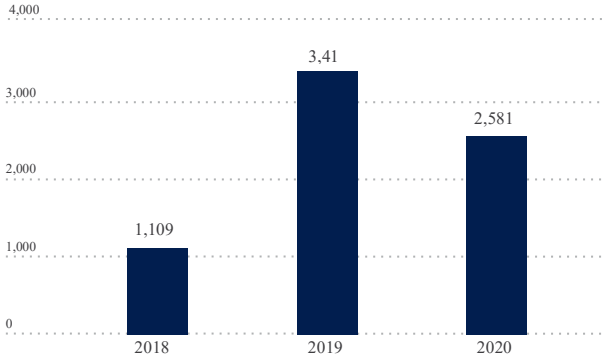


Figure 2. AI-related spending through development projects in the Russian Federation, in millions, RUB

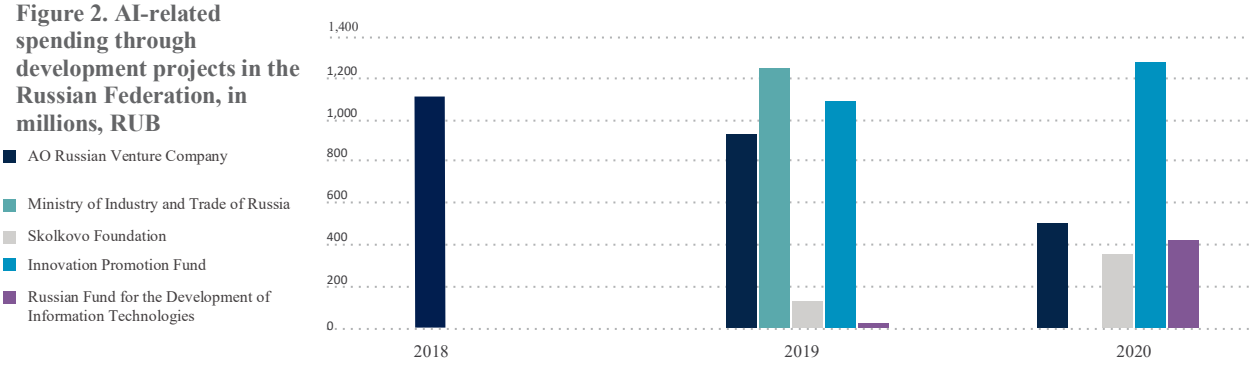


Figure 3. Distribution of approved AI-related projects by development institutions

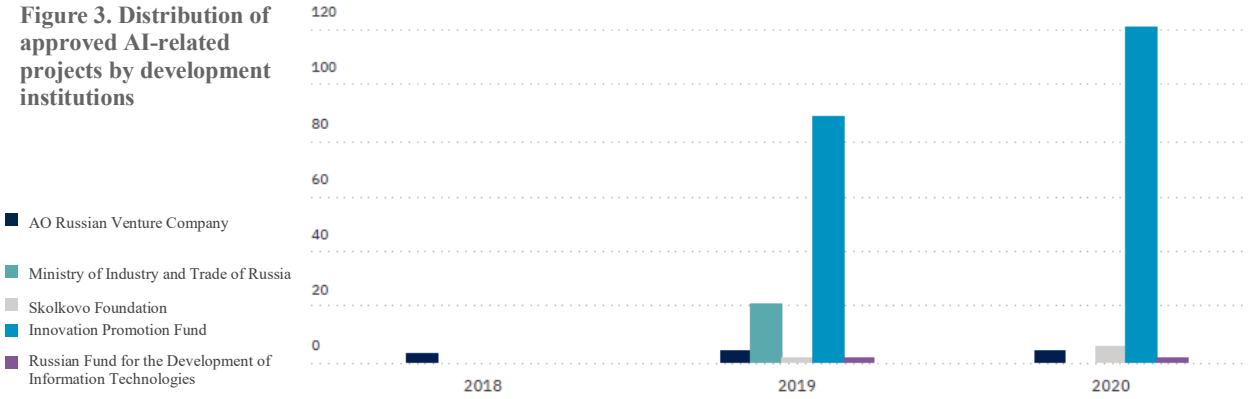


Figure 4. AI-related NTI spending, in millions, RUB

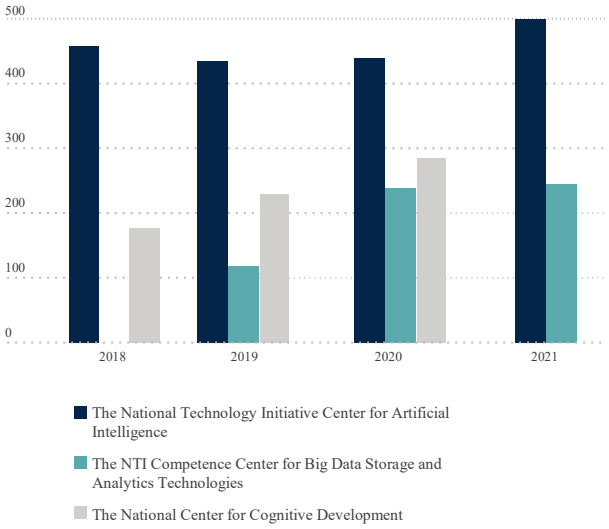
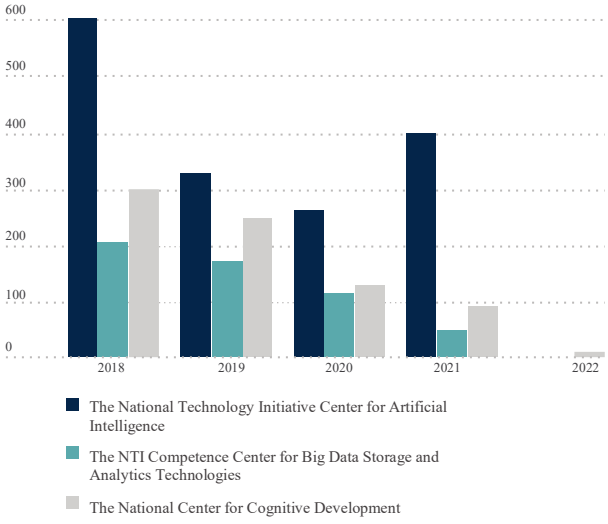


Figure 5. Extrabudgetary AI-related NTI spending, in millions, RUB



We also include in the AI development costs the creation and operation of the National Technology Initiative (NTI) Centers for Artificial Intelligence as part of the National Science and Universities Project:

- The NTI Competence Center for Artificial Intelligence at MIPT;
- The NTI Competence Center for Big Data Storage and Analytics Technologies under Lomonosov Moscow State University;
- The National Center for Cognitive Development under ITMO University.

Funding of the NTI Centers is shown in Figure 4. As we can see, state funding was provided only for 4 years, with the expectation that from the 5th year the Centers will move to self-sufficiency through partnerships.

Figure 5 shows the co-financing of the NTI Competence Centers with partners.

RUB 8.7 billion
was spent by the government on AI in 2018–2020 [40], including government contracts.

4.2 Government Procurement

Thanks to our partner Seldon, we analyzed government AI-related procurement for 2016–2020.

Seldon is a large Russian developer of open-source IT services for government agencies and private businesses: company.myseldon.com.

Government Procurement per Federal Law No. 44

Procurement per Federal Law No. 44 is carried out by government agencies. We have established 201 government purchases regulated by FL No. 44 totaling RUB 2.47 billion.[26]

Figure 1 shows total AI-related government procurement by year. As we can see, it is growing every year by more than 100% annually. Figure 2 shows the trends in government procurement volumes. The rate in the procurement volumes does not seem to grow that fast. Therefore, we can conclude that the average volume of purchases has increased annually.

Figure 1. AI-related government procurement, per FL No. 44, in RUB

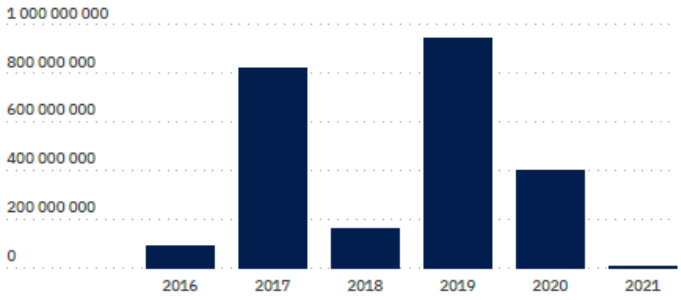


Figure 2. AI-related government procurement, per FL No. 44, in pcs

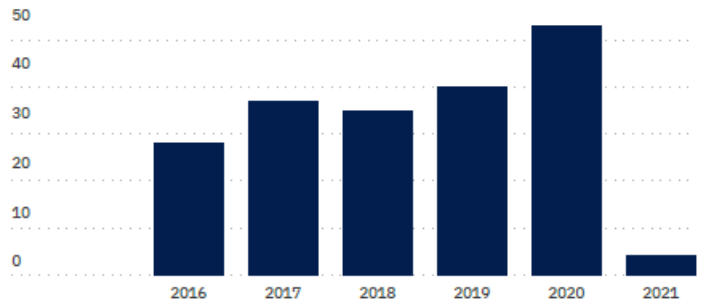


Figure 3 and Figure 4 show the volume and quantity distributions of government procurement by region. As we can see, Moscow is the most active customer of AI technologies, accounting for the most frequent and lucrative purchases.

