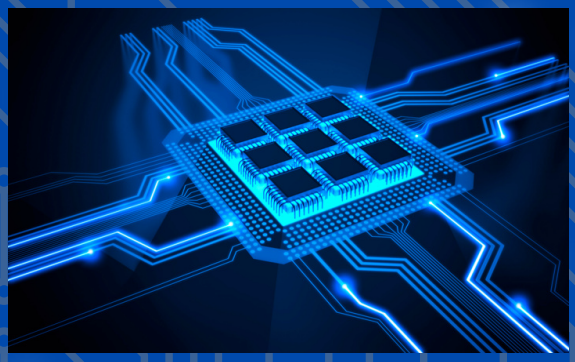
BRIEF REPORT

Microchips:

their economic and geostrategic importance in the context of the current international crises



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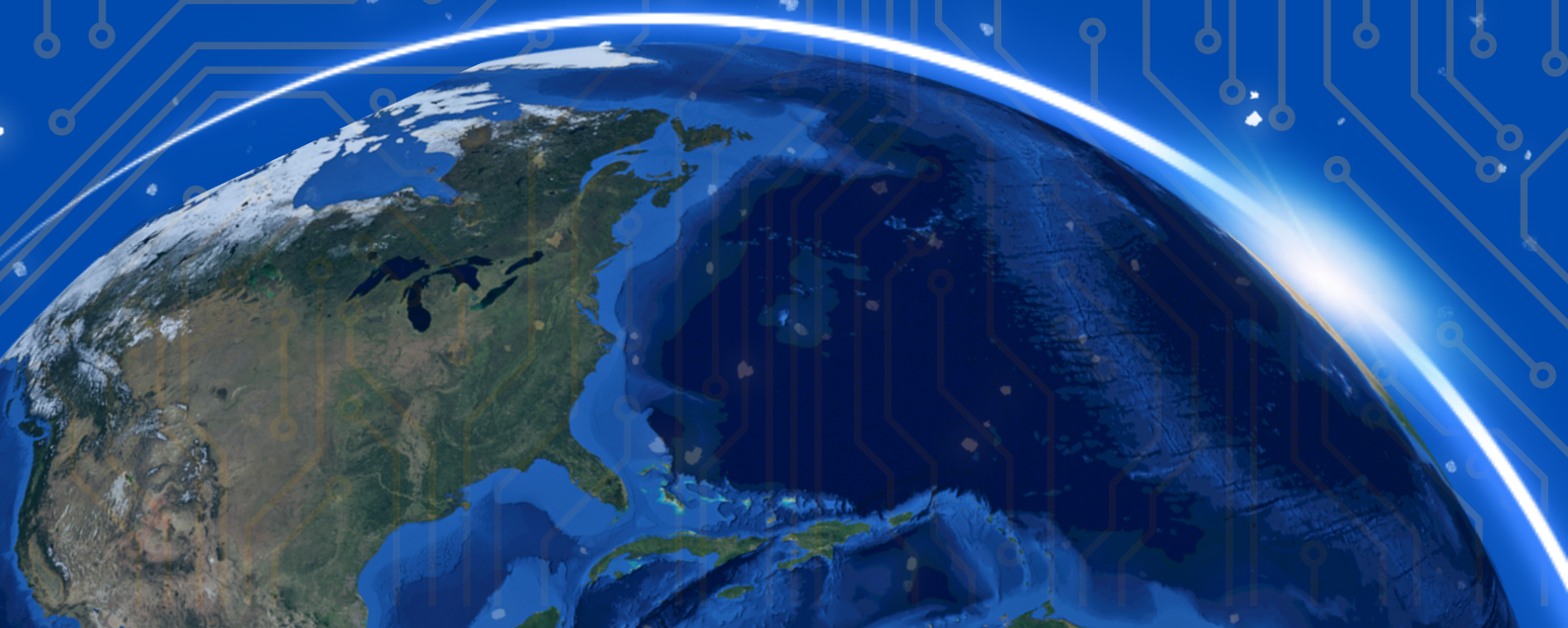

Microchips: their economic and geostrategic importance in the context of the current international crises
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Cover photo: Robot hand on blurred background holding and touching holographic smart car interface projection.
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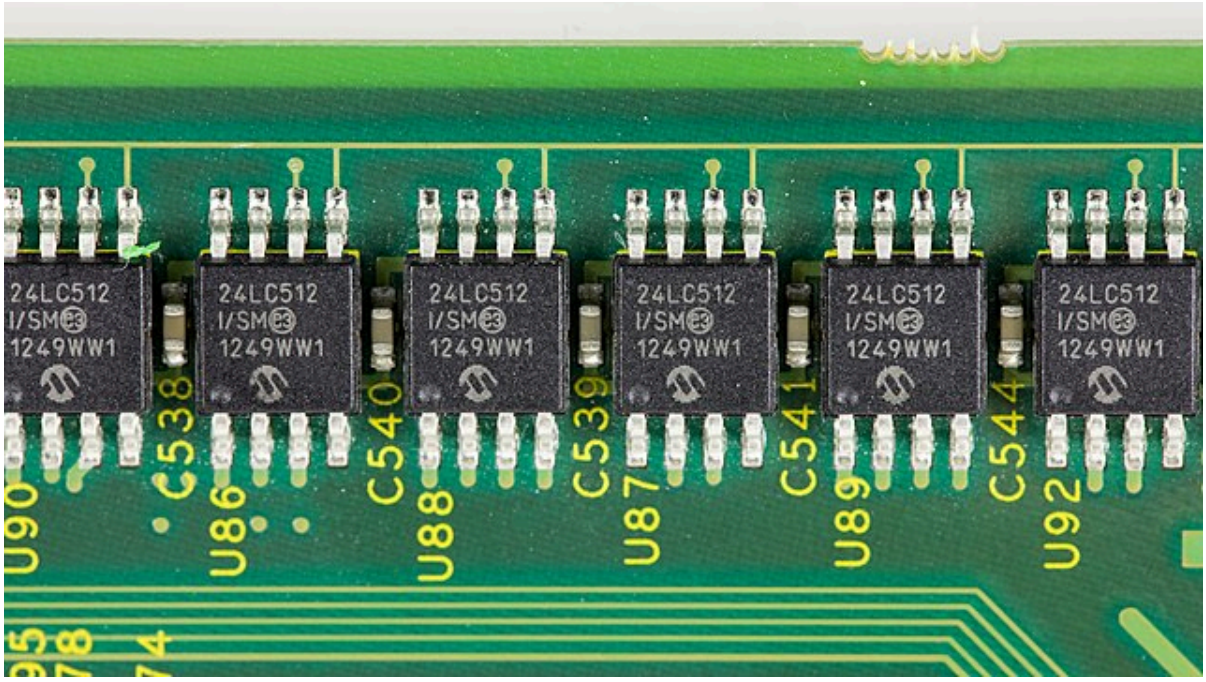


Extron DMP 128 board – Microchip 24LC512 serial EEPROM (2 July 2020). Photograph by Raimond Spekking, licensed under CC BY-SA 4.0 , via Wikimedia Commons. Available at: https://commons.wikimedia.org/wiki/File:Extron_DMP_128_-_board_-_Microchip_24LC512-9701.jpg

