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Cloud computing: global trends and challenges for Russia in the time of sanctions

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Relevance. Cloud computing brings significant benefits to economy; the speed of its adoption is crucial for emerging as well as for established businesses. In 2022, since the sanctions against Russia were introduced, the dynamically developing Russian cloud market has been dealing with new challenges, which require scholarly attention.

Research Objective. The purpose of this study is to summarize the key factors that determine cloud adoption globally, identify the peculiarities of the Russian cloud market and outline the prospects for the development of cloud computing in Russia, taking into account the sanctions imposed in 2022.

Data and methods. The study relies on the statistical data from global databases and market surveys. The methodological framework of the study comprises comparative analysis and scenario methods.

Results. The main drivers of cloud adoption are infrastructural, economic, social and legal factors. Even though in some of these parameters Russia has achieved good results, the overall level of adoption of cloud services in the country is quite low. The Russian cloud market has a large share of local players, but the negative factor is SMEs' reluctance to move to the cloud. Further growth in this sphere is possible, however, even if the size of the cloud market shrinks.

Conclusions. The 2022 sanctions have posed a major threat to the Russian cloud market as they affected the segments of the critical IT infrastructure. However, there is likelihood that local cloud service providers might be able to substitute global providers. In many ways, it depends on the success of import substitution programs in the field of IT equipment, the policy of local providers, legislative support, and businesses' willingness to move to the cloud.

KEYWORDS

cloud computing, cloud adoption, sanctions, Russian cloud market, technology adoption, developing country, import substitution, development strategy, cloud strategy

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Облачные вычисления: глобальные тенденции и вызовы для России в условиях санкций

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Актуальность. Облачные вычисления приносят значительные преимущества для бизнеса и экономики в целом, скорость их внедрения имеет решающее значение для создания новых предприятий и повышения эффективности существующих.

Цель исследования. Цель исследования — обобщить ключевые факторы внедрения облачных технологий в мире, выявить особенности российского облачного рынка и проанализировать перспективы облачных вычислений в России с учетом санкций.

Данные и методы. Статистические данные из глобальных баз данных и обзоры рынка использовались для сравнительного анализа текущего состояния внедрения облачных технологий в ведущих по размеру облачного рынка развитых и развивающихся странах. Сценарный метод был использован для выявления перспектив облачных сервисов в России.

Результаты. Основные движущие факторы внедрения облачных технологий можно разделить на инфраструктурные, экономические и социальные,

КЛЮЧЕВЫЕ СЛОВА

облачные вычисления, проникновение облачных сервисов, санкции, российский рынок облачных услуг, проникновение технологий, развивающиеся страны, импортозамещение, стратегии развития, облачная стратегия

а также связанные с законодательством и нормативными актами. Несмотря на высокие показатели отдельных драйверов роста, общий уровень проникновения облачных сервисов в России является сравнительно низким. Большая доля локальных игроков, растущая мощность суперкомпьютеров и низкое проникновение облака среди малого и среднего бизнеса – основные особенности российского рынка. Дальнейший рост проникновения облачных сервисов рассматривается как возможный и позитивный сценарий даже при снижении размера рынка.

Выводы. Санкции создали угрозу для российского облачного рынка, поскольку затронули сегменты критической ИТ-инфраструктуры. Однако у локальных поставщиков облачных услуг есть возможность заменить глобальных. Во многом это зависит от успешности программ импортозамещения в сфере ИТ-оборудования, политики местных провайдеров, законодательной поддержки и понимания выгод миграции в облако топ-менеджментом бизнеса.

БЛАГОДАРНОСТИ

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云计算：俄罗斯在制裁下的全球趋势和挑战

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摘要

现实性：云计算为企业和整个经济带来了巨大的好处，其被采用的速度对创建新企业和提高现有业务的效率至关重要。

研究目标：该研究的目的是总结全球云技术的主要驱动因素，确定俄罗斯云市场的具体情况，并分析在制裁背景下俄罗斯云计算的前景。

数据与方法：来自全球数据库和市场调查的统计数据被用来比较发达国家和发展中国家主要云市场的云技术采用现状。场景法也被用来识别俄罗斯的云服务前景。

研究结果：采用云技术的主要驱动因素可分为基础设施、经济和社会、以及与立法和法规相关的因素。尽管个别增长动力表现出色，但俄罗斯云服务的渗透率总体水平较低。俄罗斯市场的主要特点是本土企业份额大，超级计算机能力不断提高，云计算在中小型企业中的渗透率低。即使市场规模缩小，云服务渗透率的逐步提高也被视为一种可能的积极情景。

结论：制裁对俄罗斯云市场构成了威胁，因为它们影响了关键的 IT 基础设施。然而，本地云服务供应商有机会取代全球供应商。这在很大程度上取决于 IT 设备领域进口替代计划的成功、本地供应商的政策、立法支持以及企业高层管理人员对云迁移好处的理解。

关键词

云计算、云服务渗透率、制裁、俄罗斯云市场、技术渗透率、发展中国家、进口替代、发展战略、云战略

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Introduction

Cloud computing (CC) is a model of IT outsourcing where vendors provide and manage on-demand IT hardware, middleware or software to their customers.