Figure 3. AI-related government procurement by region in 2015–2021, in millions, RUB

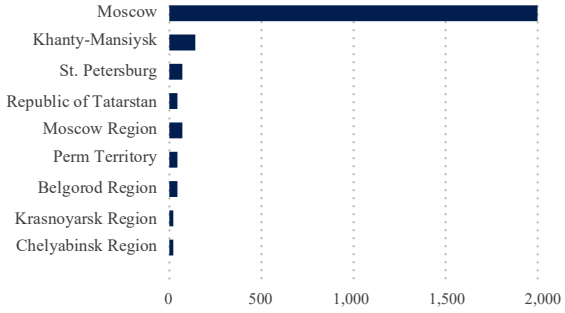
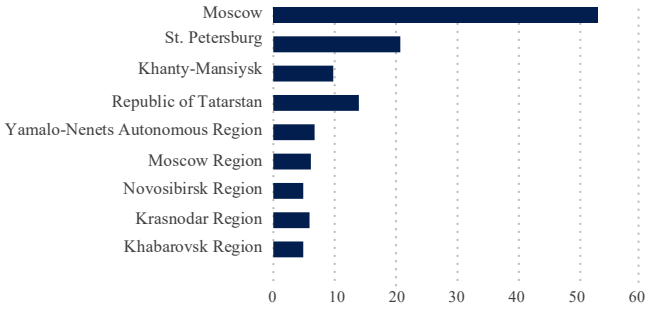


Figure 4. Number of AI-related government procurements by region in 2015–2021



If we look at the procurement structure, we can see that it involves the following main categories:

- Software development
- Purchase of equipment, software, and hardware systems
- Software development
- Provision of services related to AI or using AI

Figure 5. AI-related government procurement by category, in pcs

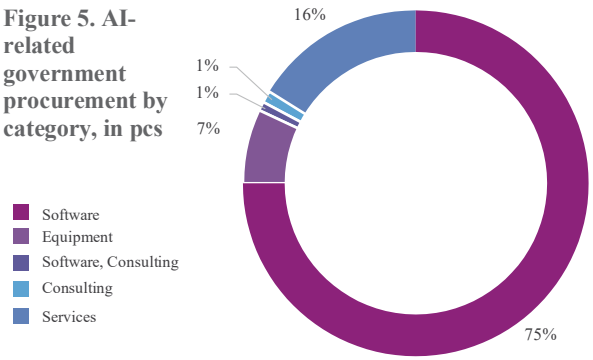


Figure 6 shows the distribution of the total purchases by these categories. As we can see, software and hardware account for the largest volume purchased. Interestingly, although services correspond to a high volume of purchases, they make up only 1% in monetary terms.

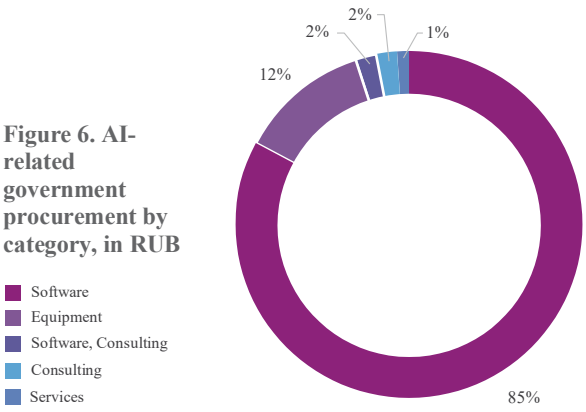


Figure 6. AI-related government procurement by category, in RUB

Seldon

Russian IT developer for government agencies and private businesses.

We work with open-source data.
Over 7,000 sources in real time.

We use advanced technologies.
Machine learning, predictive analytics.

We create services.
Tender products and solutions for businesses (monitoring, verification, automation, control). Internal and external services.

Seldon services form an ecosystem for the convenience of suppliers and customers. Thanks to product interconnectedness, we provide fast and comprehensive solutions.

20+ services | Big Data | National software registry | 12 languages | Customization | 10,000 clients

Government Procurement per FL No. 223

Federal Law No. 223 applies to procurement by large state corporations: e.g., PAO Sberbank and PAO Gazprom. Therefore, state procurement per FL No. 223 can also be deemed government AI funding. We have established 44 purchases per FL No. 223, totaling RUB 73.8 million.[27]

Figure 7 shows the total of AI-related public procurement by year. As we can see, the volume of purchases by state corporations are an order of magnitude less than purchases regulated by FL No. 44. The peak of purchases in monetary terms was in 2018. Figure 8 shows the trends in purchase quantities, and purchases seem to be decreasing.

Figure 7. AI-related purchases by state corporations, per FL No. 223, in RUB

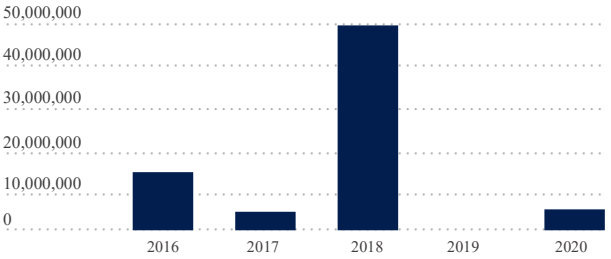


Figure 8. Number of AI-related purchases by state corporations, per FL No. 223

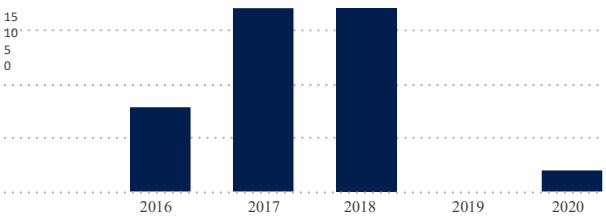


Figure 9 and Figure 10 show the volume and quantity distributions of government procurement by region. As we can see, the most active customer of AI technologies is Moscow, which accounts for the largest purchase amount, but the largest volume in the number of purchases falls on the Republic of Tatarstan.

Figure 9. Purchases by state corporations by region in 2015–2020, in RUB

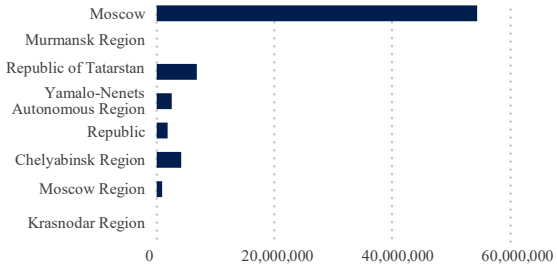


Figure 10. Number of purchases by state corporations by region in 2015–2020

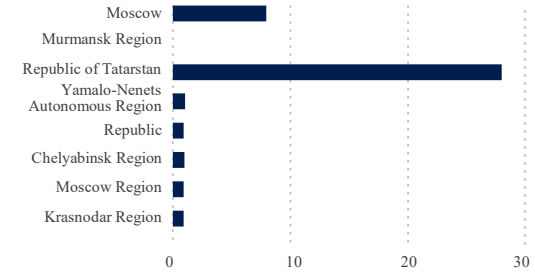


Figure 10 shows the distribution of the total purchases by these categories. As we can see, software and services account for the largest volume. Interestingly, in the number of purchases, the percentage of software purchases is only 16%, but in monetary terms it is 43%. It can also be seen that companies are much more active in purchasing services and are willing to pay for them.

Figure 11. AI purchases by category, in RUB

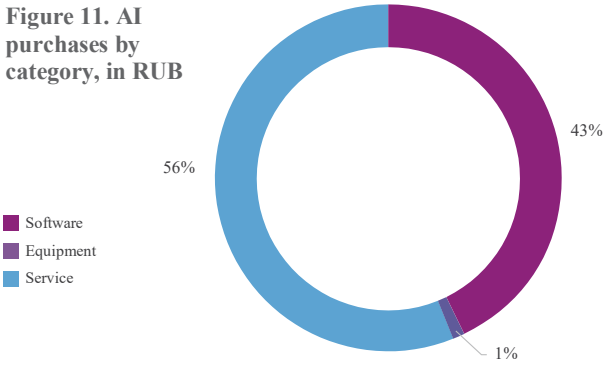
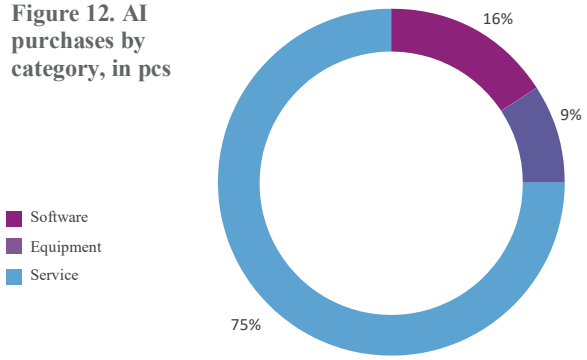


Figure 12. AI purchases by category, in pcs

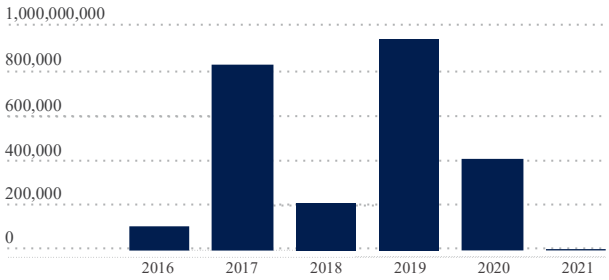


Total Procurement Figures

Thus, the total volume of AI-related purchases under FL No. 44 and No. 223 from 2016 to 2020 amounted to RUB 2.51 billion. For funding comparisons, we took as the basis the period of 2018–2020. The total purchases over this period amounted to RUB 1.57 billion.

Figure 13 shows the procurement trends by year.

Figure 13. AI-related purchases by state corporations per FL No. 44 and No. 223, in RUB



4.3 Comparing the U.S. and China

The U.S. and China are widely acknowledged as the global AI leaders. If Russia wants to become one of the world's AI leaders, it should think and act like a leader. In particular, seeing how much the leading countries have been spending on AI-related projects should help Russia figure out its strategies for future.

Of course, Russia's GDP is much less than that of the United States or China, so it would seem only natural that Russia should be spending much less than the leading countries. However, we should dig a bit deeper into the data.

