SPACE ACTIVITIES: THE RESOURCE REQUIREMENTS AND ECONOMIC ENVIRONMENT

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Abstract

In my study, I was looking for answers to the question of what kind of economic conditions are necessary for the development of space activities in a given country. I have taken data from a number of countries into account, but I have focused on the analysis of the USA, Europe, Russia and China. In addition to minerals, I focused on indicators that determine the development of countries, such as education, economic actors and ISO standards. In the course of the study, I have identified areas that help to navigate the competition between the major powers. Europe's special position and the misinterpretation of China's development are central to my study. My focus is mainly on

the period before the Covid and the Russian-Ukrainian conflict, in order to maintain continuity and context.

Keywords: economic development, minerals, multinational enterprises, ISO standards, EEE components

Disciplines: military sciences, social sciences, engineering sciences

Absztrakt

ŰRTEVÉKENYSÉGEK: ERŐFORRÁSIGÉNY ÉS GAZDASÁGI KÖRNYEZET

A tanulmányomban arra kerestem a választ, hogy milyen gazdasági feltételek szükségesek egy adott ország fejlődéséhez az űrtevékenységek területén. Számos ország adatait figyelembe vettem, azonban a hangsúlyt az USA, Európa, Oroszország és Kína elemzésére helyeztem. Az ásványi anyagok mellett kiemelten foglalkoztam az országok fejlettségét meghatározó indikátorokkal, mint az oktatás, egyéb gazdasági szereplők, ISO szabványok. A tanulmány során meghatároztam azokat a területeket, amelyek segítenek eligazodni a nagyhatalmi versenyben. Európa különleges helyzete és a kínai fejlődés félreértelmezése központi eleme a tanulmányomnak. A fókuszt leginkább a Covid és az orosz-ukrán konfliktust megelőző időszakra helyezem a folytonosság és a kontextus megőrzése végett.

Kulcsszavak: gazdasági fejlettség, ásványi anyagok, multinacionális vállalatok, ISO szabványok, EEE komponensek

Diszciplinák: hadtudomány, társadalomtudomány, műszaki tudomány

I have based the contents of the present publication on my thesis entitled The Influence of Outer Space in 21st Century Geopolitics, defended in 2024. I have evaluated the materials revealed in the course of my research independently and in context together. My research methodology is unique, with the specificity of a systematic geopolitical analysis developed by Ioannis Mazis, in addition to qualitative and quantitative methods (NET2). I combined the systematic geopolitical analysis with quantitative, qualitative and comparative methodologies, and used a sub-chapter by sub-chapter induction method to arrive at the conclusions. The central element is a comparison of the United States of America (hereinafter) US, Europe, Russian Federation (hereinafter Russia) and China. I have used the systematic geopolitical analysis method to delineate the systems and subsystems through which I have examined space as a supra-system. The systems are remarked by countries or, as in the case of Europe, by regions based on territorial size or fragmentation. I have used the designation Europe or European Union (hereinafter EU including EFTA) or European Space Agency (hereinafter ESA) throughout the study, but for space activities they overlap and I mean the same region. The systems

are linked by the subsystems where the specific space activity is carried out, such as launch stations, professional organisations or orbiting space stations.

The specificity of the systemic geopolitical analysis is given by the final element of the methodology, the "Supra-system". The difference of the "Supra-system" can be found in its name, which is separated from the "Super-system" by a faint line. The designation "super" means something on top of something and also gives a physical expression to the word association with it. The term "supra", however, refers more of a phenomenal term. This suggests a method of analysis that is more pervasive and more penetrating to the point. Thus, the main element of systemic geopolitical analysis is space activity, which permeates and embraces the specific activities of the countries of the world at a given place and time, which are related to the domain nature of space. I have also identified geopolitical factors (military, economic, political, social), which I have analysed in terms of space activities through a number of indicators such as the size of the military, the political establishment, Gross Domestic Product (hereinafter GDP), legal regulation, economic line, mineral resources, technology, social preparedness, etc.

In my study, I will examine the conditions necessary for the operation of space activities, and I look at the economic factor, in addition to the social and political factors. As an indicator, I have focused on minerals, their procurement and the associated critical space components.

According to the database of United Nations (hereinafter UN), there are 195 sovereign countries, but according to the Organisation for Economic Cooperation and Developement (hereinafter OECD) there are more, totalling 217 countries, each with different geographic characteristics and different quantities of minerals (NET3), (NET4). I analyse the mineral resources that are of major importance for the space industry and take a broad view of the mineral reserves that underpin the economic foundations of countries. I have summarised the economically important mineral resources and the countries with the largest mineral resources in 2019, where more recent research on specific minerals is not available, in Table 1 (NET5).