Introduction

In the academic space and in the political analysis circles, there is talk not only of a fierce competition for resources worldwide, but also of a veritable war of resources, especially in the context of the Russian Federation's invasion of Ukraine or China's growing pressure on Taiwan. Microchips are rapidly becoming what "oil was to the last century".[1] They are the core component of many technologies which we came to regard as integral to modern life in the span of a few decades. From computers, to smartphones, navigation systems and medical equipment, they are all powered by nanometric chips, while those technologies in themselves power contemporary society.[2]

A lack of microchips can bring to an abrupt halt the entire industry, which in turn wreak havoc with already strained global supply chains. In Germany, car companies grinded to a

[1] "Panel Va. Security and Technology. Regional Opportunities on Semiconductor Supply Chains". Black Sea and Balkans Security Forum 2022, link:https://www.newstrategycenter.ro/black-sea-and-balkans-security-forum-2022-day-1/
[2] Pandey, Ashutosh. "Computer chip shortage disrupts global car production". Deutsche Welle, 2021, link: https://www.dw.com/en/computer-chip-shortage-disrupts-global-car-production/a-56224486

standstill, as electronics and telephone companies had priority over the limited number of chips.[3] The private sector is first to be affected, especially the industrial and services sectors within the national economy. As that happens, the general economic stability is affected, which has repercussions over the national budget. This makes access to semiconductors not only important for the defense industry, but also key to maintaining overall national socio-economic stability. Therefore, whoever controls the microchip market has control not only over modern technology and its development, but also over the supply flow to other states.

Given the sanctions imposed by the West after the invasion of Ukraine, Russia's access to Western technology has been severely curtailed. This brought to the forefront a painful reality: the global chipset manufacturing is concentrated in an area at a boiling point. Russia may not need high-tech chips for maintaining its military going at the moment, but it certainly will need them in the future – not only for military capabilities but also for making sure Russian economy can develop.

Meanwhile, Taiwan's near hegemony on the microchip market and its troubled relationship with China raises critical issues regarding to world's ability to pursue a technology-driven future. China doesn't have the technology to produce high-tech chips, but it is producing some of the regular chips[4] that Russian military and generally, Russian economy needs. At the same time, the latest US sanctions targeting the Chinese semiconductor industry limits its capabilities.[5] That makes for Taiwan to grow its role internationally – at a time when the US and Europe are seeking to reshore most of their semiconductor production. Therefore, the global struggle to bring production of those critical components closer to home arises.

This study seeks to shed a light on the complex dynamics powering this shift, by providing an overview of the main players in the microchip market, from state actors to investors and the resources that enable the industry to function. Later, the paper will focus on the situation in the Russian Federation, as the prime example of the various consequences of a lack of access to microchips and Western technology in general in a regime of sanctions, both militarily and in other strategic areas such as energy and finance.

[3] Ibid.
[4] "China turns the table on Korea with low-end chips". Korea JoongAng Daily, link: https://koreajoongangdaily.joins.com/2022/06/23/business/economy/Korea-China-semiconductor/20220623192503998.html
[5] "US Chip Sanctions 'Kneecap' China's Tech Industry". Wired, link: https://www.wired.com/story/us-chip-sanctions-kneecap-chinas-tech-industry/

The Global Market: Actors and Tensions

Taiwan's significance in this discussion stems from the fact that the island located in China's neighbourhood now owns more than 60% of the world's microchip market and about 92% of the advanced chip market, with South Korea accounting for the remaining 8%.[6] Taiwan is thus a leader not only in chip production, but also in chip testing and assembly.[7]

Taiwanese chip companies operate from the vast Hsinchu Science Park located in the north-western part of the island, just 150 kilometres away from China.[8] Among them is the company "Taiwan Semiconductor Manufacturing Company" (TSMC), which is, among other things, also the exclusive supplier of microchips for iPhones and MacBook's, having contracts with other giants in the field of technology, such as AMD or Broadcom.[9] Thus, since Taiwan dominates the microchip industry, a significant market dependency has been created between these manufacturing companies located in East Asia and advanced technology companies in the West. For this reason, in the event of a crisis affecting the chip supply chain, the geographical distance between the supplier and the buyer becomes a thorny issue. The diversification of suppliers is a complicated and lengthy process, with countries from around the world seeking regional solutions.[10]

Building in Hsinchu Science Park. Source: https://en.wikipedia.org/wiki/Hsinchu_Science_Park

[6] Pandey, Ashutosh. "Computer chip shortage disrupts global car production". Deutsche Welle, 2021, link: https://www.dw.com/en/computer-chip-shortage-disrupts-global-car-production/a-56224486
[7] Kamasa, Julian. "Microchips: Small and Demanded." CSS Analyzes in Security Policy 295 (2021), p. 3.
[8] Kohlmann, Thomas. "How Taiwan semiconductors are key for global high-tech". Deutsche Welle, 2022, link: https://www.dw.com/en/how-taiwan-semiconductors-are-key-for-global-high-tech/a-62700581
[9] Ibid.
[10] Kamasa, Julian. "Microchips as a Vital Element of EU Strategic Autonomy and Digital Sovereignty". European Liberal Forum. 2022, p. 20.

In this context, it is much easier to understand why China is so interested in the island of Taiwan, as a hypothetical conquest of the island would give the government in Beijing significant control over a market that dictates world technological development. Moreover, it would also provide Beijing with an important negotiating leverage against the West and a new premise to assert itself as a world power. Of course, such a scenario would not go unchallenged. A potential conflict in the Taiwan Strait would have devastating consequences, potentially rendering Taiwan's microchip factories unusable.[11]

Speculating on the danger of a possible dependence on China, but also on the importance of this technological resource in the future, various regional and world powers began to make considerable investments in the production of domestic microchips. Thus, this year, the United States passed the "Chips and Science Act", which allocates 52 billion dollars to the production of microchips in the country.[12] This will also be achieved through a factory in Arizona, which will be built alongside TSMC.[13] Also, to avoid a possible shortage of microchips, the United States signed an agreement with Japan to create a joint research centre and develop the next generation of microchips, namely the 2-nanometer chips.[14]

Across the Atlantic, the "European Chips Act" is, as the name suggests, the European response to this issue. 43 billion euros will be allocated, aimed at doubling the European global share of chips production to 20%.[15] In the case of the West, these investments, although ambitious, are not guaranteed to be profitable in the long term. As with any other global commodity, the price of chipsets is dictated by the market, potentially posing a threat to those project's long-term viability.[16] Another possible obstacle is the lack of microchip staff and experts in the West. In the case of the USA alone, the project requires 13,000 specialists in the field, but it is speculated that only about 10,000 will be recruited.[17]

[11]Matheny, Jason. "The US Has a Microchip Problem. Safeguarding Taiwan Is the Solution". The Atlantic, link:https://www.theatlantic.com/international/archive/2022/10/taiwan-microchip-supply-chain-china/671615/
[12]Ibidem 6
[13]Ibid.
[14]"Nikkei: Japan and the United States agreed to jointly develop advanced chips", Kommersant, 29.07.2022, link: https://www.kommersant.ru/doc/5490014?query=%D1%87%D0%B8%D0%BF%D1%8B
[15]Ibidem 6
[16]Ibidem 12
[17] Ibidem 1

Nancy Pelosi. The Speaker of the House of Representatives in the US Congress, signing "Chips and Science Act". Source: 2022 Year in Review, Office of Congresswoman Suzan DelBene, https://delbene.house.gov/uploadedfiles/2022_end_of_year_report.pdf

Another country that has started significant investments in the field of microchips is India, which plans to allocate 30 billion dollars in this field.[18] Further North, in order to cope with the Western sanctions, Russia aims to double the production capacity of its Zelenograd plant by 2025. However, even with these investments, many doubt that Russia will not have the necessary capacity to make up for the significant microchip imports, which were lost due to sanctions, through their national microchip production.[19] Thus, Russian technological development will also be gravely affected, due to a shortage of high-end technology.