Figure 1. GDP in Russia, the U.S., and China, in millions, USD[28]

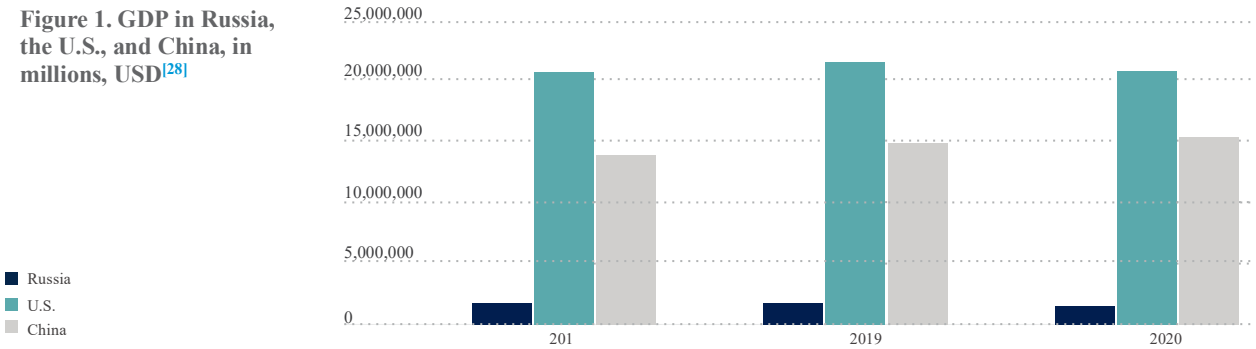


Figure 1 shows that Russia's GDP is about 14 times less than that of the United States and about 10 times less than that of China. This means that AI-related spending in Russia should be expected to be 10–15 times less than in the United States and China.

In 2020, AI-related spending in Russia was approximately RUB 3 billion, or USD 40 million at today's exchange rate.

~350 times
is by how much Russia's AI-related spending lags that of China.

On the other hand, in 2020, the U.S. invested in AI an estimated USD 6 billion, while China, an estimated USD 14.3 billion.[30, 32]

Figure 2. AI-related spending in Russia, the U.S., and China, in millions, USD

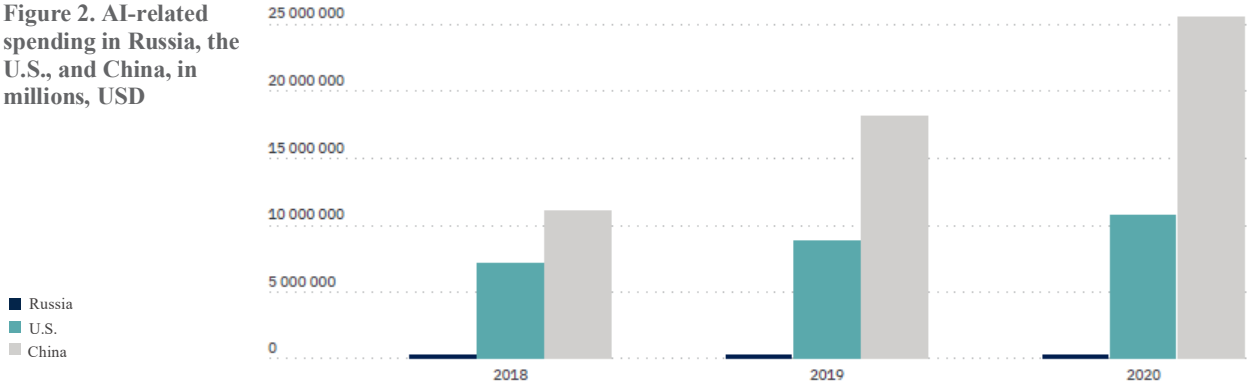
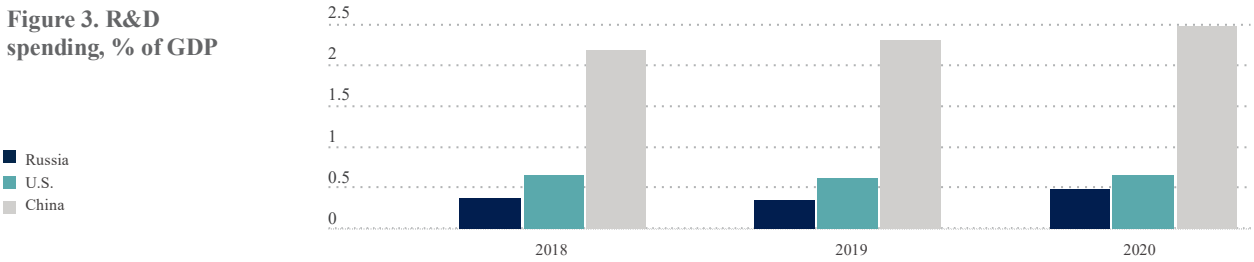


Figure 2 clearly shows that Russia's AI-related spending is about 150 times less than that of the United States and about 350 times less than that of China. So, why such a big difference?

Let's compare the total R&D spending in Russia, the United States, and China. Figure 3 shows that Russia's R&D spending as % of its GDP is comparable to that in the United States but 5 times lower than in China.[29, 31]

~5 times
is by how much Russia's R&D spending, as % of its GDP, lags that of China.

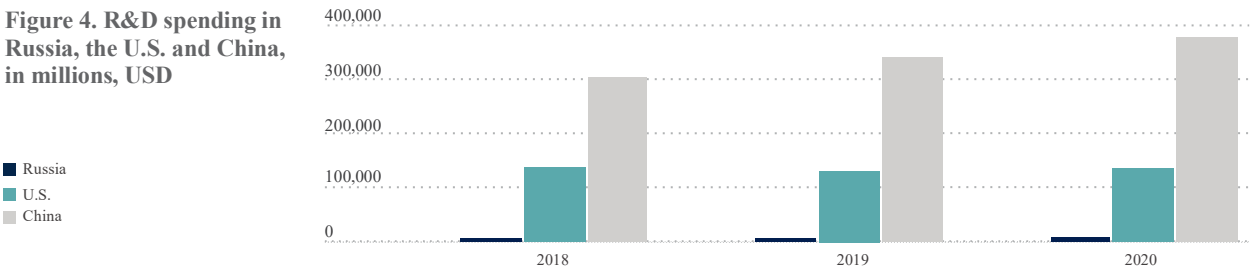
Figure 3. R&D spending, % of GDP



As a result, the spending figures of both countries are radically different, as shown in Figure 4:

~50 times
is by how much Russia's R&D spending lags that of China.

Figure 4. R&D spending in Russia, the U.S. and China, in millions, USD



In addition to the varying national R&D budgeting policies, the percentages of any AI-related spending within the national R&D budgets also significantly differ.

~7 times
is by how much Russia's AI-related spending, as % of total R&D spending, lags that of the U.S. and China.

Figure 5. AI-related spending as % of total R&D spending, in %

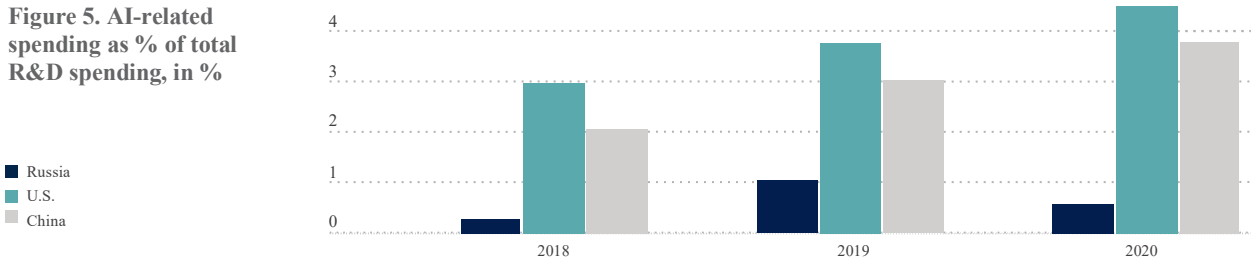
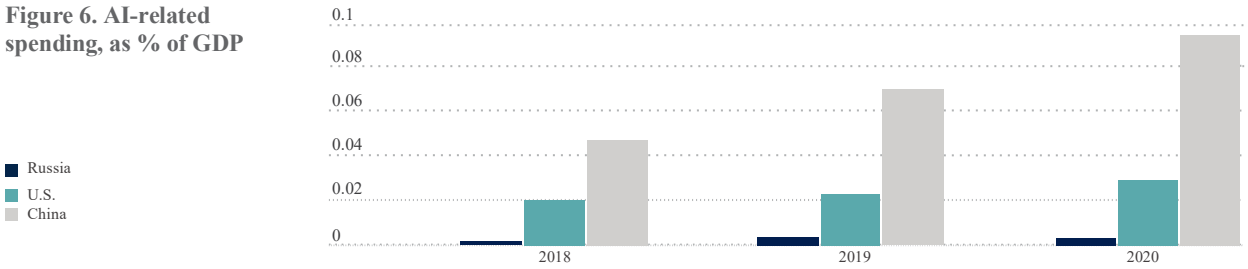


Figure 5 shows that the portion of AI-related spending within the total R&D spending in Russia is about 7 times less than in the United States and China. In other words, the U.S. and China prioritize AI more than Russia does.

~35 times
is by how much the portion of Russia's AI-related spending, as % of total GDP, is less than in China.

Naturally, the percentage of Russia's GDP allocated for AI-related R&D is about 35 times lower than in China and about 10 times lower than in the United States. Figure 5 shows AI-related expenditures in Russia, the U.S., and China as % of their GDPs.

Figure 6. AI-related spending, as % of GDP



Conclusions: If Russia intends to gain the upper hand in the AI field, it should:

1. Altogether increase its R&D spending by at least 3–5 times.
2. Increase the AI-related budgeting priority within the national R&D spending.

05. Education

Despite the 50,000 or so students graduating in Russia each year in specializations related to AI, our country continues to lack IT specialists. Having examined Russian developer teams and their qualifications, we have concluded that only those who have graduated from the top six universities and have such qualifications would be able to meet the current job requirements. And there are only about 2,000 such graduates each year.

When we studied the AI-related qualifications of specialists from different countries based on the world-famous online education portal Coursera, we established that Russian specialists rank No. 1 in the world for AI-related qualifications.

~3,500
students graduated from the top 6 universities with B.A. and M.A. degrees in 2020.[33]

No. 1
is Russia's global ranking for AI qualifications.[35]

Enrollment Trends in the U.S. and Canada

In this section, we discuss the data on enrollment in undergraduate computer science (CS) courses and degree programs in North America.

In the United States and Canada, practically all universities have implemented a so-called free education system. It means that students do not choose their specialties but simply enter universities where they have compulsory and elective subjects. Thus, any student during their undergraduate studies can select AI courses and choose to specialize in AI.