Table 1: Distributions and reserves of minerals (ores) that form the basis of the world economy. Source: NET5

Minerals	I.	II.	III.
Copper	China	Chile	Peru
Platinum	Russia	South-Africa	North-America
Iron ore	Australia	China	Brasil
Silver	Mexico	Peru	China
Gold	China	Australia	Russia
Bauxit	Australia	China	Guinea
Zink	China	Peru	Australia
Titanium	Canada	China	Mozambic

Closely related to Table 1, the ranking of the world's main mineral-producing countries in 2017 based on the 2019 survey – no similar recent research is publicly available – is in Table 2 (World Mining Data, 2019, p. 42).

Table 2: Countries that produce the most minerals. Source: NET79

Countries	Production volume (tons)
1. China	4 107 911 005
2. USA	2.013 644 488
3. Russia	1 610 817 380
4. Australia	1 271 899 033
5. India	984 418 011
6. Saudi–Arabia	673 751 592
7. Indonesia	568 394 297
8. Brazil	496 158 227
9. Canada	463 817 702
10. Iran	461 378 245
28. Ukraine	88 636 516
56. North–Korea	20 473 900
74. Israel	11 210 990
77. Hungary	9 939 832
78. Japan	8 322 026
ESA *	800 000 000
84. South–Korea	6 155 274

***(1/3 to Germany and 1/5 to Poland)**

From the data in Tables 1 and 2, it is clear that economic development varies widely between countries with the highest technological achievements and that this economic development is not necessarily related to mineral reserves. China's GDP is close to that of the US, but its population is nearly four times larger, which could be a long-term obstacle as the 2-300 million people living in rural areas are currently living at a medieval level (without basic sanitation – NET6). In India, like China, there are also around 2-300 million people without basic utilities, with a GDP output 1/5th of China's GDP output (NET7). However, in terms of its military strength, India can take on China at any time. Analysing Table 2 further, we can see that Israel, South-Korea, Japan, Russia and Ukraine, with their different mineral reserves and GDP, are space-faring countries capable of space missions thanks to their logistics and advanced industry in the field of missile technology. We can also mention North Korea and Iran, which also spend huge amounts on missile development despite their economic underdevelopment. Given Russia's role and its space race over the last 70 years, no other country has been able to challenge the US for the last few years. However, apart from its technical and military determination, Russia is not diversified enough economically to compete. This gap has been confirmed by former Deputy Prime Minister and head of Roscosmos Dmitry Rogozin, who has pointed to US superiority and greater efficiency. (NET8)

China has recently emerged as a new challenger alongside the US and Russia. At the same time, the role of India, Japan and Europe cannot be ignored, but these countries are not as threatening to the existing world order as China's presence. In terms of its economy and population, China can be seen as a competitor capable of being a worthy challenger to all space-faring countries.

Distribution of minerals, primary minerals

In addition to a number of economic and technological conditions, the existence of rare earth minerals, Electrical & Electronic Equipments (hereinafter: EEE) and advanced (cutting-edge) technological research in a country is of paramount importance for space activities.

In this study, I have analysed the state of development of rare earths and EEE, which are also of high importance for the space industry, but the many links of the space industry with other industries do not allow for a deeper and longer analysis. I have therefore analysed the main facts relevant to this study. However, to get the full picture, it is important to note that the supply and demand for rare earths in the economy is currently balanced and will inevitably change in the coming years due to continued demand. Demand will soon exceed supply capacity, but this will mainly affect the electric car, wind power and industrial hydrogen markets. These areas are forecast to account for half of the demand for rare earths over the next two decades (NET9).

With regard to the use of rare earths in the space industry, I found that it cannot be quantified separately from the needs of other industries, as we do not have accurate data on their use. In order to answer this question, I analysed the presence of rare earths in the defence (and weapon systems), aerospace and civil industries. On this basis, I found that their use in the defence (and weapon systems) industries is in (1) surveillance and navigation, (2) recording, guidance, targeting and precision systems, (3) nuclear reactors, (4) electronic equipment. In the aerospace industry, they are used in (1) microchips, (2) missile guidance systems, (3) aircraft and satellite components, (4) batteries, (5) optical devices and (6) LED or plasma displays. Their civil applications are in (1) renewable energy, (2) electric transportation, (3) nuclear energy, (4) solar and wind energy, (5) agriculture and (6) medical devices. Since many devices are linked to space through satellite systems and the use of "conventional" devices is also applicable to space exploration and space activities, it is not possible to precisely separate the specific industry needs for rare earths (Neha Mishra, 2022, p. 125-141). Despite and in spite of the sensitive and not always available source material with a year-by-year breakdown – for some tables only from 2020 for the last five years or from 2021 for other tables – I was able to draw the right conclusion and not contradictory when comparing the data.