China is an interesting case in this economic picture. It controls only 10% of the microchip market, and despite the pressure it exerts on the government in Taipei, Beijing does not dare to sanction the Taiwanese microchip industry, because it still displays its dependence on it. Chinese investment in this industry does not indicate a swift diversification away from Taiwan.[20] As such, the grounds for China's invasion of Taiwan take on a new connotation.

[18]"Indian government invests $30 billion in technology and manufacturing chips", Kommersant, 16.06.2022, link: https://www.kommersant.ru/doc/5413127?query=%D1%87%D0%B8%D0%BF%D1%8B

[19] Korolev, Nikita. "«Микрон» надеется подрасти" ["Mikron hopes to grow"]. Kommersant, 2022, link: https://www.kommersant.ru/doc/5318409

[20]"Why China is not sanctioning Taiwan's key chip industry". Al Jazeera, https://www.aljazeera.com/economy/2022/8/4/why-china-is-not-sanctioning-taiwans-crucial-tech-industry

A market with complex interdependencies

Of course, this microchip market does not depend only on microchip suppliers and buyers. There are many other materials and chemicals that microchip factories need to supply to keep production going. Among these materials, the most important are palladium, neon and nickel, elements found and processed to a significant extent in Ukraine and the Russian Federation. Thus, the geopolitical game behind this industry could be even more complicated, considering the current tensions between Russia and democratic countries, which include Taiwan.

Neon is needed in this industry to control special lasers used in chip production.[21] Some of the most important neon processing plants are in Ukraine, currently inactive or damaged due to the war. One was in Mariupol, the well-known Azovstal, now fully destroyed, and the other is in Odessa.[22] The routes necessary for neon to become usable in this microchip industry were even more complex. Neon came to Ukraine as a by-product from Russian steel factories, to then be purified in Ukraine, and it would finally reach the microchip manufacturers.[23] Before the war, more than two thirds of the world's neon was produced in Ukraine, mainly through resources coming from Russia.[24]

Azovstal iron and steel works in 2021 (27 August 2021). Photograph by Blast furnace chip worker, licensed under CC BY-SA 3.0, via Wikimedia Commons. Available at: https://commons.wikimedia.org/wiki/File:Azovstal_iron_and_steel_works_in_2021

[21] Heilweil, Rebecca. "The neon shortage is a bad sign". VOX. 2022, https://www.vox.com/recode/22983468/neon-shortage-chips-semiconductors-russia-ukraine
[22] Ibid.
[23] Lu, Christina. "Putin's War Threatens Microchips, Teeth, and Beer". Foreign Policy. 2022, https://foreignpolicy.com/2022/04/19/russia-war-neon-semiconductor-microchip-economy/
[24] Alper, Alexandra. "Exclusive: Russia's attack on Ukraine halts half of the world's neon output for chips". Reuters, link:https://www.reuters.com/technology/exclusive-ukraine-halts-half-worlds-neon-output-chips-clouding-outlook-2022-03-11/

Considering Russia's war in Ukraine and the sanctions imposed on Moscow, we can say that the supply chain of raw materials and the production of microchips will suffer consistently. After all, this is one of the few advantages that the Russian Federation has in this geo-economic battle for microchips: an abundance of raw materials. Thus, Russia holds 37% of the world's palladium reserves, second in the world after South Africa,[25] that is also exported from Moscow to the United States in significant quantities, accounting for about 35% of total US palladium imports.[26] Russia is also a major producer of nickel.[27] The Russian government has also announced plans to expand the processing of noble gases such as neon, xenon and krypton, with the aim of capturing 25% to 30% of the world market and the promise that it will not export them to "unfriendly countries".[28] Thus, while sanctions may significantly affect Russia, there is also a retaliatory capacity on the part of the Kremlin, by depriving the democratic world of access to its resources, especially those needed in the microchip market.

In the context of the war in Ukraine and of the sanctions imposed on Russia, there is a need for recalibration of the microchip production process within democratic countries. Chip-making nations will have to find new import sources for the raw materials, a complicated and time-consuming process.

Norilsk Nickel plant in Nikel, Murmansk Oblast, Russia (May 1991). Photograph by Hans Olav Lien, licensed under CC BY-SA 3.0, via Wikimedia Commons. Available at: https://commons.wikimedia.org/wiki/File:Norilsk_Nickel_in_Nikel.jpg

[25]Pollet, Mathieu. "Ukraine war could further disrupt semiconductor production", Euractiv. 2022, https://www.euractiv.com/section/industrial-strategy/news/ukraine-war-could-further-upset-the-production-of-semi-conductors/
[26]"US Geological Survey, Mineral Commodity Summaries, January 2022". US Geological Survey, link:https://pubs.usgs.gov/periodicals/mcs2022/mcs2022-platinum.pdf
[27] Ibidem 19
[28]"World chip production saved. Russia will sharply increase the production of scarce neon". C News Ru, 2022, link: https://www.cnews.ru/news/top/2022-07-26_mirovoe_proizvodstvo_chipov

Russia under sanctions: the military technological deficit

Western sanctions are causing increasing difficulties for the Kremlin in its war against Ukraine, including access to imports needed for the arms industry. Russia carefully uses its cruise missiles, which incorporate Western technology, including chips. The bulk of the destruction is caused by Soviet-generation weaponry from the 1970s and 1980s. To combat shortages caused by the sanctions, Russia compiled a list of microchips that Moscow intended to find on the world's black markets, ranked by priority.[29] This lengthy list of required chips indicates their importance to both the military and to society as a whole. According to most experts, maintaining the sanctions in place will make it impossible for Russian civil airlines to operate in a few years. At the same time, in the field of high technologies, Russia lacks not only technology, but also specialists.[30]

Fig. 1. Part of the "shopping list" prepared by the Russian authorities of microchips that are considered to be of "critical importance", according to an inside source at Politico[31]

Model number	**Type**	**Manufacturer**	**Based in**	**Approximate cost per 1 unit, in rubles**	**Cost in euros**	**Cost in dollars**
MK-253-025-335-220S	Connector	AirBorn	U.S.	8,142.7408	134.99	133.98
MM-223-025-213-4300	Connector	AirBorn	U.S.	8,549.1381	141.73	140.67
MM-253-025-000-4400	Connector	AirBorn	U.S.	7,561.2357	125.35	124.41
EP1C20F400I7N	Microchip	Altera, acquired by Intel	U.S.	5,858.0128	97.11	96.39
10M04DCF256I7G	Microchip	Altera; Intel	U.S.	66,815.7746	1,107.65	1,099.40
PEX8112-AA66BIF	Microchip	Broadcom	U.S.	3,047.5570	50.52	50.14
PEX8114-BD13BIG	Microchip	Broadcom	U.S.	2,516.2236	41.71	41.40
CY7C1460KV33-167BZC	Microchip	Cypress, acquired by Infineon	Germany	12,157.5578	201.54	200.04
HI-1573PSI	Microchip	Holt	U.S.	7,024.8483	116.46	115.59
HI-8450PSIF	Microchip	Holt	U.S.	951.4655	15.77	15.66
HI-8500PSTF	Microchip	Holt	U.S.	1,472.7278	24.41	24.23
5V41066PGGI	Microchip	IDT, acquired by Renesas	Japan	1,147.6202	19.02	18.88