Figure 1 shows how many U.S. and Canadian undergraduate students have been enrolled in Computer Science (CS) courses. As we can see, the number of enrollments in such courses has doubled over the past 10 years, having reached 140,000 in 2019.

Number of students enrolled in Computer Science courses (North America)[39]

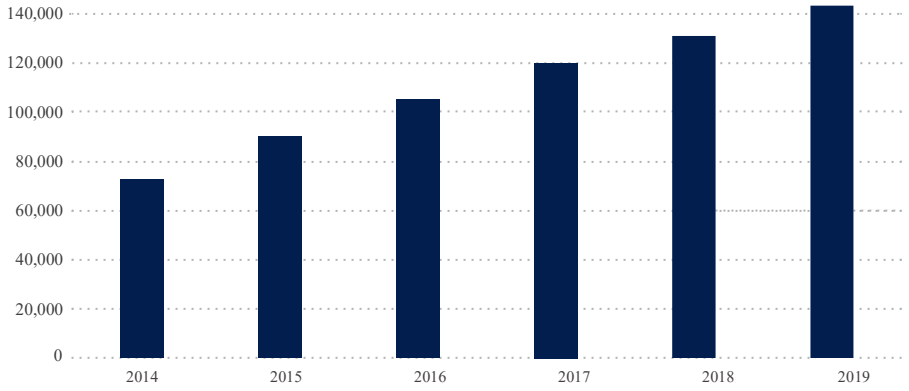
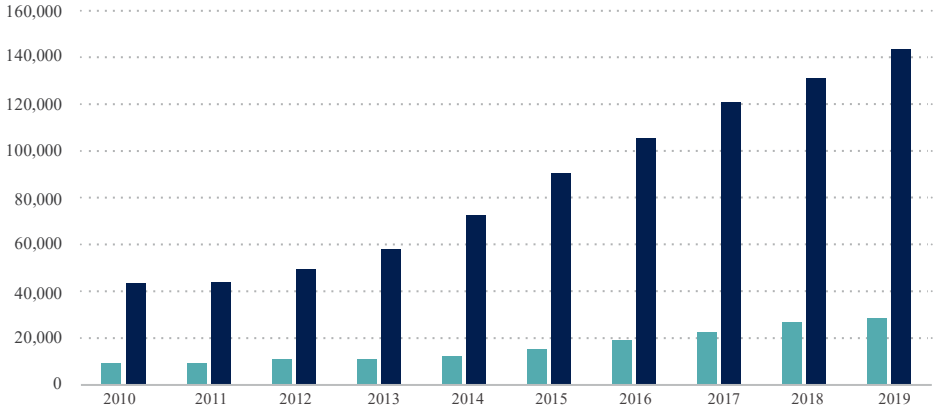


Figure 2 shows the number of students enrolled in CS courses and the number of students who have completed them. As shown, about 25% of students complete these courses and pass their exams. The high dropout percentage means that the best suited students end up graduating.

Number of current Computer Science students and graduates in North America (2010–2019)[39]



Enrollment Trends in Russia

In this section, we discuss the data on AI-related enrollments in Russia.

Contrary to the U.S. system, the Russian undergraduate programs are rigidly defined from the start, and, if a student is enrolled with the Department of Humanities, she may not be able to major in AI. Therefore, in the context of Russia, we included only those who have graduates with major in an AI-related field.

~50,000
students received a B.A. diploma in an AI-related field from one of the Russian universities in 2020.[34]

Figure 1 shows the public education enrollment trends for undergraduate degree programs in Computer Science, Computing, Mathematics, and Information Security. As we can see, in recent years, enrollment growth has been stable, each year increasing by about 7,000 students. However, the total of the B.A. graduates is almost 2.5 times less than in the United States.

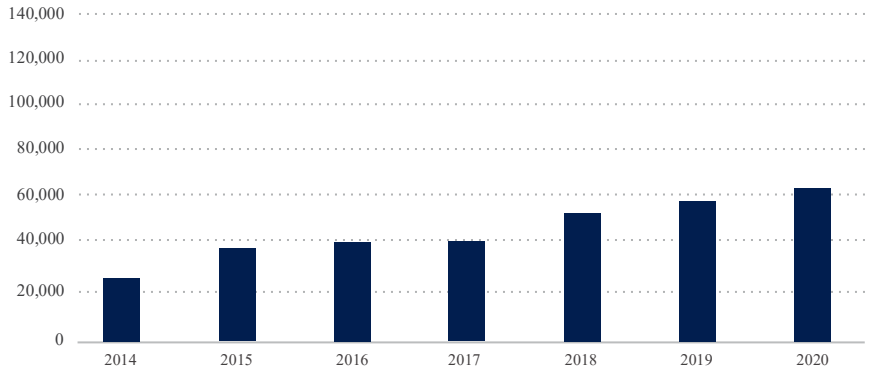
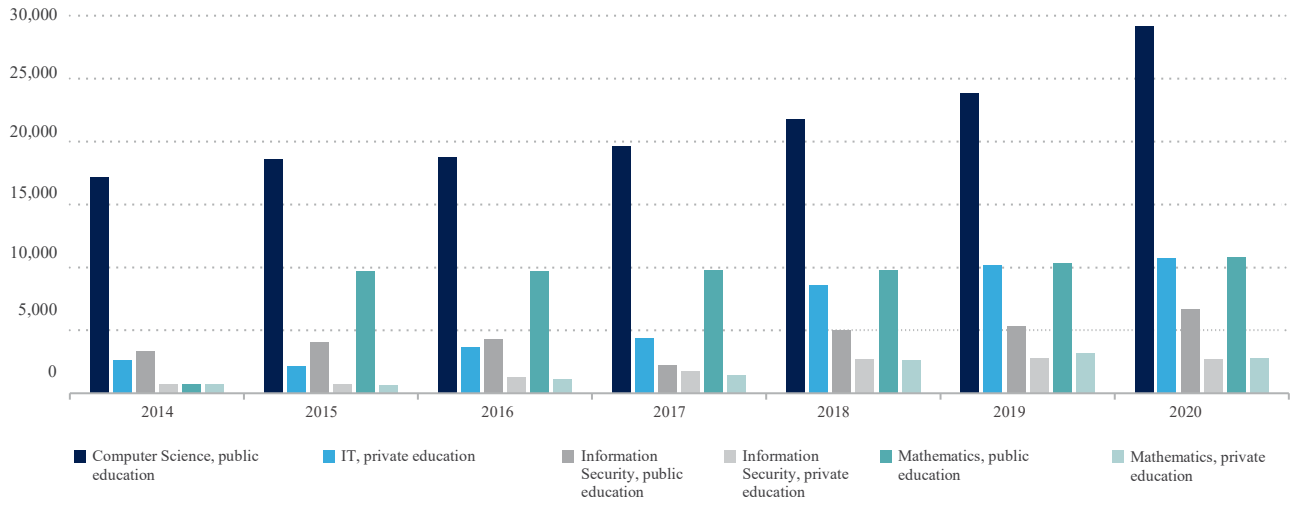


Figure 1.
Number of persons with B.A. diplomas in IT, Mathematics, or Information Security (Russia)[34]

Figure 2 shows the same trends by specialization.

Figure 2. Distribution of public/private education enrollments by major[34]



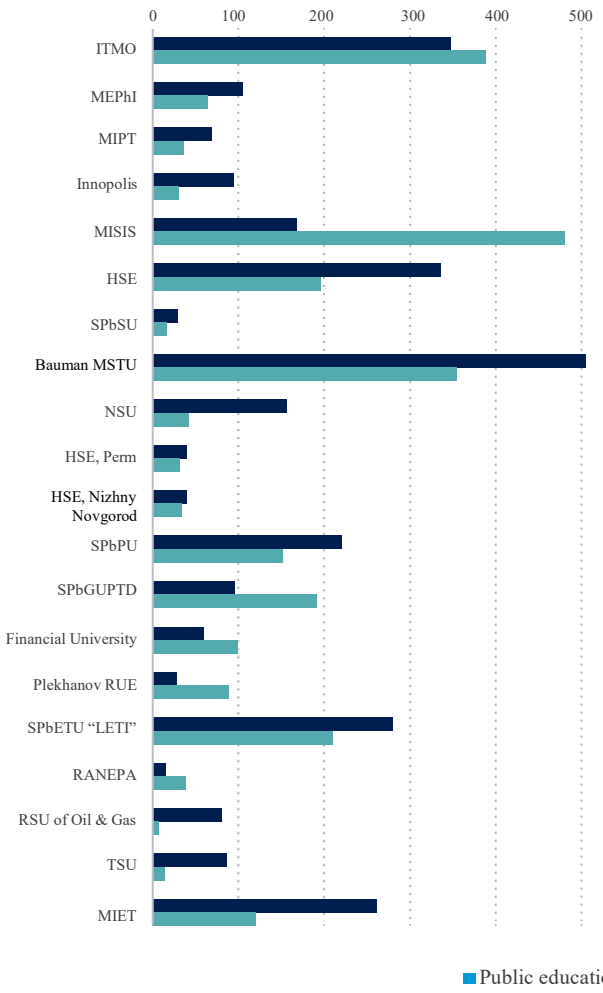
Thus, in 2020, about 50,000 students graduated from Russian universities majoring in an AI-related field.