Rare earth elements

The 17 elements that make up rare earth elements are actually quite abundant in the Earth's crust, but they are usually present as compounds, making them difficult to extract. EEE components are now an essential building block for the IT sector and chip manufacturing (NET10). Some are also used in the production of various space devices.

Table 3 shows that the world's five largest rare earth producing countries accounted for more than 90% of global market supply in 2021 (US Geological Survey – Mineral Commodity Summary, 2021, p. 133).

Table 3: Mineral resources that form the foundation of the global economy in 2021. Source: US Geological Survey 2021

Country	Share of world production in %
China	62 %
USA	12,2 %
Myanmar	10,3 %
Australia	9,9 %
India	1,4 %

In the case of rare earths, China's dominance is perhaps a cause for concern and there is a legitimate fear that any decision by China could lead to the entire rare earths-based industry shutting down and creating a shortage. In examining – from a certain perspective – legitimate concerns, it is worth looking at the world's rare earth reserves (NET11, Table 4).

The figures in Table 4 show a significant amount if we consider that the world's rare earth extraction is 240 000 tonnes per year, of which China alone produced 140 000 tonnes in 2020. The US, on the other hand, will only produce 38 000 tonnes, with its reserves in reserve (NET12). However, Canada has discovered an estimated additional 15 million tonnes, which could make it and its allies a major producer worldwide (NET13).

Table 4: World rare earth reserves by country in 2020. Source: NET12

Country	Rare earth reserves (tons)
USA	1 500 000
Australia	4 100 000
Brazil	21 000 000
Canada	830 000
China	44 000 000
Greenland	1 500 000
India	6 900 000
Russia	12 000 000
South–Africa	790 000
Tansania	890 000
Vietnam	22 000 000

In Table 5, I have sorted the world's 15 largest trading companies by country of origin. Table 5 clearly demonstrates that there is no sign of Chinese dominance in global rare earths trade, but that China has a strong presence in rare earths trading (NET14).

China's dominance in rare earth exports has been investigated by China itself for nearly two decades ago. Until the 1980s the US dominated this area, since then China has gradually taken over the position and become the world's supplier. At the same time, as China's own economy boomed, it adopted merkantilist principles, (NET15) with Western countries turning to cheaper raw materials and buying more and more from China, creating a new supply chain.

Table 5: The most important companies in the rare earth metal trading market – 2023. Source: NET14

n	Company name	Country of headquarter
1.	MP Materials Corp.	USA
2.	Hastings Technology Metals Ltd.	Australia
3.	Lynas Rare Earths Ltd.	Malajsia
4.	Alkane Resources Ltd.	Australia
5.	Arafura Rare Earths Ltd.	Australia
6.	Northern Minerals Ltd.	Australia
7.	Vital Metals Ltd.	Canada
8.	Peak Rare Earths Ltd.	Australia
9.	Shenghe Resources Holding Co. Ltd.	China
10.	China Northern Rare Earth Group High–Tech Co. Ltd.	China
11.	China Rare Earth Resources and Technology Co. Ltd.	China
12.	Jiangxi Copper Co. Ltd.	China
13.	Ucore Rare Metals Inc.	Canada
14.	NioCorp Developments Ltd.	USA
15.	Rare Element Resources Ltd.	Canada

The gradual fight against polluting practices and the curbing of practices harmful to the health of the human workforce are forcing even China to change its established working practices. This may make the extraction and processing of rare earths and other minerals so expensive that (1) either prices are reduced, with a fall in GDP (2) or they can sell less, also with a fall in GDP. The price increase will make it no longer worth buying from China, and may also put countries that can develop their own technology to extract their raw materials in the lead. China realised this at the beginning of the millennium, when in 2003 a Chinese researcher analysed the country's mineral resources, describing how China was squandering its resources and would soon need to import iron ore, magnesium or even the low-grade bauxite that it has in abundance (NET16). Repeating this and adding other minerals to it, in 2012, in the form of a White Paper, Chinese experts are now specifically proposing that China should build up reserves of rare earths for the next period, as only 23% of the world's rare earth reserves are in China, (White Paper – Situation and Policies of China's Rare Earth Industry, 2012, p. 9), (NET17) At the same time, China has already introduced new rules since 2010, such as the setting of a quota for rare earth exports or the application of a 13% indirect tax, to protect mineral reserves. (NET18) For a decade now, the world has been looking for ways to redesign the supply chain for rare earths.