Since the cloud model appeared, it has been utilized both by businesses and individuals who appreciate its benefits. CC reduces initial capital and operational expenditures thereby lifting barriers to new companies' formation, acting as a key source of innovation and employment growth (Attaran & Woods, 2019). Pay-as-you-go CC provides better controllability over IT spending, thus attracting smaller companies with limited budgets (Khayer et al., 2020). As CC helps small and me-

dium-sized enterprises (SMEs) save money and thus increase their efficiency and productivity, its widespread use has a direct influence on GDP and economy as a whole (Priyadarshinee et al., 2017).

Cloud providers build infrastructure for firms and governments, which enables the latter to shift scarce talent to higher value-added applications and business processes (Rana & Rahman, 2018).

CC's capacity for technological and economic transformation is highly appreciated, which is confirmed by the 26% annual growth of the public cloud market from 2017 to 2021¹. There is evidence that CC is used by many enterprises of

¹ Statista Public Cloud Outlook. <https://www.statista.com/outlook/tmo/public-cloud/worldwide> (Accessed: 14.06.2022).

different sizes (Sharma, Gupta & Acharya, 2021). In the European Union, the average usage of cloud services was 45% in 2021 (Eurostat, 2021). In OECD countries, more than a third of businesses used some form of cloud services in 2018². The use of CC varies across countries (Vu, Hartley & Kankanhalli, 2020). For example, in 2019, the U.S. was the global leader in the use of CC technology and the majority of people in the US (from 50 to 84%) used cloud services. In countries like Nigeria or Vietnam only 2,5% of users are implementing public cloud solutions³.

However, surveys of CC usage in businesses give a limited view on the diffusion of cloud computing as they don't show the volume or intensity of its usage. Cloud computing's share in global IT spending is estimated at only 4–7%⁴.

The purpose of this work is to analyze global trends in CC usage by identifying the key drivers of CC adoption in the world and, based on this knowledge, to assess the challenges and prospects of the Russian CC market in the face of the sanctions pressure on the Russian economy and IT industry in particular.

This goal has determined the following objectives: to review the academic research and business reports and identify the main drivers of growth in the cloud market; assess the level of the main drivers of CC development and the position of Russia in the largest cloud markets; analyze the features of the Russian cloud market and the prospects for further implementation of CC technologies in the period of turbulence and uncertainty.

The main research question that this paper focuses in is the following: what combination of cloud market drivers can contribute to the growth of cloud computing in Russia, despite the huge pressure of sanctions and macroeconomic uncertainty?

Theoretical framework

According to the National Institute of Standards and Technology, “cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of

configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction”⁵. Cloud models vary depending on the type of services provided and the target audience:

- infrastructure as a Service (IaaS) – data center capabilities for IT administrators;
- platform as a Service (PaaS) – virtual environment for software developers;
- software as a Service (SaaS) – software applications for end-users;

There are also different cloud deployment models, depending on access privacy and hardware location:

- private – enterprises with personal access to Cloud that can be located inside the user organization;
- community – accessible for limited number of entities with shared interests (e.g., research teams);
- public – accessible to anyone;
- hybrid – combination of private and public Clouds.

The first studies on cloud computing date back to 1999 and the number of publications on this topic has been steadily growing since then. However, it should be noted that the majority of research on CC are skewed towards the technological dimension rather than towards business, conceptualization or application domain (Senyo, Addae & Boateng, 2018). We reviewed the recent CC-related literature to identify the main drivers of CC development.

Digital Infrastructure

Since cloud services are built upon ICT equipment, their operation depends on the basic ICT components, and the development of CC technology is obviously limited by the level of the necessary ICT infrastructure coverage (Buyya et al., 2009).

Internet infrastructure: broadband, internet access, bandwidth availability etc.

The country's high level of informatization allows CC to develop fast. For instance, in China, the IT infrastructure began to rise simultaneously with CC, which obviously limits the pace of CC adoption compared to the U.S., where construction and popularization of IT infrastructure has

² Ker, D. (2021). Measuring cloud services use by businesses. https://www.oecd-ilibrary.org/science-and-technology/measuring-cloud-services-use-by-businesses_71a0eb69-en (Accessed: 27.06.2022).

³ Statista Public Cloud Outlook. <https://www.statista.com/outlook/tmo/public-cloud/worldwide> (Accessed: 14.06.2022).

⁴ Whyman, B. (2021). Secrets From Cloud Computing's First Stage: An Action Agenda for Government and Industry. ITIF. <https://itif.org/publications/2021/06/01/secrets-cloud-computings-first-stage-action-agenda-government-and-industry/> (Accessed: 27.05.2022).