[29]"Russia is Running Out of Technology". Kyiv Post, https://www.kyivpost.com/russias-war/russia-is-running-out-of-technology.html
[30]Ibid.
[31] Zoya Sheftalovich, Laurens Cerulus. "The chips are down: Putin scrambles for high-tech parts as his arsenal goes up in smoke". *POLITICO*. https://www.politico.eu/article/the-chips-are-down-russia-hunts-western-parts-to-run-its-war-machines/

XLL735125.000000I	Microchip	IDT, acquired by Renesas	Japan	566.0520	9.38	9.31
EP2AGX65DF25I5G	Microchip	Intel	U.S.	50,989.2822	845.29	838.98
IS61NLP102436B-200B3LI	Microchip	ISSI	U.S.	12,509.1121	207.37	205.83
88E1322-A0-BAM2I000	Microchip	Marvell	U.S.	430.8362	7.14	7.09
25HPK5761-E-62.500-AL	Microchip	Mercury	Taiwan	1,469.8661	24.37	24.19
KSZ9031RNXIA	Microchip	Micrel, acquired by Microchip	U.S.	7,192.7640	119.24	118.35
MT25QL128ABA1ESE-MSIT	Microchip	Micron	U.S.	3,061.2360	50.75	50.37
MT28EW256ABA1LJS-0SIT	Microchip	Micron	U.S.	1,814.0640	30.07	29.85
MT28FW512ABA1LPC-0AAT	Microchip	Micron	U.S.	1,993.5193	33.05	32.80
MT41K256M16TW-107 XIT:P	Microchip	Micron	U.S.	566.8920	9.40	9.33
TMS320C6678ACYPA	Microchip	Texas Instruments	U.S.	43,615.5367	723.05	717.66
V24C3V3M75BG	Microassembly	Vicor	U.S.	46,640.4636	773.19	767.43
V24C5M100BG	Microassembly	Vicor	U.S.	46,640.4636	773.19	767.43

Eight months after the Russian invasion of Ukraine, Russia is suffering from a severe technology deficit caused by sanctions. Following the loss in combat or the depletion of a considerable number of ammunition and weapons, Russian forces switched to obsolete Soviet-era ammunition stocks,[32] while the Ukrainian army is equipped with Western weapons, which have significantly aided its counteroffensive's success. Some of the circuits found in some Russian cruise missiles are, according to some engineers, the equivalent of the technology found on a games console from 20 years ago.[33] Moreover, some of these components were not of an advanced military level, sometimes containing circuits that "a team of electrical engineers from college could assemble".[34]

[32]"Russia uses old Soviet-era missiles to strike Ukraine: General". Al Jazeera, link:https://www.aljazeera.com/news/2022/6/30/russia-ramping-up-missile-strikes-ukrainian-general-says

[33]"Russia uses low-tech electronics in its high-tech weapons - NYT". Euromaidan Press, link:https://euromaidanpress.com/2022/09/04/russia-uses-low-tech-electronics-in-its-high-tech-weapons-nyt/

[34]"Important Detail About Western Electronics in Russian Missiles Revealed: Typical Circuit Boards From a Small Number of Suppliers". Defense Express, link:https://en.defence-ua.com/analysis/important_detail_about_western_electronics_in_russian_missiles_revealed_typical_circuit_boards_from_a_small_number_of_suppliers-4114.html

In addition to the fact that the Russian forces resorted to the use of Soviet technology, it is important to note that much of the remaining modern Russian arsenal is dependent on chips and electrical components of Western origin.[35] In fact, in that previously mentioned list of electrical components (fig. 1) which Moscow wants to obtain through illicit means, which included semiconductors, transformers, connectors, covers, transistors, insulators, most of which were manufactured by companies in the US, Germany, the Netherlands, the United Kingdom, Taiwan and Japan.

Moreover, according to recent British military-technical studies, which analysed 27 different forms of Russian military equipment recovered from the Ukrainian front, Russia uses in its armament 317 components originating from the United States, 34 from Japan, 30 from Taiwan and 18 from Switzerland.[36] Thus, 30% of the components found in equipment such as unmanned aerial vehicles (UAVs), radio stations, guided missile systems (such as Iskander) or anti-aircraft systems come from four American companies. More specifically, from Texas Instruments, Analog Devices, Maxim Integrated and Xilinx.[37]

Among the Western components most used in Russian weaponry are digital signal processors, flash memory modules, static RAM modules, and ethernet wiring.[38] Overall, the

[35] Byrne, James. Gary Sommerville. "Silicon Lifeline. Western Electronics at the Heart of Russia's War Machine".*Royal United Services Institute.*August 2022, link:https://rusi.org/explore-our-research/publications/special-resources/silicon-lifeline-western-electronics-heart-russias-war-machine
[36]Ibid, p. 12.
[37]Ibid, p. 15.
[38]Ibid, p. 36.

latest reports conclude that Russian war hardware, from communications systems to "Iskander" missiles, could not function without Western technology.[39]

9K720 Iskander-M missile system with 9M723K5 missiles, Army-2016 demonstration (8 September 2016).
Photograph by Vitaly V. Kuzmin, licensed under CC BY-SA 4.0, via Wikimedia Commons.
Available at: https://commons.wikimedia.org/wiki/File:Army2016demo-075.jpg

This aspect is due to the fact that Russia does not have the ability to replace certain Western electronic components with domestic products, as in some cases there is even no Russian equivalent of a Western component on the market.[40] Moreover, there were times when Russia recognized this handicap. The Russian Ministry of Defense recently stated that domestically produced drones do not even meet basic operational standards,[41] thus putting raising questions regarding the possibility of replacing such drones or other predominantly

[39] David Gauthier-Villars, Steve Stecklow, Maurice Tamman, Stepehen Grey, Andrew MacAskill. "SPECIAL REPORT-As Russian missiles struck Ukraine, Western tech still flowed". *Nasdaq*. August 8, 2022. https://www.nasdaq.com/articles/special-report-as-russian-missiles-struck-ukraine-western-tech-still-flowed
[40] Ibid.
[41] "Ministry of Defense: Most of the drones produced in Russia do not meet basic standards". Kommersant, link:https://www.kommersant.ru/doc/5582673?from=top_main_10

western technologies. The Russian military could continue its battles without these components, as low-end alternatives are to be found, but they do not provide the same accuracy, and rather account for an improvisation more than anything else.

The equation would be much simpler if military technology that reaches Russia was delivered directly from the producer to the buyer, because the largest microchip manufacturers or manufacturers of other technological parts are Western countries or its allies. In this hypothetical situation, Russia would be almost completely deprived of Western technology, as the West would have all the leverage to block their access. But living in a globalized world, one must consider that there are many third parties who import parts from the West and who then could easily resell them to Russia. Thus, the main exporter of semiconductors to Russia is China, along with Malaysia, Hong Kong, Thailand, or the Philippines.