EEE components, electronic circuits

From the point of view of EEE components (hereinafter EEE components or electronic circuits), it is important to identify the countries where the basic space industry equipment is produced. The number of exporting countries is small, but their importance is reflected in their market share (NET19). For the analysis of the data, I have taken 2020 as the base year, but compared it with 2022 below.

The countries listed in Table 6 account for 97.5% of the world's global exports. However, the order of these countries changes if we analyse the data in Table 7 to

Table 6: Export of electronic circuits in 2020. Source: NET19

Country	Amount (in billion dollars)	Share in World trade (%)
Hong Kong	134,5	18,7
China	102,2	14,2
Taiwan*	100,4	13,9
South–Korea	79,1	11
Singapore	76,9	10,7
Malajsia	44,8	6,2
USA	40,1	5,6
Japan	27,8	3,9
Vietnam	26,1	3,6
Philippines	19	2,6
Germany	14,9	2,1
Netherlands	14,6	2
France	7,7	1,1
Thailand	7,6	1,1
Ireland	7,2	1

***2022 Taiwan took over China (NET20)**

Table 7: Net exports of electronic circuits in 2020. Source: NET80

Country	Exportable value (in billion dollars)
Taiwan	46,7
South–Korea	43,4
Singapore	16,3
Malajsia	12,9
Japan	9,3
USA	7
Ireland	6,6
Philippines	5,5
France	3,9
Israel	1
Malta	207,4 millions
Switzerland	92,5 millions
Belarus	9 millions
Saint Helena (UK offshore territory)	2,3 millions
Brit Virgin Islands (UK offshore territory)	1,6 millions

see which countries have surpluses in addition to their own consumption. Examining the data in Tables 6 and 7 and comparing them with the 2022 data, stagnation is observed, with no significant changes in the market trends. In addition to several years of equilibrium, the main change is in the proportional increase in prices and the number of trade volumes (NET21). If the order of import constraints is taken from Table 8, the situation changes further if we look beyond domestic consumption to countries in need of imports (NET22).

Table 8: Electronic circuits import balance in 2022. Source: Net21

Country	Import (in billion dollar)
China	–203,7
Mexico	–19,1
Hong Kong	–16,8
India	–9,7
Brasil	–4,1
Thailand	–3,8
Hungary	–2,9
Vietnam	–2,8
Poland	–2,1
Germany	–27
Chechia	–1,9
Romania	–1,4
Indonesia	–1,13
Russia	–1,11
Netherlands	–16

To get the full picture, we need to identify those countries that, whether they source the raw materials for production domestically or from other sources, have the technological capacity to control minerals. In doing so, I have compiled and analysed the main players in the international electronic circuit trade in Table 9, with country of origin, with each company identified by subsidiary (NET23).

Table 9: Major companies producing electronic circuits in 2020. Source: NET23

Company	Country (Parent Company)	Subsidiary location
Advanced Micro Devices	USA	Singapore
CML Microcircuits UK Ltd	UK	Singapore
EnSilica	UK	China
Ferranti Computer Systems	Belgium	Singapore
Fujitsu	Japan	
Hitachi	Japan	
Integrated Device Techology	USA	Malajsia, Singapore, Shanghai (China)
Intel	USA	
MediaTek	Taiwan	
MicroSystems International	Canada	
Nordic Semiconductor	Norvegia	
NXP Semiconductors	Netherlands	
Plessey	UK	Hong Kong, Australia
Renesas Electronics	Japan	

From the data in Table 9 we can conclude that neither China nor Russia has the potential to influence world trade in manufacturing. However, smaller European countries such as the Netherlands, Belgium or Norway have world production potential alongside Taiwan and Canada.

Semiconductors

The trade in semiconductors (e.g. germanium, silicon, etc.) is intrinsically linked to the electronic circuits analysed in previous section, and it is also necessary to identify the main players. These are summarised in Table 10, indicating the country of origin (2021; NET24).

Table 10: Major semiconductor device manufacturers in 2021. Source: NET24

Companies	Country of origin, region
Intel	USA
Samsung	South–Korea
TSMC	Taiwan
SK Hynix	South–Korea
Micron	USA
Qualcomm	USA
Broadcom	USA
Nvidia	USA
TI	USA
MediaTek	Taiwan
AMD	USA
Infineon	Europe
Apple	USA
ST	Europe
Kioxia	Japan

Most of the minerals needed for semiconductors, like rare earths, are found in China, but the country of origin of the companies identified in Table 10 illustrates the technical and technological differences between each country and China, and highlights that while everyone is interconnected in the global chain, Western countries are in a privileged position to supply semiconductors because of their unique capabilities.