⁵ Mell, P., & Grance, T. (2011). The NIST definition of cloud computing. <https://csrc.nist.gov/publications/detail/sp/800-145/final> (Accessed: 22.03.2022).

completed before the cloud era⁶. Skafi, Yunis & Zekri (2020) also highlight that in developing countries, poor IT infrastructure is a big barrier to such internet-based technologies as CC.

Vu et al. (2020) in their cross-country research argued that broadband and internet are the key underlying technologies for CC enablement and indicated the important role of fixed broadband in predicting the trends of CC development. Broadband quality and speed become more critical, as more IT infrastructure and applications migrate to the cloud; high-speed networks are required to support cloud-based services⁷. However, Andrews, Nicoletti & Timiliotis⁸ emphasized that the presence or the absence of high-speed broadband connections can't fully explain the differences in cloud adoption rates among OECD countries.

Well-developed mobile infrastructure also stimulates cloud adoption. Since mobile communication frequently suffers from higher latency than fixed broadband, and its speed depends on the type of connection used, mobile network coverage is important.

IT skills, Technical Expertise, IT consultancy etc.

Vu et al. (2020) considered Internet penetration as a proxy for IT skills and experience that can help in predicting trends of CC development. They confirmed that ICT infrastructure quality and IT skills are important for cloud adoption. Raghavan et al. (2021) considered the lack of technical expertise as a barrier to cloud adoption in the public and healthcare sectors in Japan, South Korea and Singapore. Kreslins, Novik and Vasiljeva (2018) noted that the lack of IT consultancy limits the adoption of CC by SMEs in the Baltic countries. The adoption of complex CC solutions in various industries seems to be higher in countries where the level of training of non-ICT workers, especially low-skilled, is higher⁹. Moreover, Sharma et al. (2016) showed the importance of job opportunity, defined as users' perception

of the extent to which the use of a new technology creates higher employment opportunities for them, for the adoption of cloud services.

Among other drivers of CC development there is the presence of *supercomputing industry*. The approach to building CC centers next to regional supercomputing sites had a favorable influence on the development of CC in China (Kshetri, 2016).

Economic & Social Factors

Krauss, Loebbecke and Tewes-Diehl (2021) identified CC as a driver for economic and social development, especially in developed countries. In turn, many economic and social factors are proven to have an impact on the development of CC.

GDP, Population, Income Per Capita

GDP is a useful predictor of technology diffusion. Kannan, LaRiviere, & McAfee (2021), studying IaaS and PaaS technology diffusion across and within countries, identified GDP as a positive factor with the highest impact.

Vu et al. (2020) noted that GDP per capita also plays an important role, as the key CC providers are multinational companies that don't offer significant price variations based on their customers' geography. They highlighted the significance of such factor by confirming that higher-income countries have advantage in CC adoption as enterprises in these countries are more likely to afford to purchase CC services.

Vu et al. (2020) also considered the population size as a proxy for the number of firms that could potentially adopt Cloud. More populous countries tend to have a higher level of CC adoption, controlling for other factors. Moreover, Raghavan et al. (2021) assessed the role of ageing population in the integration of CC in healthcare systems and showed that CC adoption reduces the burden on healthcare in terms of cost savings and resource optimization.

Vu et al. (2020) proved that countries with a larger *share of the services sector in GDP* generally have higher rates of CC adoption. For a given country, a simple increase in the share of the service sector will not be reflected in the wider adoption of cloud technologies.

Labor Cost. Vast supply of low-cost labor could be a barrier to the development of CC. Comparing the U.S. and China¹⁰, it was noted that with almost

⁶ Peng, M. (2021). A Comparison of the Cloud Computing Market between China and the United States. <https://www.alibabacloud.com/blog/597886> (Accessed: 22.03.2022).

⁷ Zaballos, A.G., & Rodríguez, E.I. (2018). Cloud Computing: Opportunities and Challenges for Sustainable Economic Development in Latin America and the Caribbean. <https://publications.iadb.org/en/cloud-computing-opportunities-and-challenges-sustainable-economic-development-latin-america-and> (Accessed: 22.03.2022).

⁸ Andrews, D., Nicoletti, G., Timiliotis C. (2018). Digital technology diffusion: A matter of capabilities, incentives or both? https://www.oecd-ilibrary.org/economics/digital-technology-diffusion_7c542c16-en (Accessed: 27.05.2022).

⁹ I bid.

¹⁰ Peng, M. (2021). A Comparison of the Cloud Computing Market between China and the United States. <https://www.alibabacloud.com/blog/597886> (Accessed: 22.03.2022).

identical costs of digital products and services in China and the U.S., the cost of labor in China is only about 12% of the cost of labor in the U.S. It is for this reason that Chinese enterprises are more inclined to use labor instead of information technology to meet the needs of their businesses.