Distribution of Majors in Universities

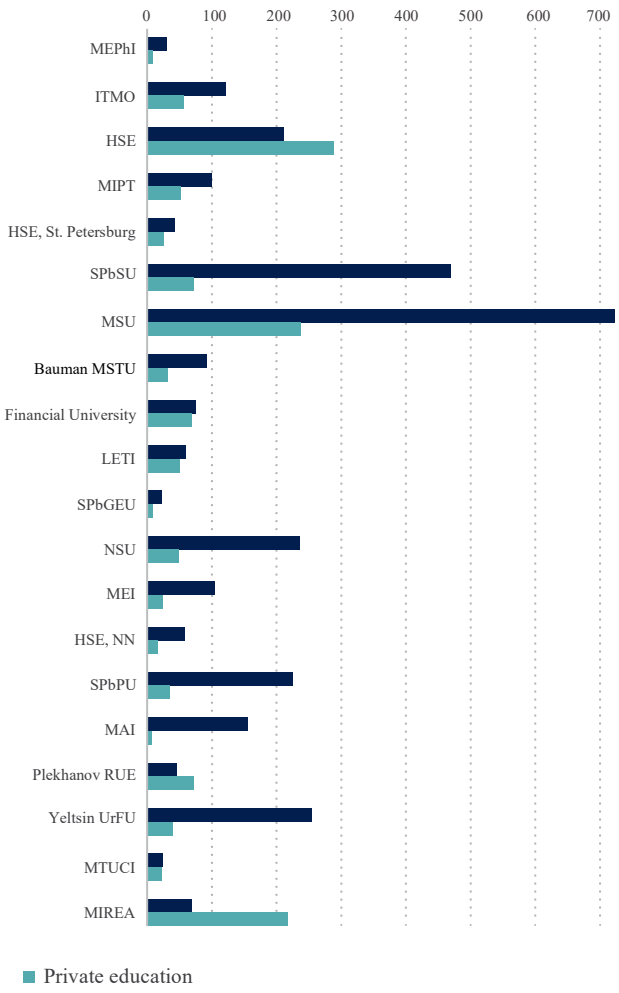
In this section, we discuss the data on AI-related program enrollments for different universities.

Universities tend to specialize in specific fields. Figure 2 and Figure 3 show the enrollments in various majors for the top 20 universities, based on the average National College Entrance Exam (NCEE) scores received by applicants on admission.

TOP 20 universities, as defined by the admission requirements, based on the average NCEE scores for IT and Computer Science Programs[34]



TOP 20 universities, as defined by the admission requirements, based on the average NCEE scores for Mathematics Programs[34]



Moscow State University and SPbSU clearly lead in Mathematics, while Bauman Moscow State Technical University, ITMO, NRU HSE, and MISIS lead in Computer Science and Computer Technology.

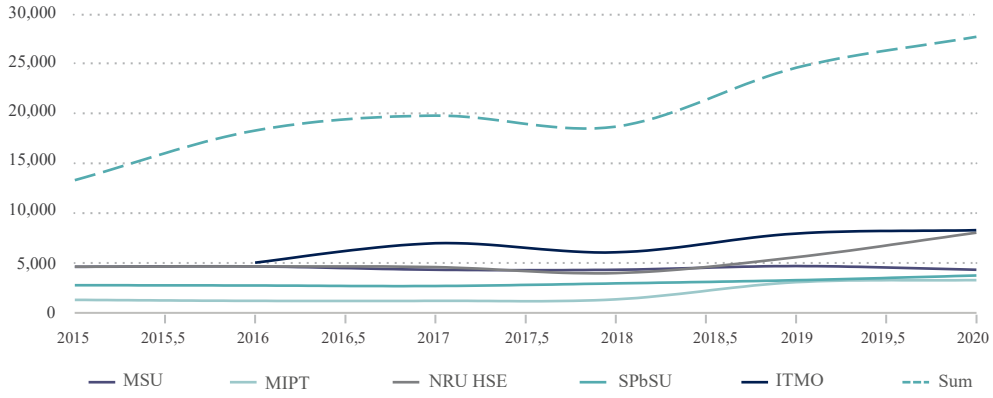
The total quotas for these majors in the universities above were 2,062 undergraduate program students and 2,023 master's degree program students.

Undergraduate and Master's Degree Program Enrollments

In this section, we discuss the numbers of enrollments in AI-related majors at the top universities in Russia from 2015 to 2018.

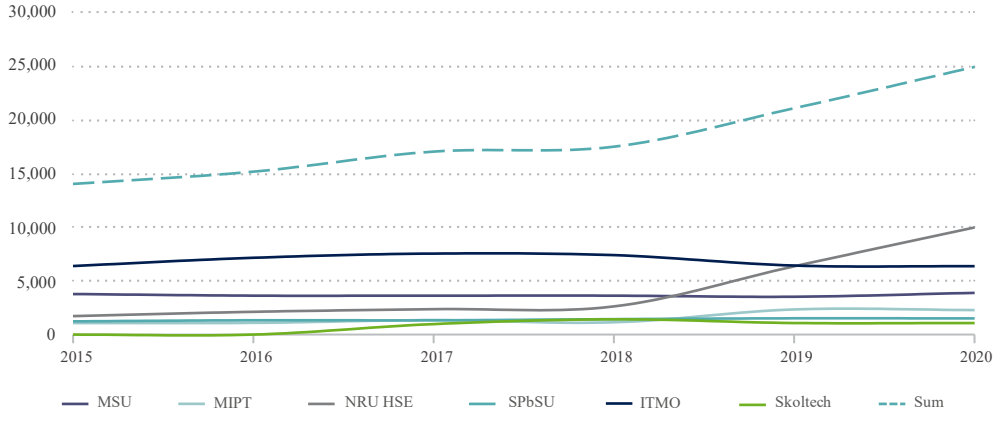
However, despite the seemingly growing number of graduations, the HR shortage in the AI field has not been decreasing. This is primarily due to the fact that the key tasks in AI can be performed only by those who have received ML training. These include those who have graduated from MIPT, MSU, NRU HSE, SPbSU, Skoltech, and ITMO.

The enrolment trends for the top 6 universities, as shown in the figures, suggest that, in the recent years, the number of such enrolments has barely increased. According to our data, about 3,500 students were enrolled in 2020 (bachelor's + master's degrees). Ninety percent of the students have completed their studies, with 70% of the B.A. graduates having applied for admission into the master's degree program.



Number of B.A./ specializations in top 5 AI universities

~3,500
students graduated from the top 6 universities with B.A. and M.A. degrees in 2020.[33]



Number of AI-related master's program enrollments by the top 6 universities

~650
graduates from the top 5 universities in 2020 meet the job requirements of the AI Alliance companies.[33]

The annual numbers of B.A. and M.A. graduates majoring in AI from the top 6 universities have remained virtually the same in the recent years—namely, 3,500 students or so per year. This is much less than the current HR needs in the field, which we estimate to be at least 5,000 specialists.

Comparison of AI Competency Levels

In this section, we evaluate the AI qualifications of specialists in Russia in comparison with other countries based on the Coursera data.

The 2021 AI Index Report did not provide any information on the qualifications of specialists in different countries in view of the 2020 data, although such information had been provided in the earlier reports. We found the information we needed in the 2020 Coursera Report, and what we have learned is hardly trivial.

2020 saw a great surge in the demand for online education resources due to the pandemic. One of such resources is Coursera, a leading e-learning platform. From March to December 2020, Coursera recorded over 69 million course enrollments—an increase of up to 430% comparing to the same period last year.

No.1 is Russia's global ranking for AI-related qualifications and skills.[35]

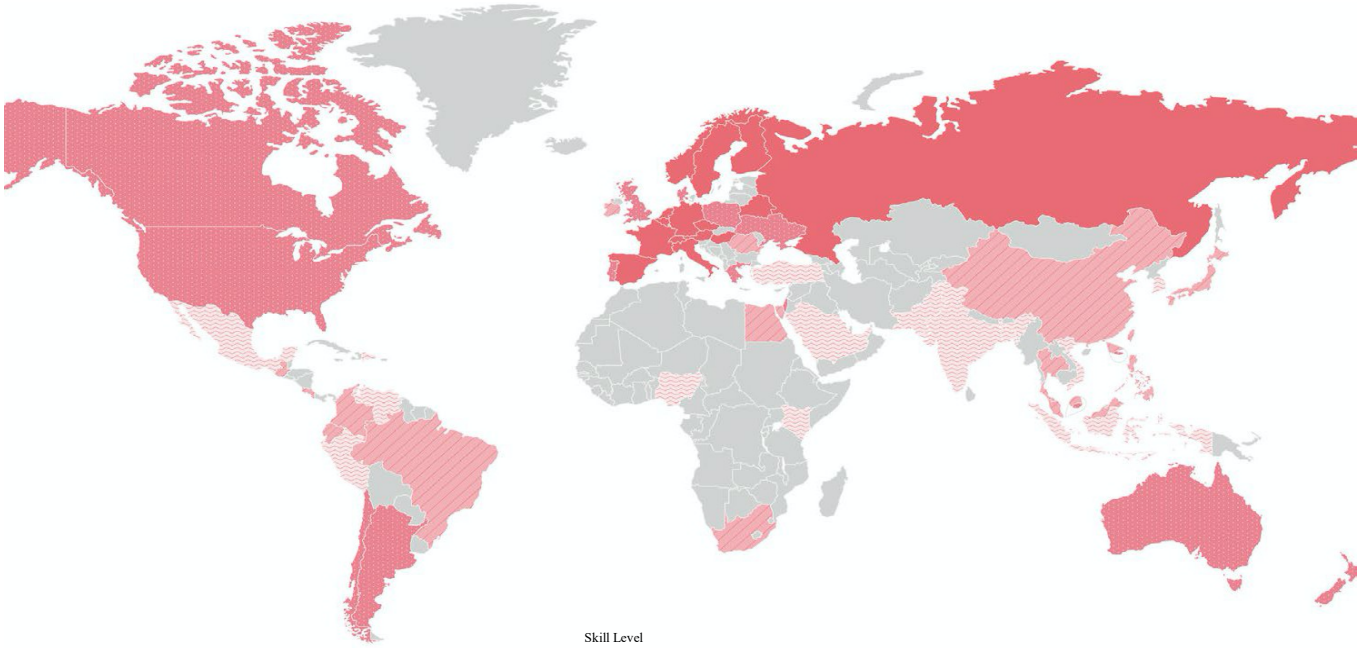
One should note the impact of the unusual circumstances on the 2020 enrollments, which included not only young students but also adults signing up for continuing education courses. The sample from this cohort is even more representative for measuring the impact of industry specialist qualifications.

In 2020, Russia-based Coursera students ranked No. 1 in terms of their competence for all AI-related technologies.