Technolgical inventions

For both EEE components and rare earths, there is advanced research that offers a solution in the field of recycling, thus

increasing the self-sufficiency of economic actors while reducing vulnerability to the global chain.

For EEE components, mechanical and chemical processes have been developed that use biotechnology or dissolve plastics by thermal decomposition, thus transforming all disused electronic equipment into useful waste (NET25). In the case of rare earths, processes are also being developed to extract the minerals in larger quantities and more efficiently (NET26). The chemical process uses a non-toxic ionic liquid to extract the rare earths from the coal and its combustion product, the fly ash. Trials of the process are underway in a number of countries, but mostly in the US and some EU member states.

Currently, a more serious problem is the disruption in the supply of liquid fuel components, which are more prevalent in space exploration than the various chip shortages. In recent years, several space programmes have become uncertain due to problems/obstacles in the supply of liquid oxygen and nitrogen. The launch of NASA's Earth observation satellite has been postponed to 2021 due to the lack of liquid nitrogen (NET27). Also, the issue of liquid oxygen supply constraints was highlighted by SpaceX during a presentation at the 36th Space Symposium on 24 August 2021 (Colorado Springs, CO). In addition to supply chain disruptions, unexpected situations, such as COVID-19, require a country or space company to be prepared for any eventuality to maintain the continuity of space travel.

Supply chains

Generally speaking, most of today's global economy is based on supply chains. By supply chain we mean when economic actors plan and organise their activities from the extraction of raw materials to the delivery of processed products, completed with services, to the consumer. At the heart of the supply chain is the process, Supply Chain Management (hereinafter SCM), whereby actors gain economic benefits in terms of profit or increased turnover. (NET28) The vulnerability of the supply chain in our globalised world is something we hear about almost daily. For this reason, many countries are paying particular attention to maintaining the resilience of the global supply chain. The OECD is constantly monitoring the functioning of global supply chains - and value chains – and making recommendations for their maintenance. The optimisation of supply chains is not new and the 2008 economic crisis was the most recent to draw attention to the need to strengthen them. Today, 70% of international trade passes through these supply chains (NET29). Supply chains must meet four main conditions: building trust, open markets, anticipating risk and minimising exposure (NET30). Maintaining supply chains is in the interest of all countries as it is the only way to gain access to certain raw materials or processed products. However, it can be argued that there are services along the entire length of the supply chain – including technology transfers – that can be of paricular importance

for a country with an abundance of raw materials to acquire.

GARTNER, a US-based consulting firm with thousands of experts in nearly 100 countries and a member of the S&P 500 US stock exchange organisation, regularly analyses the companies with the best supply chain management (NET31).

Table 11: Leading companies in supply chain management in 2022. Source: NET31

n	Companies	n	Companies
1.	Cisco Systems	14.	Wallmart
2.	Schneider Electric	15.	HP Inc.
3.	Colgate–Palmolive	16.	Diageo
4.	Johnson & Johnson	17.	Dell Technologies
5.	PepsiCo	18.	Inditex
6.	Pfizer	19.	BMW
7.	Intel	20.	AbbVie
8.	Nestlé	21.	Siemens
9.	Lenovo	22.	AstraZeneca
10.	Microsoft	23.	General Mills
11.	L'Oréal	24.	British American Tobacco
12.	The Coca–Cola Company	25.	Alibaba
13.	Nike		

Table 11 shows that the best-managed firms are still concentrated in Western countries. This is due to the way SCM principles are established and supply chains are designed. The concept of supply chains was used in the early 20th century, but SCM only emerged in the 1980s. Of course, one could go back to antiquity and perhaps a complex trade similar to today's supply chains can be found in the Roman Empire, which in the first 500 years of the 1st century AD already had hundreds of trading companies for the procurement of goods from Asia. But SCM in the modern era began with the African slave trade in the Caribbean, with sugar cane plantations. Then, in the 1920s, the advent of assembly lines and mass production – Ford factories – set the process in motion. In the second half of the 20th century, the US developed a system of standards and the advent of containers made warehousing and transport more efficient (NET32). This was followed by the emergence of technological and other software support, the use of which eventually spread to international trade and took the form we have today.

In the space industry, the SCM system was introduced by NASA in recognition of the need for the space industry to efficiently service the space missions planned above LEO. The essential elements of SCM are comprehensively concerned with (1) information systems; (2) mechanisms for materials, information, and best practices; coordinated with (3) adequate budget and funding (NASA, 2006, p. 1-3).