Legal & Regulatory Factors

An institutional environment with strong rule of law is likely to increase business confidence and reduce risk perception when introducing new technologies such as CC (Hashem et al., 2015; Ali & Osmanaj, 2020), since it is known that in such environments, business interests will be better protected. For instance, Vu et al. (2020) among others proved that the quality of the legal system, reflected in the rule of law and control over software piracy, plays an important role in predicting CC adoption. Regulatory environment is one of the vital factors of CC adoption in the services sector (Jianwen & Wakil, 2019).

Economic sanctions applied against a targeted country may affect economic and social factors in the short or long-run. For example, the sanctions imposed against Russia in 2014 did not have a significant short-term impact on economic performance, but strengthened the previously established negative trends (Balashova, 2016). The special role of technology and digitalization in the modern economy, world politics and international relations led the researchers (Danilin, 2021) to conclude that US technological sanctions against China have the nature of a technological war and are aimed at a long-term impact. One of the measures to mitigate this threat is to encourage Chinese industrial companies to become less dependent on foreign supplies and resources (Kheyfets & Chernova, 2022). The sanctions imposed on Russia in 2022 can also be described as a technological war and measures to mitigate their long-term effects are needed.

Methodology and Data

The methodological framework of the study comprises methods of comparative analysis and scenario methods. The study relied on the statistical data from global databases and market surveys. The research procedure was as follows.

At the first stage, we provide a comparative analysis of top-5 developed and top-7 developing countries, including Russia, with the biggest public cloud market. Countries were compared to each other by the value of the drivers identified in

the literature review by using methods of descriptive statistics. The data are retrieved from Statista Country Outlook, which provides aggregated data from the World Bank, IMF, OECD, UN and Eurostat. Analytical reports and operational data from business publications and other sources are used to identify the main features of the Russian ICT and cloud technologies market that may affect the pace of CC development.

At the second stage, we assessed the potential willingness of Russian customers to switch from the services of global cloud providers to Russian ones. Search queries and visits to the websites of Russian cloud providers in March-April 2022 were analyzed by using Yandex Wordstat and SimilarWeb for web analytics.

At the third stage, the drivers that were identified and analyzed in the literature review were used to investigate the scenarios for the development of the Russian cloud computing market and the adoption of cloud technologies, taking into account the context of the 2022 sanctions.

Results

This section discusses the state of the Russian cloud market by comparing the position of Russia with the leading cloud markets, highlights the features of the domestic market, and analyses the post-sanction behavior patterns of local CC providers.

The Russian cloud market before the 2022 sanctions

From 2017 to 2021, the Russian cloud market was growing at the compound annual rate of 26%, at the same pace as the global market, and by 2021-2025 it was expected to outpace the global market by 5 p.p.¹¹. In 2020, the Russian cloud market accounted for 0,48% of the world market, while Russia's share in global GDP was approximately 1,75%.

Table 1 compares Russia with developed and developing countries with the largest volume of the public cloud market. It should be noted that the private cloud market is not included in this comparison because of the lack of reporting data for many of these countries. In Russia, it is estimated that the private cloud market is estimated at 15,4% of cloud spending in 2019¹².

¹¹ Statista Public Cloud Outlook. <https://www.statista.com/outlook/tmo/public-cloud/worldwide> (Accessed: 14.06.2022).

¹² Russia Cloud Services Market 2020–2024 Forecast and 2019 Analysis. <https://www.idc.com/cis/research> (Accessed: 27.05.2022).

As can be seen from Table 1, Russia ranks 20th by the size of the public cloud market globally and 10th among the 12 selected countries. In terms of the public cloud revenue per capita, Russia is also in the 10th place. Russia is at the top of the ranking in terms of the percentage of the population with upper secondary education and it ranks 5th in terms of the population size, 6th in broadband connection speed and GDP per capita, 7th in broadband connections per 100 capita. Given all that, Russia still had a room for improvement on the global scale.

However, the lowest Rule of Law Index, relatively low minimum wage and share of value added by the services sector could negatively affect the country's position and could hinder successful CC development in Russia.