Of course, the West is aware of this and has reacted accordingly. For example, the United States has threatened to impose export controls on Chinese companies if they defy US restrictions and supply Russia with semiconductors made with American technology. Such a move would "essentially shut down" these companies.[42] There have also been sanctions at the individual level in the wake of the Ukraine war, as the US sanctioned a Hong Kong-based distribution firm in June, that was part of a technology supply network run by an agent of Russia's secret service, the FSB.[43] The European Union is also very active in sanctioning Russia, already reaching its eighth sanctions package. In other EU sanctions packages against Russia, such as the sixth package, sanctions were adopted targeting export restrictions designed to deprive the Kremlin's military and industrial complex.[44] Now, with this new package, electrical components are also included on the sanctions list. This will deprive Russia of "certain electronic components, additional chemicals and goods that can be used for capital punishment, torture or other cruel, inhumane or degrading treatment", including technological components used by Russia in the military and security fields.[45] The sanctions will apply both to the member states that directly export such technologies to Russia, and to third parties that could be involved in the supply process.[46]

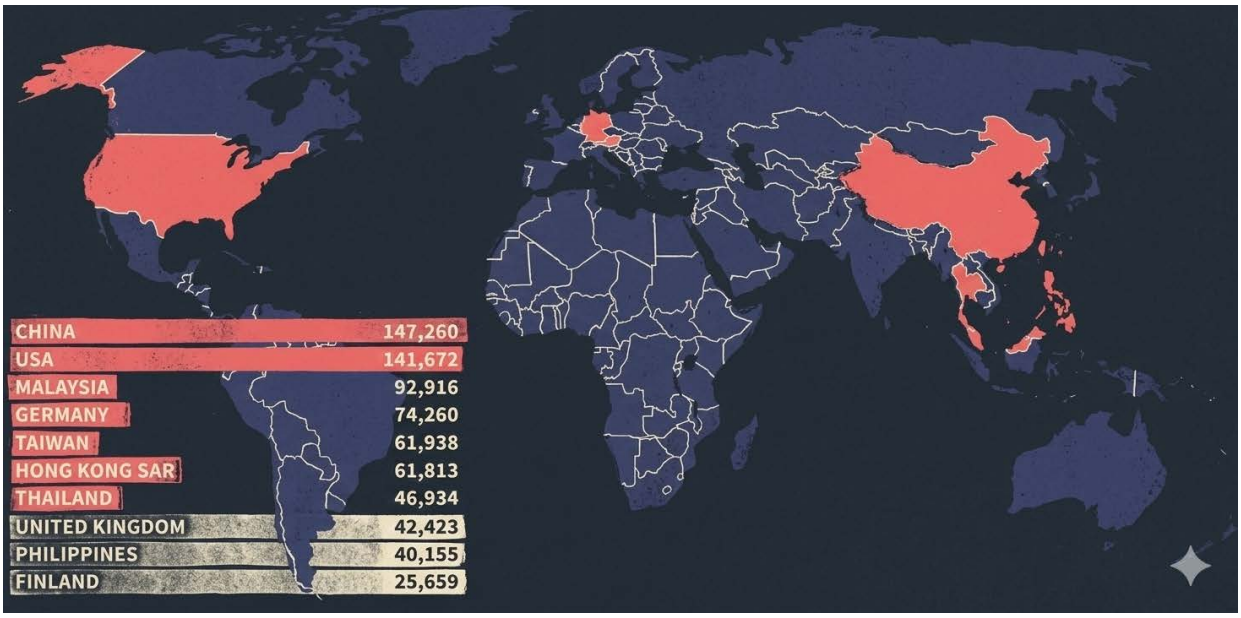
[42]Shalal, Andrea. "US will 'absolutely' hit Chinese firms if they violate export controls on Russia, says Raimondo". Reuters, link: https://www.reuters.com/world/asia-pacific/us-will-absolutely-hit-chinese-firms-if-they-violate-export-controls-russia-says-2022-03-23/

[43] Byrne. Sommerville. "Silicon Lifeline. Western Electronics at the Heart of Russia's War Machine", p. 50.

[44]"Russia's aggression against Ukraine: EU adopts sixth package of sanctions". Council of the European Union, link:https://www.consilium.europa.eu/en/press/press-releases/2022/06/03/russia-s-aggression-against-ukraine-eu-adopts-sixth-package-of-sanctions/

[45]"EU adopts its latest package of sanctions against Russia over the illegal annexation of Ukraine's Donetsk, Luhansk, Zaporizhzhia and Kherson regions". Council of the European Union, link:https://www.consilium.europa.eu/en/press/press-releases/2022/10/06/eu-adopts-its-latest-package-of-sanctions-against-russia-over-the-illegal- annexation-of-ukraine-s-donetsk-luhansk-zaporizhzhia-and-kherson-regions/

[46]Ibid.



The main exporters of chips/microelectronics in Russia. Source: Image generated by Gemini at the request of New Strategy Center.

However, while Western efforts to prevent the supply of technology to Russia are now increasing, Western interventions in this regard have been limited, and it is difficult to believe that such isolated, uncoordinated actions are sufficient. Before the war in Ukraine, when Russia was already under sanctions, there were transactions between Moscow and various third parties that bypassed the sanctions regime, as recent as September 2021.[47] Thus, of the 5,597 companies importing microelectronics into Russia, data shows records for more than 40 companies that either appear directly on US or international export control/sanctions lists or that are partially owned by companies that are in this position.[48] It is clear that pre-war sanctions did not completely block this illegal high-tech market, and are unlikely to do so now. According to Russian customs data, more than 15,000 shipments of Western electronic technology have taken place since the invasion of Ukraine.[49]

Russia has experience with technological espionage, procuring and transporting foreign military technology since the days of the Soviet Union. For example, in the 1980s, Russian spies were able to procure new Western technology that reduced submarine detection.[50] Even nowadays, during the war in Ukraine, Moscow was able to use commercial ships to move military equipment from Syria to Russia, in violation of Turkey's restrictions

[47] Byrne. Sommerville. "Silicon Lifeline. Western Electronics at the Heart of Russia's War Machine",p. 52.
[48]Ibid.
[49]" Ibidem 37
[50]"Russia's Weapons Use Old and Even Western Electronics, Report Shows". Popular Mechanics, https://www.popularmechanics.com/military/weapons/a41234073/russias-weapons-use-old-electronics/

regarding access into the Black Sea through the Straits.[51] This situation shows how easy it is for Russia to bring in Western technology and thus avoid sanctions.

Moreover, according to military engineering experts, high-end military chips are not even needed for much of the Russian equipment to work. According to some military-technical reports, some of the Western chips found in Russian weaponry are 30 years old and "for the most part, they're the same chips you find in your car or in your microwave."[52] Thus, although these chips do not offer a performance that is comparable to that offered by the new chips, they are enough to make Russian missiles work, maybe at a lower capacity, but still enough to accomplish their mission most of the time. In particular, Russia is eyeing FPGA chips (Field Programmable Gate Arrays), which are extremely flexible, as they can be quickly reprogrammed and recycled from one military equipment to another. Thus, Russia has various options to avoid Western efforts targeting the Russian war machine.