In the context of international cooperation, the assessment of the materials and information needed for space travel and the appropriate forecasting of data are of particular importance. In 2004, a report by the US Government Accounting Office (hereinafter GAO) provided the basis for a renegotiation of some of NASA's previous procurement and operational principles and the introduction of a more efficient SCM.

The origins of the tools and materials used in space exploration today are clearly linked to Earth. At the same time, space

conditions, such as the harsh environment, the transport of information and materials from Earth and the distance to be travelled, also lead space actors to use space materials in their missions. This would save considerable cost and time in repairing and replacing equipment and other supplies. In the 2010s, a new concept of Made in Space emerged, which adds new processes and principles to SCM and replaces the Earth-to-Space solution with the Space-to-Space solution, i.e. to produce what is possible not from Earth but from materials found in space, or at least to make the logistics of space assets launched more efficient. However, detailed knowledge of this remains to be gained. For the time being, the SCM model applied to the specificities of space has proved its worth, one example being Indian Space Research Organization (hereinafter ISRO), which used the system to organise its satellite programme. It has set a record, which still stands today, for the most satellites successfully launched in a single launch, 104 in all. Another example is China, which also carried out an analysis of the SCM model before implementing and coordinating the delivery of a multi-turn payload to its space centre under construction (Joel O. Wooten és Christopher S. Tang, 2018, p. 15).

Economic background

In my other publication "The Story of Space activities", the economic characteristics of each space-capable country have already been discussed, but given the fact that space travel is expensive, a more in-depth analysis of the economic background of each country is necessary. I will focus on the economic factor among the geopolitical factors and analyse the educational, corporate and governmental line related to the space industry as indicators, through selected economic details.

I have concluded that only the US, Europe, Russia and China need to be examined further, and the other countries are only referred to in the relevant section in addition, where necessary, to allow comparison of the data. I have focused mainly on China because of the close alliance between Europe and the US and the weakness of Russia's economy. China on its own is more economically important than the other countries, which sometimes face off against the West.

Over thousands of years, the economic structure has been completely transformed and the former agriculture and trade-based economy has changed. The primary barrier to the acquisition of wealth was the size of the land. This could be increased or lost in wars of conquest. Kingdoms grew from nothing and disappeared in the blink of an eye. Only the Industrial Revolution, which began in the post-Renaissance era, marked a major turning point. This started primarily in England, but it was the advent of machines and their spread across the European continent that brought about the real change. The size of the land was no longer so important, and by the middle of the modern age all countries were trying to industrialise. This was achieved to varying degrees. The industrial revolution continued to evolve as the methods and tools

used became more widespread and the new rules of production increased efficiency. By the end of the 20th century, we had reached the point where individuals were able to achieve the expected economic wealth without having to acquire land, even sitting in a room and working in cyberspace. Depending on the endowment, anyone can produce some know-how and other copyright products, regardless of land or industry. Of course, the minerals used and the wealth invested are an essential part of development, but the world has opened up to individuals. The same land no longer necessarily needs to be worked by hundreds of people, but each person is able to find work that is attractive to him or her in economic diversification. At present, the only limit to development is the organisational capacity of a society. The more economically diversified a country is, the more stable its economy (NET33).

The economic condition for a society can be achieved through individuals, for which the provision of adequate training and the presence of domestic and international companies in a given country are essential. Of the regions of the space-capable countries, only the study of China, Europe and the USA provides the comprehensive picture needed to identify future geopolitical conflicts. The other countries cannot compete economically with these three large areas/regions and their space industries lag behind. However, as a benchmark, each country remains a good example to determine how far a major power region is from another major power region.

Educational data

Table 12 shows which country(ies) have the highest number of universities in the world rankings. This analysis is necessary because of the high-tech applications in the space industry, as both the technical and the structural, social impacts are studied by academics, so it is essential to ensure proper education. There are many assessments that do not change much over the years, so looking at the top 100 universities, the UK and the US clearly have the 'world's knowledge' (NET34).

In terms of specific data, the only universities in the top 10 are in the UK and the US. However, if we look at the top 100 university rankings, we find that 38 out of 100 are "only" US universities, and the order is in Table 12.

The data in Table 12 show that the Western countries are clearly leading in science. Neither Russia, nor India, nor North Korea has an university recognised in the academic world that has made it into the Top 100. We can conclude that population numbers are not, but the GDP-to-GDP ratio is a better indicator/reflection of the scientific development of a country. Russia's first university in the world ranking is 150th, India's has been hovering around 300th for years (NET35).