Apart from the common drivers identified in the literature review, the Russian market also has some peculiar characteristics of its own. For instance, in the Russian as well as in the Chinese cloud market, the shares of local suppliers outweigh the shares of global players, which is especially evident in the IaaS market, where global

Table 1

Cross-country data on drivers of cloud adoption, 2020

Group of Drivers	Driver	Developed countries					Developing countries							Russia's ranking position
		US	Germany	Japan	UK	Canada	China	Brazil	India	Mexico	Russia	South Africa	Turkey	
Infrastructure	Fixed & Mobile Broadband Connections (per 100 capita)	194	133	254	146	125	14430	111	38	95	119	89	104	7
	Average Fixed Broadband Connection Speed, in mbit/s	47	37	51	33	42	3	11	11	13	22	12	8	6
Social & Economics	GDP, \$ bn	20894	3843	5045	2710	1644	15213	1445	2660	1074	1479	335	720	8
	Population in mln, 2020	331	84	126	68	38	1447	213	1380	129	146	59	84	5
	GDP per capita, PPP, \$ th, 2020	63.2	54.8	42.4	46.5	46.6	17.2	14.8	6.5	18.4	29.8	13.4	27.2	6
	Value added by services sector in % of GDP, 2018	77	62	69	71	68	53	63	49	60	54	61	55	10
	Minimum monthly wage in \$, 2019	1257	1743	1360	1737	1457	320	253	n/a	n/a	175	242	451	10
	Population with upper secondary education %	50	48	44	34	25	19	32	25	19	59	41	25	1
Legal & Regulatory	Rule of Law Index, 2019	1.5	1.6	1.5	1.6	1.8	-0.3	-0.2	0	-0.7	-0.7	-0.1	-0.3	12
Cloud characteristics	Country's Public Cloud Market Position, 2020	1	3	4	5	6	2	15	17	18	20	23	32	10
	Public Cloud market size, \$mln, 2020	115846	11984	9610	8869	6408	18424	1874	1581	1552	1278	1028	416	10
	Public Cloud CAGR 2016–2020, %	25	39	28	24	25	58	32	16	16	26	19	9	5
	Public Cloud revenue per capita, 2020, \$	350.0	143.0	76.0	130.6	169.8	12.7	8.82	1.1	12.0	8.76	17.3	4.9	10

Source: The authors' calculations are based on the data of Statista, World Bank, IMF, OECD, UN and Eurostat.

Note: for each of the drivers the latest available data are taken.

players tend to form an oligopoly (Musin, 2021). As shown in Figure 1, local IaaS players dominate the market in both countries.

Such market structure can be explained by the data protection legislation, which is quite strict compared to other countries (El-Gazzar, Hustad & Olsen, 2016). On the other hand, relatively low purchasing power reduces the willingness of global providers to invest in data center infrastructure to comply with regulatory requirements, as they do in China to capture lucrative Chinese customers (Wang et al., 2018).

Another characteristic of the Russian market is its growing supercomputer power. In the recent cross-country supercomputer ranking (TOP500), Russia occupies the 8th place by supercomputer system total count, 2 positions higher than it was in the previous ranking; Russia also ranks 9th by maximum performance achieved¹³. CC development can be stimulated by building cloud centers in proximity to regional supercomputing sites. Russia's most powerful supercomputers are located in data centers of big tech companies such as Yandex, Sberbank or MTS, where companies deploy their internal private or public cloud service infrastructure.

As mentioned above, there are no regular full enterprise-level cloud adoption surveys in Russia, which complicates the monitoring of this process.

Based on the MTS Cloud 2021 study, we can estimate that on average 50% of Russian companies use cloud services with Moscow region accounting for 65% of usage¹⁴. According to Selectel study of 2017, 80% of large and mid-size enter-

prises used cloud solutions in their business¹⁵. Selectel report of 2020 showed that more than half of SMEs in Russia still keep their IT systems on-premise, while in the West, 80–90% of companies use cloud services and commercial data centers¹⁶, which means that large enterprises are more willing to adopt cloud services than SMEs (Alkhatir, Walters & Wills, 2018; Karunagaran, Mathew & Lehner, 2019).

However, the number of companies using cloud solutions doesn't fully reflect the level of cloud adoption. As already mentioned, CC accounts for 4–7% of IT-budgets. Table 1 shows that cloud spending per capita in Russia was only \$9 in 2020, at the same level as in Brazil, higher than in India and Turkey but significantly lower than in developed countries or China.

The Russian cloud market after the sanctions

In February – March 2022, the Russian ICT market faced an enormous number of restrictions that affected all technology-related segments:

- import restrictions of data center equipment and component base from most global vendors and manufacturers;
- disabling licenses and technical support from global application and system software operators;
- withdrawal from the market of global cloud service providers;
- outmigration of IT personnel, estimated at 120–170 thousand people in March and April¹⁷.

¹⁵ Selectel. <https://selectel.ru/about/newsroom/press/oblaka-okutali-krupnyi-i-srednij-biznes/> (Accessed: 27.05.2022).

¹⁶ Comnews. https://www.comnews.ru/content/204634/2020-02-18/2020-w08/rynok-cod-dalek-nasyscheniya?utm_source=telegram&utm_medium=general&utm_campaign=general (Accessed: 27.05.2022).

¹⁷ Cnews. https://www.cnews.ru/news/top/2022-03-22-poslableniya_ne_pomogayut (Accessed: 29.03.2022).