Here is an excerpt from the Coursera Report:

RUSSIA IS AHEAD OF THE GAME IN TECH EDUCATION

> Russia is the most skilled country in technology and data science. The country is unparalleled in its software engineering, statistical programming, data management, database, and operating systems skills. All of Russia's tech and data science competencies are categorized as cutting-edge or competitive.
>
> Russia produces some of the most talented Software Engineers in the world. The country consistently dominates international programming contests, outperforming both China and the U.S.[51] Its STEM education also has scale; Russia produces the most engineering graduates of any country— more than 450,000 per year. Russian students get a head start in computer science compared to students in countries like the U.S.; Russia's Federal Educational Standards (FES) mandate that informatics be compulsory in middle school. Students' technical skills are then fostered through a career-focused curriculum in higher education; Russia's Higher School of Economics, for example, recently announced the first top tier online master's program in data science that offers three career-related tracks for Data Scientists, Machine Learning Engineers, and Researchers in Data Science.



GLOBAL VIEW

Data Science

TRENDING SKILLS:

Python
Data Storytelling
SQL
R
Deep Learning
TensorFlow
Cloud APIs
Multi-Task Learning
Linear Algebra

	CUTTING-EDGE	PERCENTILE
01	Russia	100%
02	Switzerland	98%
03	Belgium	97%
04	Austria	95%
05	Finland	93%
06	France	92%
07	Germany	90%
08	Belarus	88%
09	Netherlands	86%
10	Norway	85%
11	Sweden	83%
12	Spain	81%
13	Hungary	80%
14	Czech Republic	78%
15	Italy	76%

	COMPETITIVE	PERCENTILE
16	Hong Kong	75%
17	Singapore	73%
18	Israel	71%
19	Denmark	69%
20	Poland	68%
21	Canada	66%
22	Argentina	64%
23	United States	63%
24	United Kingdom	61%
25	New Zealand	59%
26	Portugal	58%
27	Greece	56%
28	Australia	54%
29	Ukraine	53%
30	Chile	51%

	EMERGING	PERCENTILE
31	Philippines	49%
32	Romania	47%
33	Ireland	46%
34	Guatemala	44%
35	China	42%
36	Ecuador	41%
37	Costa Rica	39%
38	Thailand	37%
39	Brazil	36%
40	Japan	34%
41	Colombia	32%
42	Taiwan	31%
43	Malaysia	29%
44	South Africa	27%
45	Egypt	25%

	LAGGING	PERCENTILE
46	Republic of Korea	24%
47	Venezuela	22%
48	Mexico	20%
49	Dominican Republic	19%
50	United Arab Emirates	17%
51	India	15%
52	Peru	14%
53	Vietnam	12%
54	Saudi Arabia	10%
55	Turkey	8%
56	Indonesia	7%
57	Bangladesh	5%
58	Pakistan	3%
59	Kenya	2%
60	Nigeria	0%

06. Job Market

Having estimated the number of available jobs and résumés (CVs) created in the areas related to artificial intelligence, we have concluded that, despite the annual influx of fresh college graduates, the market continues to experience a chronic staffing shortage of at least 5,000 specialists.

Moreover, interestingly, the U.S.'s share of available AI jobs is 4 times higher than that of Russia (relative to the total pool of job offers).

~ 5,000

Data Scientists were the chronic staff shortage in the Russian market in 2020.[36]

×4

is by how many times the percentage of available AI jobs in Russia fall behind the U.S.[10]

This Chapter was prepared in collaboration with

AI Job Market

Data from our partner, HeadHunter, have provided us with a snapshot of job vacancies and résumés (CVs) by AI-related occupations. Such occupations, of course, include data specialists as well as AI model and algorithm specialists. And, finally, we will examine Product Managers, as we did before.

> We understand that the HeadHunter data is only partially representative of the total market. However, we estimated the HeadHunter share of job vacancies/résumés (CVs) at approximately 50% of the total number of job vacancies/résumés (CVs) in this market segment, so we believe that their data is fairly representative.

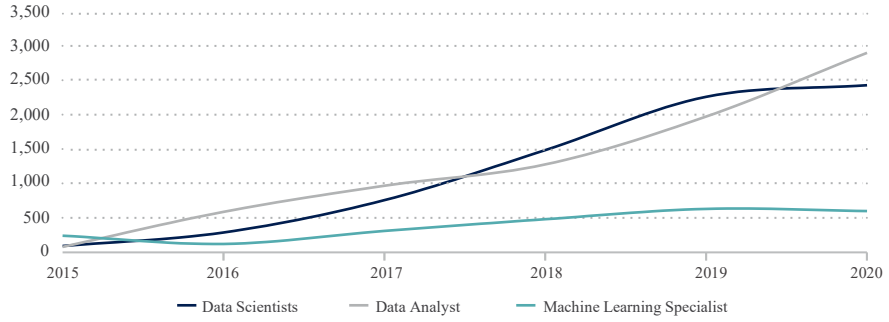
Trends in AI Job Openings

> This section provides estimates of AI-related job offers of the past 5 years.

Figure 1 shows the trends in AI job postings. As we can see, despite the systematic yearly growth, there was no growth in job offers for Data Science and ML specialists in 2020. The same was true for the United States. Based on various other data, we believe that, in 2020, companies cut their development budgets and instead focused on productization and sale of their already developed technologies.

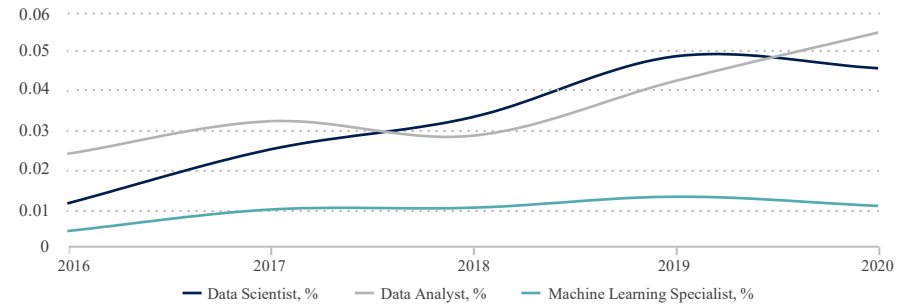
Figure 2 shows the trends in AI job offers as percentages of the total number of job vacancies. We should note here that, in Russia, this percentage (adjusted for the HH percentage) is about 4 times lower than in the U.S. (0.2% vs. 0.8%), while the total number of job offers is about 25 times lower (around 12,000 in Russia vs. 300,999 in the U.S.).

Figure 1. Breakdown of job offers



5,921
of AI job offers were posted in 2020.[37]

Figure 2. Percentages of the total jobs posted



4 times
is by how much Russia's share of available AI jobs fell behind that of the U.S. (as % of total jobs pool).[10]

AI Résumé (CV) Trends

This section provides estimates of AI-related résumé (CV) created over the past 5 years.

Figure 3 shows the résumé (CV) trends by AI-related positions. As we can see, in 2020, the growth in the number of created résumés (CVs) has been significant. We believe that, in 2020, companies cut their budgets for salaries and employee benefits, and many professionals updated their résumés (CVs) in search of better employment terms.

Figure 4 shows the share of AI résumés (CVs) in the total number of résumés (CVs) created. In order of magnitude, the number and percentage of résumés (CVs) created roughly correspond to the number of job offers. We also know that many companies have trouble finding specialists to hire. We have found that, as new job offers continue replacing the old ones, the urgent HR needs of about 5,000 extra specialists remain unmet.

Figure 3. Résumé (CV) trends

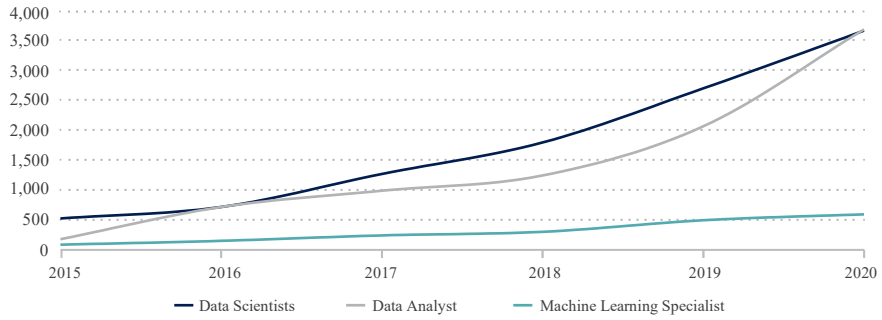
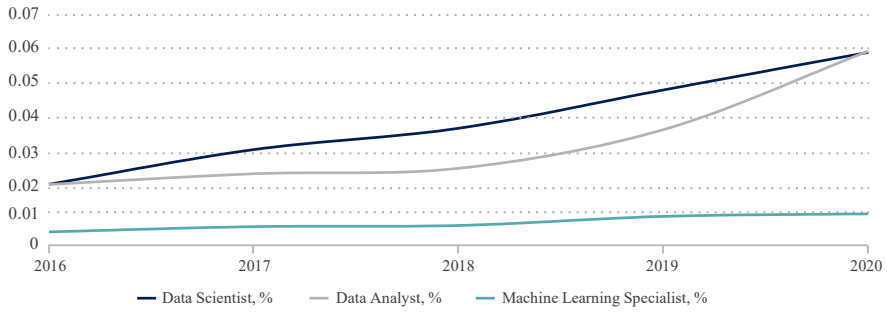


Figure 4. Percentage of the total number of résumés (CVs) created



7,916
résumés (CVs) for AI specialists were posted or updated in 2020.[36]

Product Managers

12,059
Product Manager job offers were posted.[37]

11,133
Product Manager résumés (CVs) posted[36]

As in the last year, we see that the demand for Product Managers has not subsided. Product Managers are responsible for commercializing technologies. Today, this is perhaps the most pressing issue in the AI industry in Russia. We have many people who develop technologies and many potential applications. However, we need those who turn technologies into products by communicating with the customer, understanding

why and who needs the product, and managing the development of the product, including a convenient interface for interactions, user trainings, etc.

In Silicon Valley and Europe, it is entrepreneurs and startup founders who perform such functions. In Russia, large corporations hardly ever purchase products from startups and instead try to do everything in-house. Therefore, companies' own Product Managers or Product Owners are prioritized.

Data Analyst

Data Analyst is responsible for analyzing and resolving any issues related to data, data types, and relationships between data elements in business or IT systems. Below is a cloud of qualifications that most employers want to see in their Data Analysts. As we can see, it is strongly biased towards working with structured data (different SQL formats), even though nowadays the global trend involves working with unstructured data.