In relation to the academic world, the following summary of Table 13 clearly illustrates in 2020 – later during the COVID-19 period, there were no

Table 12: The best universities in the world in 2022. Countries are ranked according to the number of universities they have in the ranking list. The number in brackets indicates the ranking of the first university. Source: NET34

Country (best position)	How many universities are on the list	First university in a given country
UK (1)	11	Oxford University
USA (2)	38	CalTech
Switzerland (15)	3	ETH Zürich
China (16)	6	Tsinghua
Canada (18)	5	University of Toronto
Singapore (21)	2	National University of Singapore
Hong Kong (30)	4	University of Hong Kong
Germany (32)	7	LMU Munich
Australia (33)	6	University of Melbourne
Japan (35)	2	The Univeristy of Tokyo
Sweden (39)	1	Karolinska Institute
France (40)	3	Paris Science et Letters–PSL Research University
Belgium (42)	2	KU Leuven
Netherlands (53)	7	Wageningen University & Research
South–Korea (54)	2	Seoul National University
Denmark (96)	1	University of Copenhagen

Table 13: Foreign guest students in 2020. Source: NET81

Country	Number of foreign students	Foreign students in total (%)	Sending countries
USA	1 075 496	5,5%	China, India, South– Korea
UK	551 495	22,3%	China, USA, India
Canada	503 270	23,7%	India, China, France
China	492 185	1,2%	South–Korea, Thailand és Pakistan
Australia	463 643	31,3%	Kína, India, Nepal
France	358 000	13,4%	Marocco, Algeria, China
Russia	353 331	8,5%	Kazahstan, China, Türkmenistan
Germany	302 157	11,7%	China, India, Syria
Japan	228 403	6,2%	China, Nepal, Vietnam
Spain	125 675	7,9%	Italy, France, USA

adequate statistics due to data distortion – that the West clearly leads the competition in terms of foreign students and that China is not such an attractive destination for developed countries (NET36). At the same time, based on Table 13, we can conclude that there is no country where China does not provide the most foreign students at the universities of a given country. Based on the analysis, it can be concluded that the educational attractiveness of the USA – also an OECD, Western country – is outstanding.

Economic companies

According to the data examined, both GDP and multinational companies play a significant role in the field of space industry. Space exploration is a multi-disciplinary field and the economic mechanisms related to it are also cross-border activities. Based on this, it is necessary to examine additional indicators of the economic factor, which help to understand the complex processes of space activities. In Table 14, I present the export of non-military aerospace and space-related equipment for the most significant export countries in 2022. Trade in aerospace equipment is a broader concept, but it also includes space equipment, and the two areas are interconnected (NET37).

Table 14: World trade in aircraft. Source: NET37

Country	Export value (in billion dollar)
1. USA	102,8
2. France	32,8
3. Germany	29,2
4. UK	13,2
5. Canada	10,1
6. China	5,6
7. Italy	5,6
8. Spain	5,4
9. Singapore	5,1
10. Brasil	3,0
11. Israel	2,3
12. Ireland	2,2
13. Netherlands	2,1
14. Thailand	2,01
15. Turkey	1,99

Table 14 shows that the US alone exports almost as many aircraft as all countries in the world. There are nearly 100 countries that are linked to the space industry by some means (not necessarily their own). In aircraft industry, China lags well behind the OECD countries and Russia is not even in the top 15. Both have to compete with small countries like the Netherlands or Ireland. World trade in aerospace products is clearly controlled by countries in the West (including the EU). As a complement to the above, I have analysed the world's 100 largest air companies by revenue in 2019. Among these, India, China, Taiwan, Russia, Turkey, Italy, Sweden, Spain have 1 to 1 company, while South Korea, Belgium, Norway, Switzerland and Israel have 2 to 2 companies, Japan has 4 companies, France and Germany have 10 to 10 companies, and the US, Canada and the UK have the remaining 60% (NET38). Of particular interest, in addition to the above, is the global distribution of space companies, i.e. the existing 10 000 companies in 2021 (NET39). Table 15 is based on firms directly involved in the space industry, other occasional or ancillary space exploration firms are not included.