As recently as October 2022, Russia has showcased its complex technology theft networks. As such, the US federal prosecutors have recently arrested five Russians and two Venezuelans, who were using a company operated by Russians from Germany to transport American semiconductors and satellites.[53] Some of that equipment was found even found in the Ukrainian battlefields, the whole equipment transfer involving a significant money laundering scheme behind it, the usage even of cryptocurrency.[54] In a similar case around the same period, individuals were arrested on Latvian soil for attempting to transport an American jig grinder to Russia, a machine that can be used "in nuclear proliferation and defense programs".[55]

There has also been growing concern over a sudden and unexpected increase in European exports of washing machines, refrigerators, and even electric breast pumps. Based on Eurostat data, in the first months of 2022, Armenia imported more washing machines than in the past two years combined, while Kazakhstan imported $21.4 million in European refrigerators. What's more, despite a decline in birth rate in both Armenia and Kazakhstan, electric breast pumps exports to Armenia nearly tripled in the first half of 2022 compared to the same period last year, while exports to Kazakhstan increased by 633%.[56] While Russia stopped publishing official statistics after the invasion of Ukraine, Kazakh government data shows that the Russian demand for electric breast pumps from Kazakhstan more than doubled during the first eight months of the year compared to 2021. In addition, the country has delivered $7.5 million in washing machines to Russia so far in 2022, compared to

[51]Nardelli, Alberto. Alex Wickham. Jennifer Jacobs. "Russia Is Scouring the Globe for Weapons to Use Against Ukraine". Bloomberg, link:https://www.bloomberg.com/news/articles/2022-08-09/russia-is-shopping-around-the-world-for-military-weapons-for-its-war-in-ukraine#xj4y7vzkg

[52] "SPECIAL REPORT-As Russian missiles struck Ukraine, Western tech still flowed". Nasdaq.com, link: https://www.nasdaq.com/articles/special-report-as-russian-missiles-struck-ukraine-western-tech-still-flowed

[53] "Russians charged with exporting US military tech". Deutsche Welle, link: https://www.dw.com/en/five-russians-charged-with-exporting-us-military-technology/a-63499948

[54] Ibid.

[55] Ibid.

[56] Nardelii, Alberto. Baschuk, Bryce. Champion, Marc. "Putin Stirs European Worry on Home Appliance Imports Stripped for Arms". *Bloomberg*. October 29, 2022. https://www.bloomberg.com/news/articles/2022-10-29/putin-stirs-european-worry-on-home-appliance-imports-stripped-for-arms?leadSource=uverify%20wall

practically nothing in the previous two years. Its refrigerator exports to Russia had increased tenfold over the previous year.[57]

Russia is not alone in such endeavours, as China has also attempted to take American technology and then cover its tracks. As such, in a recent case, Chinese nationals bribed a US official in order to tamper with an FBI investigation. The target of the investigation is a major telecommunications company, and it is highly speculated to be the case of Huawei,[58] a company which has a reputation for attempting to steal American technology.[59] Furthermore, in another case, China attempted to recruit three former US officials through a fake think tank, with the hope that these individuals would ship American technology to China.[60]

These examples showcase the importance of international cooperation in preventing technology smuggling, since different authoritarian states, especially Russia, have operatives in a wide array of countries. They have the capacity to efficiently operate under the radar, if not for a clear effort of democratic countries to unmask these black-market transactions.

Thus, although the chips acquired from other forms of electronic equipment do not offer a performance that is comparable to that offered by the new chips, they are enough to make Russian missiles work, maybe at a lower capacity, but still enough to accomplish their mission most of the time. In particular, Russia is eyeing FPGA chips (Field Programmable Gate Arrays), which are extremely flexible, as they can be quickly reprogrammed and recycled from one military equipment to another. Thus, Russia has various options to avoid Western efforts targeting the Russian war machine.

Still, the war depends on Russia's ability to find a way to increase its access to high-tech chips. In extreme cases, the Russians will probably end up using the chips found in household appliances, such as refrigerators, as stated, for example, by the President of the European Commission, Ursula von der Leyen.[61] Some US national security veterans argue that Western governments lack the ability to stop other regimes, such as China, from transferring microchips to Russia. Matthew Turpin, the US National Security Council director for China from 2018 to 2019, claims that Russia and China share a 4,300-kilometer border, so there is absolutely no way to ensure that no chips are being shipped between the two countries. At the same time, the US Commerce Department has repeatedly stated that it has found no evidence of technology transfers from China to Russia. If evidence is indeed

[57] Ibidem.
[58] Demusmann Jr, Bernd. "US charges alleged Chinese spies in telecoms probe case". BBC, link: https://www.bbc.com/news/world-us-canada-63378817
[59] Stacey, Kiran. "US accuses Huawei of stealing technology from six companies". *Financial Times*, link: https://www.ft.com/content/3174481a-4e8b-11ea-95a0-43d18ec715f5
[60] Demusmann "US charges alleged Chinese spies in telecoms probe case".
[61]"2022 State of the Union Address by President von der Leyen". European Commission, link:https://ec.europa.eu/commission/presscorner/detail/ov/SPEECH_22_5493

found, the United States would impose severe sanctions on Beijing. At the same time, the Chinese government has declared that it will not limit its trade relations with Russia.[62]

On the other hand, British analysts from the Royal United Services Institute believe that there are solutions that can exponentially limit Russia's access to the latest technologies, especially to high-level ones. Thus, the West should urge and assist its high-tech companies to more closely monitor the market flow of their products and close supply networks that violate international laws. Another proposed measure is revoking licenses for the production of technology in states that support Russia or that are suspected of transferring technology to Russia.[63] Of course, given the large number of third-party actors that can supply Russia, there is an urgent need for close international collaboration between technology producers in democratic countries and distributing countries.[64] In the case of some countries, however, it will be more difficult to reach a compromise. Such cases are China, which supplies Russia with technology to a large extent, or India, whose defence industry imports come to a proportion of 45% from Russia.[65] Therefore, a balance must be found by the West between cooperation and coercion.

These sanctions do not only affect Russia's arms and technology purchases, but also have effects on other areas related to Russian society, such as the banking and the energy systems.

[62]"The chips are down: Putin scrambles for high-tech parts as his arsenal goes up in smoke". Politico, link:https://www.politico.eu/article/the-chips-are-down-russia-hunts-western-parts-to-run-its-war-machines/
[63] Byrne. Sommerville. "Silicon Lifeline. Western Electronics at the Heart of Russia's War Machine", p. 5.
[64]Ibid, p. 58.
[65]Ibid.

Russia under sanctions: the impact on the country's banking system and energy revenues, the connection to the microchip market

With the start of Russia's brutal invasion of Ukraine, the West reacted by adopting several sanctions packages, aimed at affecting Moscow's war machine, and the Russian economy as a whole and putting pressure on Russian society. Banking was one of the most affected sectors.

Due to the imposed sanctions and the voluntary departure from the Russian market of some international manufacturers, Russia is facing an acute shortage of chips for bank cards. One of the solutions for this problem, which the specialists from the cyber department of the Sberbank in Russia thought up, is to "reimplant" chips from non-activated cards into new ones. Against the background of the sanctions and given that previously the bank was sourcing chips to a large extent from European manufacturers, this new measure covered the minimum amount of required chips. In total, there are about 375 thousand non-activated cards per month, and the chip reimplantation method will allow Sberbank to save 1 billion roubles ($16 million) this year. Furthermore, Visa and Mastercard have left the Russian market, leading to increased demand for domestic Mir cards.[66]

The number of Mir cards issued in Russia in the first five months of 2022 turned out to be three times higher compared to the same period in 2021. Demand has increased amid fears that the number of accessible cards will be reduced. The Russian population was also forced to switch from Visa and Mastercard to the Mir system, since cards issued on the territory of the country cannot be used abroad, working only in Russia until the expiration date.[67] The number of Mir cards issued by the Dom.RF bank in 2022 is even higher than the previously mentioned average, where the number increased five times compared to 2021. Until March, such cards were of particular interest to budgetary or social aid organizations.[68]

[66]"Sberbank began to rearrange chips from unused bank cards", RBC.ru. link:https://www.rbc.ru/finances/07/07/2022/62c6e9739a79475f30c99260
[67]"WORLD TIME: Russians issued a record number of bank cards in 10 years". Izvestiya, link:https://iz.ru/1354353/mariia-kolobova-natalia-ilina/mirovoe-vremia-rossiiane-oformili-rekordnoe-za-10-let-chislo-bankovskikh-kart
[68]Ibid.