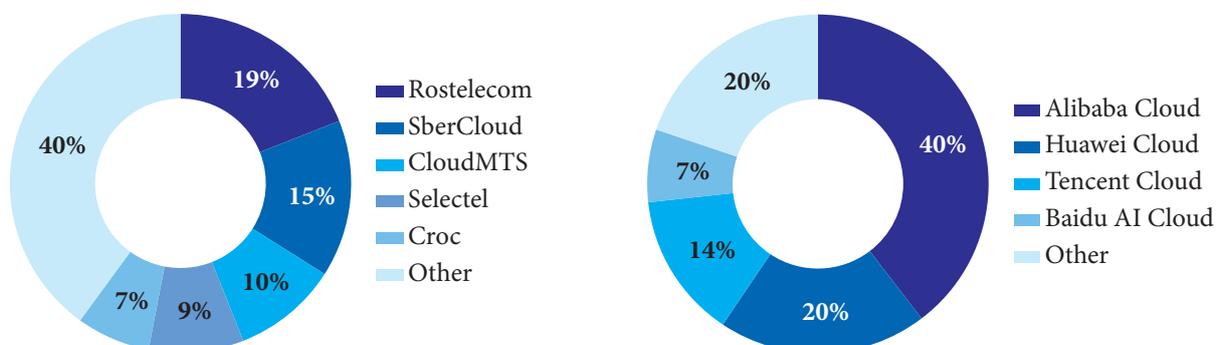


Figure 1. Market shares of IaaS providers in Russia, 2021 (left) and China, 1Q 2021 (right).

Source: The authors' calculations are based on iKS Consulting (<http://survey.iksconsulting.ru/page23992645.html>) (Accessed: 20.06.2022) and Canalys (<https://www.canalys.com/newsroom/china-cloud-infrastructure-Q2-2021>) (Accessed: 20.06.2022))

The critical restrictions are those related to data center equipment like servers, storage and networks, and component base like processors, RAM, motherboard etc. The latter is the most critical as over 90% of the cutting-edge processors built on process technology below 32 nm are imported. Their main suppliers – Intel, AMD, Qualcomm (U.S.), Samsung (South Korea) – have already suspended the supply of semiconductors to Russia. Taiwan's TSMC, the largest manufacturer of custom semiconductors, also suspended the production of Russian processors Elbrus and Baikal¹⁸.

These restrictions have affected Russian cloud providers as they use their own data centers and rent capacity from data center operators. For the latter the situation is difficult, since the restrictions have affected the data center industry, which remains under-saturated compared to developed countries and requires a large amount of additional capacity, despite the 69% growth from 2015 to 2020¹⁹. For those who have their own data centers, the restrictions associated with the supply of server equipment have less negative consequences than the lack of the component base. IaaS providers such as Selectel buy servers as a set of components that can be purchased from different suppliers, not as whole solutions from vendors like HP.

On the other hand, those Russian enterprises that have already used cloud services began to

massively switch from global cloud providers' services to Russian alternatives in order to localize and secure their critical business²⁰. Russian providers recorded a multiple increase in requests in the first weeks of March. According to KROC research, the number of requests for KROC Cloud Services increased by 960% compared to the same period last year. Due to the lack of financial reporting of the Russian cloud providers in the first and second quarters, only indirect indicators could be considered. For example, there was a significant monthly growth of search queries and website traffic in March. As seen from Table 2, for some companies, the median growth of search queries and website visits has increased by 34% and 19% respectively.

Although this trend reversed dramatically in April, search volume and visits remained at a much higher level than in February.

Such reversal could be caused by the fact that at the end of March, many Russian cloud providers began to raise prices for their services, which was explained by higher exchange rates, supply chain issues, and an increase in the demand for domestic software, which was up to 300% since the end of February²¹.

¹⁸ RBC. https://quote.rbc.ru/news/short_article/621b55739a79477349224743 (Accessed: 29.03.2022).

¹⁹ iKS Consulting. <http://survey.iksconsulting.ru/page23038062.html> (Accessed: 29.03.2022).

²⁰ RBC. https://www.rbc.ru/technology_and_media/05/03/2022/6220da129a7947b71ab44c6a (Accessed: 28.03.2022).

²¹ Cnews. https://www.cnews.ru/news/top/2022-03-23/oblachnye_provajdery_nachali (Accessed: 02.04.2022).

Table 2

Search queries and website visits of Russian cloud providers in March-April, 2022

Company	Market position, 2020			Changes in search queries, Month-over-Month growth, %		Changes in website visits, Month-over-Month growth, %	
	IaaS	PaaS	SaaS	March	April	March	April
SberCloud	2	1	–	36	–12	62	–8
MTS Cloud	3	–	–	34	–2	–12	–7
Selectel	4	10	–	82	–34	38	–2
Croc Cloud Service	5	–	24	66	–31	13	–31
Yandex Cloud	–	3	–	69	–7	54	6
VK Cloud Solutions	–	8	15	94	–12	63	–14
SKB Kontur	–	–	2	21	–3	19	2
Tensor	–	–	3	12	–1	3	–1
Mango Office	–	–	4	2	–3	–0,4	–12
Bitrix24	–	–	6	16	–10	11	–1
MyOffice	–	–	<35	12	–17	315	–8
Median	–	–	–	34	–10	19	–7

Source: The authors' calculations are based on the data from SimilarWeb, Yandex Wordstat, Cnews, iKS Consulting.