3,672 Data Analyst résumés (CVs) posted in 2020.[36]

Data Scientist

Data Scientists are responsible for analyzing and interpreting large volumes of data. A very broadly defined occupation, Data Scientist is often referred to as both an ML specialist and a DL specialist, or simply a data analyst. Below is a cloud of qualifications that most employers want to see in specialists of this profile.

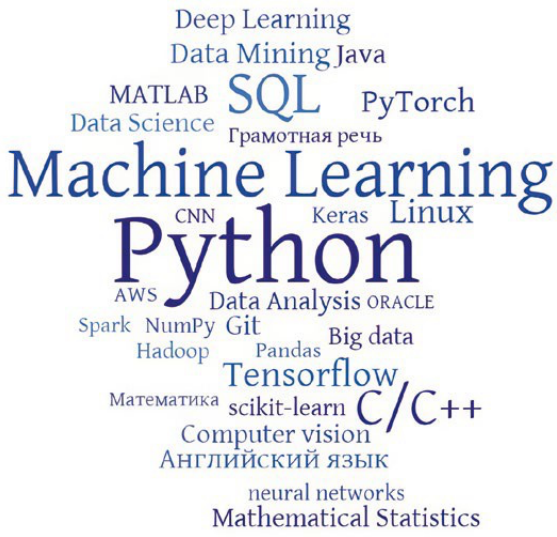
The set of qualifications here is clear: The Python language, which is preferred for use in data analytics, is the top requirement.

3,653 Data Scientist résumés (CVs) posted in 2020.[36]

Machine Learning (ML) Specialist

ML Specialists are responsible for developing new algorithms or adapting the existing algorithms that can be trained on various kinds of data and, as a result, make predictions. The base ML language is usually Python. Below is a cloud of qualifications that most employers want to see in specialists of this profile.

591 ML Specialist résumés (CVs) posted in 2020.[36]



Product Manager

Product Managers are responsible for creating new products, performing market analysis, developing assortment policy, pricing, creating product promotions, KPI planning, product requirements, and determining the purpose of the product. We believe that, currently, Product Managers are the most sought-after specialists in the AI industry in Russia. Unlike Data Scientists, whose core qualifications are more prominent, Product Managers have broader skills, and all of them are important. Therefore, finding and hiring Product Managers is much more challenging.

11,133 Product Manager résumés (CVs) posted in 2020.

Compared to last year, sales-related qualifications seem to have been in high demand. We believe this is a misunderstanding by employers of the functions and tasks of Product Managers, who should not so much sell as understand what the customer is willing to purchase and in what form.

07. Conclusions and Recommendations

Conclusions

DISCUSSION AND CONCLUSIONS

In this Report, we wanted to look at the AI industry from different angles so that we could evaluate several key characteristics for each of the AI properties. Moreover:

1. We understand that in some cases we have provided data that only indirectly characterize AI properties. For example, the number of research publications is not an unambiguous indicator of R&D status. Unfortunately, we do not have more accurate metrics. This problem is not only ours but of scientometrics, in general.
2. In many cases, we are unable to double-check the numbers and have to publish the data sent to us by our partners or published online.

Nonetheless, the few key takeaways are as follows:

GENERAL CONCLUSIONS

1. As of 2020, Russia has not been among the AI leaders and has been noticeably lagging in most AI areas. Russia's AI-related R&D is lagging most of all. There are a few "stars" in the industry: such companies as Yandex and Kaspersky Lab are internationally recognized.
2. We can clearly see the potential points of growth, and, if we act with urgency, we can start seeing the growth—as an industry and, overall, as a nation.

Science & Education

1. Russia has a huge potential for growth, and the figures we have provided in our Chapter on Education attest to that. In 2020, Russia ranked first in the world in terms of Russian specialists' AI qualifications and skills. So, we should start developing and strengthening this advantage in every possible way by investing energy and money in education.
2. Quality education is potential energy that will turn into kinetic energy, meaning, successful research or lucrative business. However, this cannot be done without proper R&D spending or decent working and living conditions for leading specialists so that they do not have an incentive to seek work abroad.
3. Compared to other countries, Russia does not provide for sufficient financial support of the entire AI stack: basic research, applied sciences, R&D, product development, and consumer incentives. Our spending should be increased 3- to 5-fold to cover all these areas.
4. In Russia, product management remains the most sought-after occupation in the AI industry thanks to its focus on how to turn technology into a product and market it. This prioritizes the customer's needs, which in turn necessitates industry knowledge and the deep understanding of technology—the qualifications attributed to developers. In other words,

this requires interdisciplinary skills as well as advanced communication skills, something that most technologically minded specialists tend to lack. Therefore, we need to continue expanding our undergraduate educational programs by combining science and humanities.

Business & Investment

1. The Report clearly shows that the AI industry is the engine of economic growth. After all, in the last decade, the growth rate of AI companies has been on average 7.5 times higher than the growth of the entire economy. Any government investment in businesses and startups will pay off many times.
2. Some of the successful companies in the AI industry were until recently small startups and received support from the Innovation Promotion Fund, the Skolkovo Foundation, and other development institutions. As we can see, development institutions have been gradually playing their formative role in the formation of a new industry, helping future market leaders. However, in 2020, such development institutions were reformed, which will inevitably cause some organizational chaos, at least for some time. Still, we remain hopeful that the recent reorganization will not affect its efficiency (as is usually the case) and will instead enhance it.
3. The most competitive areas reveal the fastest growth rates and the most frequent technological innovations. The competitiveness among large companies—Yandex, Sberbank, Mail.ru, and others—prompts them to seek the most effective solutions and business models. We must support competition in every possible way and limit any market monopolization efforts. This will contribute to the overall growth of the industry.

HR & Job Market

1. The demand for Data Science and ML specialists, which for many years had been growing, slowed down in 2020. The same was true for the United States. Based on various other data, we believe that, in 2020, companies cut their development budgets and instead focused on productization and sale of their already developed technologies.
2. Judging by the trends in résumé (CV) creations and job offers, knowing that many companies have trouble finding specialists to hire, we conclude that, as new job offers continue replacing the old ones, the urgent HR needs of about 5,000 extra specialists remain unmet.

Government

1. Government spending on the AI industry is still dozens of times lower than that of other countries, which have already made significant advances in AI. On the one hand, we do not need to blindly copy others. If there are obvious shortcomings, we need to correct them. If Russia truly wants to become the world leader in AI, we need to significantly increase our government spending on the AI industry and remove any barriers in the way.
2. The pace of adoption of the key documents and allocation of funding is still very slow. Almost two years have passed since Russian President Vladimir Putin gave instructions to come up with a plan for the development of artificial intelligence in the Russian Federation (on May 30, 2019). Now, at last, we can observe the emerging measures of support. This pace of decision processing is, no doubt, due to the joint elaboration of such support measures together with industry. Yet, it is still too slow in today's AI world.
3. Procurement analysis shows that large state corporations and government agencies hardly ever purchase solutions from small companies. And this greatly limits the growth opportunities for any new market participants. We must take special measures to stimulate purchases from small companies.

Recommendations

As observers, we are not very happy about the current state of the AI industry. Criticizing is not enough, however. What we need is a constructive approach. We will try to suggest some measures and steps that, in our opinion, need to be taken to remedy the situation.

Scientific Efforts

There are still very few high-quality AI-related publications in Russia. This is not because we have fewer talents, but because researchers lack motivation. Here, we can suggest two things:

1. Our spending on research, whether fundamental or applied, should be increased 3- to 5-fold. There is no need in any new funding channels as they take time. We just need to inject cash into the existing channels: the RAS, universities, any grant-issuing foundations, etc.
2. In the funding itself, we must shift our focus to people. We should stop spending money on equipment; it will not create anything by itself. We must increase salaries for research assistants and professors and establish very high bonuses and extra incentives for A* conference publications and publications in Q1 of peer-reviewed journals. This approach is already being implemented by Skoltech University and NRU HSE. It certainly works, but it

needs to be scaled up and strengthened. Only then young, talented students will remain in research and create new AI algorithms, instead of going to work in banking or commerce.

Business

As for business, we have only one recommendation: Do not change anything! The one thing we can do for businesses is to ensure that they have stable and invariable rules of the game. They will take care of the rest.

Startups & Investment

For this category, we have three recommendations:

1. Funding for small and medium-sized companies that have AI technologies should be increased many-fold. There is no need for any new funding channels as they take time. We just need to inject cash into the existing channels: grant-issuing foundations, development institutions, etc.
2. We must amend our regulations to protect investors from constant scrutiny by authorities. We need to legislate at the highest level to show any potential investors that they need not fear any persecution should the projects they have invested in fail. Such failures are inevitable: For every 100 promising companies invested in, only 5–7 of them survive. We need to ensure that investing in startups is not itself a risky business. Without this, any increase in funding would be pointless.
3. The industry desperately needs exits, i.e., strategic startup acquisitions by larger companies. To do this, we need to encourage companies to buy startups instead of trying to lure their talents with bigger salaries. Today, all our large companies are trying to do everything in-house. This prevents young talented teams from growing. We need to ensure that startup founders get an opportunity to make money by selling their companies! Just a few such success stories would give a strong boost to the market.

Education

We have very few AI specialists graduating in Russia. This is mainly due to the sluggishness of the Russian education system, which is extremely slow to rebuild itself to meet market needs. So, at times, it just ends up ignoring such needs. Two recommendations:

1. We should introduce a nuclear education model in our universities (implemented by leading American colleges). Under such model, a student simply enrolls in a college without being tied to a particular department, and is able during the course of study to freely select elective courses in addition to the compulsory (nuclear) program. This way, any interested students could choose AI courses. However, such courses in Russian universities can be assigned only to students who major in appropriate disciplines, which greatly limits their numbers. To ensure the growth of AI specializations, we need to provide all students, and not only mathematicians or physicists, with an opportunity to study AI. This would be possible only through a free education model, which is much more flexible to respond to the needs of the market.
2. Ideally, we would need to revise all university programs by restructuring our technical specialization strategies, which in Russia have been traditionally kept outside the national university network and provided by technical colleges, polytechnic institutes, or specialized training schools. Nowadays, all educational programs have to be coordinated with the Ministry of Education and Science, which only adds more bureaucracy and greatly delays the process. Instead, universities could coordinate their programs with their industry supervisory boards. Today, Russian universities are almost completely ignorant of market needs, even though any future job requirements for their students will be determined by the corporate sector, acting within the real economy. If we want in 5 years to have not 10,000 but 50,000 specialists, we need to restructure and spread this process across all universities to ensure they create their programs relying on industry input.