Commemorative coin marking the launch of the "Mir" national payment system cards (15 December 2015). Image by the Central Bank of Russia, public domain, via Wikimedia Commons. Available at: https://commons.wikimedia.org/wiki/File:RR5111-0310R.jpg

Considering the chip supply issues, as an alternative option, it was decided to extend the validity of the issued cards. Reorienting imports to China and expanding domestic production will allow for minimal coverage of this deficit, but problems will continue as long as access to high-performance chips is restricted.[69]

The Mir payment system was supported internationally by Turkey and private banks, being considered a way for Moscow to circumvent sanctions. Meanwhile, since the end of September, no bank in Turkey accepts these cards anymore,[70] similar measures being replicated in countries with close ties to the Russian Federation, such as Kazakhstan, Armenia, or Vietnam.[71]

Sanctions have altered Russia's economic landscape for the foreseeable future. In comparison with almost all other economies around the world, which are integrated into a globalized system, Russia's technology market will be completely isolated and formed, according to Russian experts, from the following elements: old Soviet production technology, technology developed by Russia in collaboration with the West over the last 30 years and technology imported from the few remaining "friendly countries".[72] Thus, Russia is in a process of detachment from the global economy, a process seen by economic experts as long and painful, including for the banking domain.

[69]Ibid.
[70]Sezer, Ben. "Turkey's state banks suspend use of Russian Mir payment system - finance ministry". Reuters, link:https://www.reuters.com/business/finance/turkeys-ziraat-bank-suspends-use-russian-mir-payment-system-ceo-2022-09-29/
[71]"Russian media: Armenia, Vietnam and Kazakhstan suspend use of Russian Mir cards". The Kyiv Independent, link:https://kyivindependent.com/uncategorized/russian-media-armenia-vietnam-and-kazakhstan-suspend-use-of-russian-mir-cards
[72]"Tragedy of a little thing". Kommersant, link:https://special.kommersant.ru/import/butrin.php

In this regard, Putin has already signed a decree requiring the forced replacement of foreign software in banks and facilities that hold critical information. As such, these facilities no longer have the right to purchase foreign technology without state consent and are forced to make a transition to domestic infrastructure by 2025.[73] So far, Russian sources say that the country's banks have replaced less than half of their Western technological infrastructure, with the dependence being high especially on the software used by the banks.[74] Russian entrepreneurs are not so sure that this transition and deadlines are realistic, with one of them stating that a full transition of banks to 100% Russian technology would take 5 to 10 years and require billions of roubles of state investment.[75]

Western sanctions on oil and gas technology have been targeting Russia since 2014, following the annexation of Crimea, specifically blocking the export of oil and gas refining technology.[76] However, Russia has managed to adapt to those sanctions before the 2022 Ukraine war, with Russian energy companies even increasing their total extraction output.[77] Russia has also invested in its own pipeline production, geological studies and hydraulic fracturing technology, but is still heavily dependent on Western technology.[78]

[73]"Replacement finance. How banks can localize software and hardware". Kommersant, link:https://special.kommersant.ru/import/finance-2.php
[74]Ibid.
[75]Ibid.
[76]"US Targets Russian Oil Sector With Equipment-Export Ban". Bloomberg. March 2022, link:https://www.bloomberg.com/news/articles/2022-03-02/us-allies-target-degrading-russia-as-a-leading-oil-producer?leadSource=overify%20wall
[77]"Western Sanctions on Russia's Oil and Gas Sector: a Damage Assessment". Carnegie Moscow. 2018, link:https://carnegiemoscow.org/commentary/76909
[78] Kapustin, Nikita O., and Dmitry A. Grushevenko. "A long-term outlook on Russian oil industry facing internal and external challenges." Oil & Gas Science and Technology–Revue d'IFP Energies nouvelles 74 (2019).

Prirazlomnaya offshore oil platform (Gazprom Neft) in the Pechora Sea (22 July 2019). Photograph by SenkYou, licensed under CC BY-SA 4.0, via Wikimedia Commons. Available at: https://commons.wikimedia.org/wiki/File:01_gazprom-ru_5.jpg

This aspect, namely the capacity of the rich Russian energy industry to adapt to sanctions, calls into question the effectiveness of the current Western sanctions on the energy field, although, of course, the gravity of the current situation is greater than that of the first sanctions packages. Currently, following the invasion of Ukraine, large energy companies, such as Exxon Mobil or Shell, have withdrawn their activities from Russian territory as part of Western sanctions.[79] The European Union in March of this year limited the supply of oil refining and natural gas liquefaction equipment to Russia and expanded the list of technologies for the oil and natural gas industry banned for export to Russia.[80] These moves, some experts say, will over time affect Russia's energy industry, which is essential to the country's gross domestic product. While Russia's oil and gas extraction and refining processes may remain operational, they will be with older, slower technology and higher operating costs than Western energy companies have access to, which could affect Russia's production in the long term.[81]

According to energy experts, "every valve, every pump [in Russia] is practically 90% foreign."[82] This has a double negative effect on Russia. On the one hand, dependence on Western components will force Russia to use outdated parts. On the other hand, most foreign parts can only be properly repaired by a foreign engineer familiar with those

[79]Ibidem 76
[80]"Russia critically dependent on imported technology for refineries, offshore production - expert". Interfax. 20th April 2022, link:https://interfax.com/newsroom/top-stories/78395/
[81]Samylovskaya, Ekaterina, Alexey Makhovikov, Alexander Lutonin, Dmitry Medvedev, and Regina-Elizaveta Kudryavtseva. "Digital Technologies in Arctic Oil and Gas Resources Extraction: Global Trends and Russian Experience." Resources 11, no. 3 (2022), p. 16.
[82]"Ibidem, 71.

components. Thus, if a microchip or any component of the machinery used in the field of oil and gas breaks down, it is possible for that to lead to delays in production, either because of the lack of specialized foreign personnel or because of the reluctance of Russian companies to admit that they are experiencing technical problems, so as not to affect the international image of the Kremlin.[83] Overall, Russia needs foreign technology to ramp up production and keep infrastructure operational. As such, an official at Russia's private oil company Lukoil said that replacing Western technology imports with domestic technology would require colossal state investment.[84]

Russia does not have the same high-performance technology, especially when it comes to the software component of the extraction and refining systems, including microchips,[85] pipeline transport vessels, or drilling systems.[86] In the literature specialized on the energy sector, it is often emphasized that the Russian extractive industry cannot evolve without a collaboration with the West, especially regarding Arctic exploration. Thus, in Arctic oil and gas exploitation projects, which require the most advanced technology, Russia is dependent between 80-95% on Western technology.[87] The current technology sanctions could halt Russian efforts to expand oil and gas exploitation, which could affect the country's long-term production and income.