Note: Rostelecom and Softline, market leaders in IaaS and SaaS, aren't included because of their wide range of services.

Discussion

Since the sanctions were imposed, the prospects of the Russian cloud market have become rather hazy. Nonetheless, despite the current difficulties, there are a number of factors contributing to further development of the CC market in Russia:

1. *High IT capacity utilization due to virtualization and multi-tenancy.* As mentioned in previous sections, cloud service providers are generally more efficient in managing data centers and power consumption than companies for whom running a data centre is not their core specialization (Abid et al., 2020; Shukur et al., 2020). Russian cloud providers have managed to ensure higher server utilization compared to classic, on-premise servers: 40–70% versus 12–18%²².

Most Russian cloud providers used software from American companies VMware and Microsoft, which in 2022 suspended their activities in Russia. About half of the largest Russian providers use their own virtualization solutions or open-source solutions modified to providers requirements²³. They also tend to have better expertise of cloud solution architects in comparison with data centre operators and their customers, which makes them more resilient in the current circumstances.

2. *Addressing human resources shortages and limited supply of equipment through the centralization of IT resources.* Cloud providers have sufficient resources and deep expertise in IT solutions (Weinhardt et al., 2009). As human resources are becoming scarcer and the supply of equipment limited, centralization of competencies for installation, configuration and administration of facilities, support of system software and development of application solutions can provide customers with the necessary level of IT services.

3. *Alternative supply chains.* The current restrictions make new IT equipment for companies' data centers more difficult or even impossible to procure. The inability to supply the necessary solutions to Russia directly or reorientation to solutions from vendors from other countries, e.g., China, will lead to the increasing complexity and cost of the supply chain. In this case companies

whose core business isn't focused on data centers' operations and which deploy IT solutions in their own data centers may choose to move part of their workloads to the cloud.

4. *Own IT equipment manufacturing.* To enhance their market positions and increase adoption, Russian cloud providers in the mid- to long-term could start manufacturing their own IT equipment. For example, 100% of Yandex's servers are manufactured in Taiwan and China according to the company's own design and architecture. Yandex also launched servers manufacturing in Russia in 2021²⁴. If the most critical problem – component shortages – could be solved, such domestic manufacturing driven by cloud providers could fill the gap in IT capacity.

Apart from the above-described factors, further development of the Russian cloud market also depends on macro-economic factors, legal regulation, the state of the infrastructure, and decisions made by individual enterprises regarding their cloud strategy.

Cloud development can be predicted by looking at the dynamics of GDP but for Russia this indicator, along with other macroeconomic indicators such as gross national income or minimal wage, are now complicated to forecast. Internet connection, its speed, cost and quality will depend on the Russian telecom infrastructure operators' ability to find a way around the sanctions restricting Western exports of equipment to Russia.

New measures introduced by the regulators could also have an impact on cloud adoption. For instance, in June 2022, the Russian Ministry of Digital Development signed a corresponding contract with Rostelecom, Russia's IaaS leader, worth 1,8 billion rubles, under which the Company will provide its data center capacities for the needs of the GEOP (unified state cloud platform) project until December 2022. Another project aimed to stimulate cloud development is GosTech – unified cloud infrastructure and platform for hosting and developing government digital services. Moreover, in 2021, the Russian Ministry of Digital Development proposed to oblige government departments to abandon the construction of their own data centers and use mainly domestic cloud services as part of digitalization. Such measures are likely to increase the rate of CC adoption among government de-

²² Data Center Efficiency Assessment. <https://www.nrdc.org/sites/default/files/data-center-efficiency-assessment-IP.pdf> (Accessed: 23.03.2022).

²³ CNews Analytics: IaaS 2021 rating. https://www.cnews.ru/reviews/oblachnye_servisy_2021/review_table/2e5f90781144779340a66ce5686695f89dc1d59b (Accessed: 27.06.2022).

²⁴ VC.ru. <https://vc.ru/tech/321627-predpriyatye-yandeks-lanita-vtb-i-gigabyte-vypustilo-pervye-200-serverov-v-rossii> (Accessed: 02.04.2022).

partments. A similar trend is observed in India, where the government is the biggest spender on cloud services (Kushagra & Dhingra, 2021).