Government

For this category, we have three recommendations:

1. The government should encourage competition in the market at all levels and limit monopolization. This will contribute to the overall growth of the industry because, as we know, the best growth is prompted by competition. It is through competition that the best solutions and business models are efficiently selected.
2. To improve competition, the government (represented by state-funded budgetary institutions, state corporations, etc.) should spend more on goods and services offered within the free market system—by small startups and medium-sized companies. The main problem for startups is the lack of a sales market. The government could support them through open tenders.
3. Decision-making, support, and funding at all levels need to be dramatically accelerated. Nowadays, speed and response times have become critical for the AI industry.

We cannot list here all the recommendations in detail. However, we are open to discussing them outside the Almanac. Our task is only to show you that there are many ways to radically improve the situation.

08. Appendices

The References and Methodology Used for Generating the Report

1 https://deepmind.com/blog/article/alphafold-a-solution-to-a-50-year-old-grand-challenge-in-biology.

2 https://www.myheritage.com/deep-nostalgia?lang=RU.

3 https://arxiv.org/abs/2005.14165.

4 https://super.gluebenchmark.com/leaderboard.

5 http://robot-design.org.

6 https://openai.com/blog/dall-e.

7 https://blog.inten.to/hardware-for-deep-learning-part-4-asic-96a542fe6a81.

8 https://www.eetimes.com/nvidia-google-both-claim-mlperf-training-crown.

9 http://faculty.washington.edu/ebender/papers/Stochastic_Parrots.pdf.

10 https://aiindex.stanford.edu/wp-content/uploads/2021/03/2021-AI-Index-Report_Master.pdf.

11 https://www.nscai.gov/wp-content/uploads/2021/03/Full-Report-Digital-1.pdf.

12 https://ai.googleblog.com/2019/03/simulated-policy-learning-in-video.html.

13 http://portal.core.edu.au/conf-ranks.

14 Data on Russian and global AI-related articles, conference publications, patents, and repositories were taken from the Microsoft Academic Graph — 2021 AI Index Report: (https://docs.google.com/ spreadsheets/d/1HL8-F2gDDPOmZVK15FV3HrXS_r57TLSQ6dhaInXvd10/edit).

15 Data on Russian publications at conferences A* were provided by the Skolkovo Institute of Science and Technology.

16 Data on Russian publications at NerlIPS and ICML conferences: https://chuvpilo.medium.com/whos-ahead-in-ai-research-in-2020-2009da5cd799 https://medium.com/criteo-engineering/neurips-2020-comprehensive-analysis-of-authorsorganizations-and-countries-a1b55a08132e.

17 Data on Russian AI publications by affiliation type were taken from the Elsevier — 2021 AI Index Report:

https://docs.google.com/spreadsheets/d/1NoLVGlSnelAVojrutYnleL7_yVaPjt99/edit#gid=1766375576.

18 Data on Russian journal publications were taken from the OECD AI Policy Observatory: https://oecd.ai.

19 The TOP 20 RUSSIAN AI RESEARCHERS BY PUBLICATIONS ranking was compiled based on the RSCI data: https://elibrary.ru/project_risc.asp? and Google Scholar: http://scholar.google.com.

20 Data on the trends of Russian publication on arXiv for 2013–2020 were taken from the ArXiv – 2021 AI Index Report: https://docs.google.com/spreadsheets/d/1Ojx0MA9Fvc2b-8_Jw7dMUr0R411DixcimF4lOl0L7J0/edit#gid=1734746380 in the following Chapters:

cs.AI — computer science.artificial intelligence

cs.CL — computer science.computation and language

cs.CV — computer science.computer vision

cs.LG — computer science.learning

cs.NE — computer science.neural and evolutionary computing

cs.RO — computer science.robotics

stat.ML — statistics.machine learning

21 The data were prepared by IP Laboratory LLC and mapped to the Russian Artificial Intelligence map: http://airussia.online/. The map was last updated on 03/30/2021.

22 Information on the companies' revenues for 2019 was provided by Seldon (https://seldongroup.ru/).

23 Data on business agreements was provided by Dsight.

24 https://aiindex.stanford.edu/report/.

25 Data on government AI funding in the Russian Federation were provided by ANO Digital Economy.

26 Information on procurement regulated under FL No. 44 since 2016 was provided by Seldon (www.seldongroup.ru). To search for purchases under FL No. 44 since 2016, related to purchases with AI technologies, a filter was prepared. The filter searches for the names of purchases and lots with any given word combinations, and the sample of purchases is limited to the selected OKPD2 (see the Appendix for the list of OKPD2). With any of the words / phrases: artificial * intelligence, artificial intelligence *, neuron * networks, networks neuron *, neural network, machines * trained *, trained * machines *, smart assistant, smart assistant, chat bot, chat bot, chat bot, chat bot, chat bot, chat bot, big data, recommendation system, predictive * models, predictive * models, predictive * models, predictive * models, recommender * systems, recommender * systems, modeling, artificial intelligence, machine learning, deep learning, data science, deep learning. Based on the performance results of the system using such search filter, we have established 260 purchases totaling around RUB 3.6 billion. Having also analyzed it manually, we ruled out 59 purchases that are not related to AI, leaving total of 201 purchases of about RUB 2.47 billion.

27 Information on procurement regulated by FL No. 223 since 2016 was provided by Seldon (seldongroup.ru). The search tool features relevant filters to help search any AI-related purchases regulated by FL No. 223 since 2016. The search filter searches for purchases by names and batches, by any given phrases, with the purchase selection limited to selected OKPD2 (please see the Appendix for the OKPD2 list). With any of the words/phrases: artificial* intelligence, artificial intelligence*, neuron* networks, neuron networks*, neural network, machine* trained*, trained* machines*, smart assistant, smart assistant, chat bot, chat bot, chat bot , chat bot, chat bot, chat bot, big data, recommendation system, predictive* model, predictive* models, predictive* models, predictive* models, recommender* systems, recommender* systems, modeling, artificial intelligence, machine learning, deep learning , data science, deep learning. Based on the results of the system's operation with this filter, we found 62 purchases for a total of RUB 138 million. After analyzing it additionally manually, we excluded 18 purchases that are not related to AI, and

left 44 purchases for a total of RUB 73.8 million.

28 GDP of Russia, USA and China: https://knoema.ru/atlas.

29 https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm.

30 https://www.idc.com/getdoc.jsp?containerId=prUS46794720.

31 https://www.bloomberg.com/news/articles/2021-03-01/china-s-r-d-spending-rises-10-to-record-378- billion-in-2020.

32 Chinese Public AI R&D Spending: Provisional Findings CSET Issue Brief: https://cset.georgetown.edu/wp-content/uploads/Chinese-Public-AI-RD-Spending-Provisional-Findings-1.pdf.

33 The total enrollments in AI for undergraduate and graduate programs of the top 6 Russian universities were estimated based on the official websites of the university admission offices:

MSU (http://cpk.msu.ru/), NRU HSE (https://ba.hse.ru/; https://ma.hse.ru/), St. Petersburg State University (https://abiturient.spbu.ru/).

The enrollment data for the MIPT and ITMO undergraduate and graduate programs, and the Skoltech master's programs were provided by the university staff. In our assessment, we considered the following areas of training:

- Applied Mathematics and Computer Science
- Fundamental Informatics and Information Technology
- Informatics and Computer Engineering
- Information Systems and Technologies
- Applied Informatics
- Information Security
- Infocommunication Technologies and Communication Systems
- Mathematics and Computer Science

34 The data on total undergraduate enrollments in Mathematics and Computer Science was taken from the NRU HSE study of monitoring of the quality of college admissions: https://ege.hse.ru.

35 Coursera’s competency metrics. The methodology for this study is taken from the Coursera Global Skills Index (GSI) Report: https://blog.coursera.org/announcing-the-coursera-2020global-skills-index.

36 The data on created résumés (CVs) by specialization: Data Scientist, Data Analyst, ML Specialist, Product Manager posted on HeadHunter as of February 29, 2020, provided by HeadHunter.

37 Data on the number of job offers by specialization: Data Scientist, Data Analyst, ML Specialist, Product Manager posted on HeadHunter as of February 29, 2020, provided by HeadHunter.

38 https://content.fortune.com/wp-content/uploads/2020/11/T1042_pred_0_v1-.light-blue.jpg?w=1024.

39 Based on the Computing Research Association Taulbee Survey 2021: https://drive.google.com/drive/fold ers/1BWPqxrkJU1XPBIYLEFD2EJw9mdHNFhAu.

40 This year, we have posted the raw data we had collected from various sources, in particular, the data on government AI spending in the Russian Federation. You can view the data at: https://www.dropbox.com/sh/qtztcyw1sfvuqqv/AAA5UoaU40Uu7nZaLt1qwA3Ha?dl=0.

41 https://www.tadviser.ru/index.php/Article:Study:_Penetration_of_Artificial_Intelligence_based_Solutions into_Russian_companies

DISCLAIMER

This Analytics Report has been prepared using the data from the Stanford University study, available at: https://drive. google.com/drive/folders/1YY9rj8bGSJDLgIq09FwmF 2y1k_FazJUm?usp=sharing, and by analyzing open-source resources, including academic papers, patents, media, company websites, university websites, etc. We also used closed search systems and large text machine analysis, which process such open-source resources as MAG, Seldon, and Dimensions.ai. The Report contains all the necessary references to the sources and procedures for obtaining certain figures. Due to the nature of such method of collecting and processing information, we may have overlooked certain companies, universities, or individuals. We have not included in the Report any military AI applications as no reliable, open-source information regarding them is available. Nor have we included any information on any ongoing academic or corporate applied projects as no objective metrics for their assessment are available. This Analytics Report expresses the opinions of the editors and may not coincide with the official positions of the NTI Competence Center for Artificial Intelligence at the MIPT and/or its members and/or partners of this publication.

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We are inviting any organizations interested in partnering with us and participating in our next Almanac issues!

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