There are also more sceptical voices, who believe that Russian energy giants, such as Gazprom or Rosneft, will not be so easily affected by the sanctions. Russia's oil production, for example, has fallen by only 3% since the invasion of Ukraine, as Moscow has been able to tap into the Asian market.[88] However, it should be considered that energy exports to Europe represent around 7% of the total GDP of the Russian Federation. In the case of oil, although Russia used to send around 50% of its oil to Europe, it can be redirected to other destinations relatively easily, as oil is mainly transported by sea.[89] Despite this, market transition and distancing from the European market is not easy, especially for natural gas. 70% of Russian natural gas was exported to Europe in 2021.[90] A focus of the gas exports to Asia would be complicated, especially from an infrastructural point of view, and experts say the Asian energy market will not be able to replace the European market any time soon.[91] Although total energy exports to China, for example, account for about 3% of Russia's GDP, and Asian countries such as South Korea and Turkey are major importers of

[83]Ibid.
[84] Ibidem 76
[85]Samylovskaya. Makhovikov. "Digital Technologies in Arctic Oil and Gas Resources Extraction [...]", p. 24.
[86]Sonnenfeld, Jeffrey, Steven Tian, Franek Sokolowski, Michal Wyrebkowski, and Mateusz Kasprowicz. "Business retreats and sanctions are crippling the Russian economy." Available at SSRN 4167193 (2022), p. 25.
[87]Samylovskaya. Makhovikov. "Digital Technologies in Arctic Oil and Gas Resources Extraction [...]", p. 16.
[88] Ibidem 76
[89]"The Russian economy and world trade in energy: Dependence of Russia larger than dependence on Russia.", Oesterreichsche Nationalbank Eurosystem, link:https://www.oenb.at/dam/jcr:c7d95c7b-c469-4834-ac94-98554c5e6f5f/2022-04-15-russian-economy-and-world-trade-in-energy.pdf
[90]Ibid.
[91]Trickett, Nicholas. "Asia Can't Save Russia's Energy Sector". The Diplomat, link:https://thediplomat.com/2022/06/asia-cant-save-russias-energy-sector/

Russian oil and gas, they cannot replace revenues from the huge European market pre-war.[92]

Overall, Western technology sanctions will affect the infrastructure underlying Russia's energy economy, as there are a considerable number of components that cannot be replicated domestically at this time. Currently, the results of these sanctions are not visible, but one can speculate that over time, as extraction, drilling, and storage equipment degrades, Russia's oil and gas production will slow and/or decline. This depends only on how quickly Russia will find domestic replacements for foreign parts, or how tightly the West's lock on its own technologies will be maintained. Moreover, the reorientation towards the Asian market may only reduce further the losses of Russian energy companies, but at the moment it is clear that Russia's dependence on the European market is as high - or perhaps even higher - than Europe's dependence on Russian energy.

[92] Ibidem 89

Conclusion

Source: Image generated by Gemini at the request of New Strategy Center

Microchips play an essential role in determining the geopolitical map of the world in today's political context. As this study has presented, the world's major powers are in a race to increase domestic chip production.

In the near future, Taiwan will most likely continue to dominate this industry, thus maintaining its central political and economic role for the West. In this sense, the West, especially the United States, has a responsibility to limit China's threats and aggressions towards Taiwan, but also to limit China's capacities to supply the Russian Federation with microchips. The United States has showcased a strong position on these two subjects. President Joe Biden has said the US will defend its democratic partner Taiwan in the event of a Chinese invasion[93] and, as mentioned above, Washington will maintain a firm stance should China's sale of microchips to Russia come to light. In October 2022, the Biden administration also published a set of export controls that limit China's access to

[93]Brunnstrom, David. Trevor Hunnicutt. "Biden says US forces would defend Taiwan in the event of a Chinese invasion". Reuters, https://www.reuters.com/world/biden-says-us-forces-would-defend-taiwan-event-chinese-invasion-2022-09-18/

semiconductors manufactured with American equipment.[94] This demonstrates that the US wishes to close as many valves as possible in Russia's supply of Western technology.

If Russia is further deprived of quality microchips by the West, this could have an impact on the war with Ukraine. The Ukrainians, who are now equipped with high-performance technology, could significantly pressure the Russian military, whose weaponry will have to resort to outdated or underperforming capabilities more often. Moreover, if the West is able to coordinate to also shut down the supply networks of less capable but still usable technology to the Russian military, then Moscow's capacity to continue a war of attrition will be severely impaired. Of course, as mentioned, a coordinated international effort is needed in this regard, which can only be initiated when Western and democratic leaders realize the impact of such a mobilization on the Russian war effort.

Finally, the process of depriving Russia of microchips and other Western technologies is lengthy, owing to the time required for contraband and Russian-made technology to replace Western technology. The West has to promptly maintain its sanctions, but also to cooperate with third parties that import considerable amounts of technology to Russia. With China and countries of Southeast Asia, such as Thailand, the Philippines, or Malaysia, it will be necessary to create channels of collaboration between them and the West, but warnings will also be necessary, in case one of these nations aims to compromise the sanctions against Russia and supports the Kremlin's war machine. Even if there will be channels to import technology into Russia, it is unlikely that they will compensate for Russia's technological gaps, since, as mentioned before, most of that smuggled technology is not state-of-the-art.

Especially in the military field, the shortage of advanced technology will have immediate effects on Russia's performance in the war, already visible through Ukraine's advance on the front. Given how many weapons Western chips require, it is obvious that the war effort under current conditions cannot be sustained for long under the current sanction regime.

In the case of the banking and energy systems, Russia will make considerable efforts to adapt to these new economic realities. Russian banks will face isolation in international collaborations and problems in the transition to domestic technology. Instead, the infrastructure needed to extract and process oil and gas will suffer, having to operate with outdated equipment and facing technical failures, which will be solved harder and slower, The energy sector, vital to the GDP of the Russian Federation, could suffer immensely, as components essential to the forging and storage of oil and gas fail and need to be replaced, and the equivalent of those parts will not be available for Russia. Moreover, the new frontiers of oil and gas extraction, specifically Arctic exploration, are currently being explored almost exclusively with state-of-the-art Western technology, to which Russia will

[94]"US aims to hobble China's chip industry with sweeping new export rules". Reuters, link:https://www.reuters.com/technology/us-aims-hobble-chinas-chip-industry-with-sweeping-new-export-rules-2022-10-07/

have restricted access. Thus, it is possible that Russia will be outclassed in this energy field and will be deprived of the precious resources of the Arctic zone.

Generally, Russia is not as dependent on semiconductors as developed Western countries, given that Russia is not a service-based economy. Nevertheless, there are various Russian sectors that can be affected by the availability, such as the industry of extraction of oil and gas, the banking sector, the aeronautics industry, space industry, as well as the defence industry, especially for the higher technology components. In time, Taiwan and the democratic world will be able to change the sources of raw materials needed to produce chips, but Russia will not be able to change the source of the final product, the microchip itself, and will in no way be able to make up for this shortage with its own production any time soon. However, it is obvious that Russia is moving in the direction of technological and economic isolation, so it remains to be seen how painful this transition process will be for the Russian economy and how bearable it will be for Russian society in general.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