On the level of individual enterprises, cloud adoption will depend on the strategic decisions their top management has to make (Oliveira, Thomas & Espadanal, 2014). In the current situation, the budgets of Russian companies are likely to be under much pressure, which means that decisions to move to the cloud will depend, among other things, on the cost of migrating and the availability of cloud consulting and integrators' services. Furthermore, local providers should be able to replace the global providers that withdrew from Russian market, which means that they have to provide the same level of service level agreement (SLA, i.e. agreement between a cloud service provider and a customer that ensures that a minimum level of service is maintained), availability of advanced features, exhaustive and understandable documentation, and appropriate technical support. As price reduction has a significant effect on businesses' intention to use cloud computing (Yaokumah & Amponsah, 2019), a temporary re-

duction in cloud tariffs can provide an additional argument in favor of switching to the cloud. Otherwise, management, especially in medium-sized or large enterprises, can choose to develop their own solutions.

In view of the considerable uncertainty surrounding all of the above aspects, the following possible scenarios for the development of the Russian cloud market can be outlined (Table 3).

Conclusions

Cloud computing is on the rise in many developed and developing countries, contributing to more efficient use of IT infrastructure and software, reducing costs for businesses and increasing their profitability. The key drivers of CC development and barriers to the broader adoption of this technology on the regional and global levels are of infrastructural, economic, legal and social nature.

Our comparative analysis shows that the leading positions in the ranking of the public cloud markets are occupied by the countries with high values in the indicators shown in Table 1. Even

Table 3

Scenarios of the development of the Russian cloud market

	Market falls	Market grows
Cloud adoption decreases	<p>Infrastructure:</p> <ul style="list-style-type: none"> – reduced internet connection speed and quality – lack of cloud-related expertise <p>Macro:</p> <ul style="list-style-type: none"> – long-term decrease in GDP, national income and minimum wages <p>Legal & Regulatory factors:</p> <ul style="list-style-type: none"> – introduction of additional restrictions on data processing and storage in the cloud – introduction of excessive measures that burden cloud providers <p>Enterprise level</p> <ul style="list-style-type: none"> – companies abandon or limit their cloud plans 	<p>Infrastructure:</p> <ul style="list-style-type: none"> – reduced internet connection speed and quality – sufficient cloud-related expertise <p>Macro:</p> <ul style="list-style-type: none"> – mid- to long-term flattening of GDP or increase in GDP, national income and minimum wages <p>Legal & Regulatory factors:</p> <ul style="list-style-type: none"> – introduction of additional restrictions on data processing and storage in the cloud <p>Enterprise level</p> <ul style="list-style-type: none"> – companies don't change their strategy
Cloud adoption increases	<p>Infrastructure:</p> <ul style="list-style-type: none"> – internet stays stable or improves – sufficient cloud-related expertise <p>Macro:</p> <ul style="list-style-type: none"> – long-term decrease in GDP and national Income – stagnation or decrease of minimum wages <p>Legal & Regulatory factors:</p> <ul style="list-style-type: none"> – allocation of benefits or subsidies for migration to the cloud <p>Enterprise level</p> <ul style="list-style-type: none"> – companies accept or expand their cloud plans 	<p>Infrastructure:</p> <ul style="list-style-type: none"> – internet stays stable or improves – sufficient cloud-related expertise <p>Macro:</p> <ul style="list-style-type: none"> – mid- to long-term flattening of GDP or increase in GDP, national income and minimum wages <p>Legal & Regulatory factors:</p> <ul style="list-style-type: none"> – allocation of benefits or subsidies for migration to the cloud <p>Enterprise level</p> <ul style="list-style-type: none"> – companies accept or expand their cloud plans

Source: Created by the authors

though Russia ranks high in some of the parameters (education, average fixed broadband connection speed), its overall performance is quite low compared to other countries.

The Russian cloud market is characterized by the low level of adoption of cloud services among SMEs, which points to the digital gap between large businesses and SMEs. Another feature is the large share of local players among cloud service providers, whose importance has increased significantly since the imposition of sanctions in 2022. Cloud computing can increase the utilization of IT capacities, which is extremely important in the context of disrupted supply chains. Local providers have considerable expertise in cloud solutions, which local customers can benefit from. They are capable to increase the level of digitalization of Russian companies in the face of the shortage of IT specialists.

Scenario analysis shows that even if the cloud market shrinks due to the macroeconomic factors, one can expect an increased use of CC services provided that local providers manage to maintain their expertise and that migration to the cloud is supported on the legislative level. This process is also influenced by the strategic decisions of individual enterprises to move to the cloud.

It should be noted that our estimations of the cloud market size and the level of CC adoption refer only to the public market while the size of the private cloud market (a cloud whose services are available only to one enterprise) is more difficult to estimate. Moreover, the CC adoption level does not reflect the benefits of cloud solutions compared to data centers or other solutions. For further analysis, a new indicator reflecting the rate of CC adoption should be developed to evaluate the effectiveness of cloud services compared to non-cloud solutions.

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