Table 15: Distribution of space companies by country in 2021. Source: NET39

Country	Number of space companies
1. USA	5582
2. UK	615
3. Canada	480
4. Germany	402
5. India	368
6. China	288
7. France	269
8. Spain	206
9. Japan	184
10. Israel	179
11. Australia	177
12. Netherlands	161
13. Italy	111
14. Sweden	109
15. Switzerland	98
16. Singapore	97
17. Brasil	94
18. Ireland	82
19. Belgium	77
20. South–Korea	61
21. Russia	56
22. Finnland	53
23. Turkey	49
24. Poland	48
25. Norvegia	48
26. Denmark	47
27. UAE	41
28. Czechia	40

Based on Table 15, I have reaffirmed the conclusions reached for air exports and the number of air companies that OECD countries, including Western countries, completely dominate the space space exploration space reserved for private industry. China and Russia also have to compete with countries that are much smaller than them and also have lower

GDPs. For the above, it is necessary to analyse the budgets of the main space-faring countries, for comparison in 2020 and 2022 (NET40 and NET41). The amount each country spends shows the extent to which it is developing its space capabilities.

Table 16 shows that, in addition to the US – which alone spends almost $62 billion of the $103 billion spent by countries – Europe's space economy has advantages that any other country would struggle to match. But it is not just the economic fundamentals that are more solid in the US and Europe, the costs of carrying out space activities are also outstanding. At the same time, the US develops and achieves much of its technological achievements on its own. More than half of the space companies currently operating are based in the US.

Table 16: Space industry spending in 2020 and 2022. Source: NET82

Country	2020 (in billion dollar)	2022 (in billion dollar)
ESA	4,87	7,15
EU	2,57	2,60
USA	54,59	61,97
Russia	3,57	3,42
China	10,29	11,94
India	1,96	1,93
Japan	4,21	4,90
Germany	2,38	2,53
Germany	3,95	4,20
Italy	1,48	1,74
UK	1,46	1,15
South–Korea	0,68	0,72

China is more in competition with some EU Member States, as well as Canada, Japan and India. Notable is China's economic GDP base, which is several times the annual GDP of some EU Member States, Japan or India. Also it can be concluded that China has a very high population ratio, which implies a lower GDP per capita. The US, as the world's largest economy, accounts for 1/4 of China's population, and the EU, as the world's second largest economy, for 1/3 of China's population, as the world's third largest economy. The EU, given its organisational – intergovernmental – nature, is not usually considered as a potential challenger to the US, but its economic strength is seen to outweigh China's. At the same time, it also highlights the fact that China, when confronting the West, should take into account that the EU agrees with the principles of the US and is clearly an ally of the US.

In 2021, five countries accounted for more than 2/3 of GDP (Germany, Italy, France, Spain, the Netherlands – NET42) which, when added to four other countries, gives us 4/5 of the EU's GDP (Poland, Sweden, Belgium and Austria). It should also be noted that 12 countries (Luxembourg, Croatia, Greece, Malta, Hungary, Bulgaria, Estonia, Latvia, Lithuania, Slovakia, Slovenia, Cyprus, Luxembourg and Malta) account for only 1/20 of EU GDP (NET43). However, it is also worth noting that the UK, which has a GDP of USD 2 707 billion, was the second largest in the EU before its exit. However, the UK is still an ESA member state.

On 29 June 2023, the Space Café "Highlighting the Vital Drivers that Strengthen and Maintain Europe's Future

Sustainable Position in Space" (Moderator Torsten Kriening indicated to the participants, including the representative of the European Commission's European Innovation Council and SMEs Executive Agency – EISMEA – Stela Tkatchova) hosted by event management company SpaceWatch Global, reported that Europe overtook the US in total space investment in 2022 and was already the second largest space economy in 2021 (NET44). My research has confirmed that Europe is a force to be reckoned with, ahead of China. Following on from the above, I have introduced a series of data that is not just a benchmark, such as GDP or other indicators, but a measure of a country's expenditure coverage. This is the amount of government revenue. Depending on GDP and the economic structure, each country has different revenue and other economic indicators may give the wrong conclusions about the economic strength of a country (NET45). No more recent data than 2021 is available for all three columns of Table 17, but the relationship between countries can be justified and the GDP figures for 2022 have not caused any change.

The data in Table 17 shows the revenue side, the most important side of the states' budgets. The GDP ratio is a good measure of a country's growth relative to other countries, but it does not give an accurate picture of the amount of money a country is 'living on'. By contrast, income is an exact figure that a country spends to cover its expenditure and maintain its society and decide how to fund space programmes.

Table 17: Government revenues as a percentage of GDP in 2021, by country. Source: NET83

Country	Sum of income (in 1000 billions dollar)	GDP (in billion dollár)*	GDP proportionate income (%)
USA	7 336	23 320	31.46
France	1 557	2 960	52.62
Japan	1 796	5 010	35.86
UK	1 151	3 120	36.89
Spain	625	1 430	43.73
Italy	1 023	2 120	48.27
India	635	3 150	20.16
China	4 726	17 760	26.61
Germany	2 025	4 260	47.53
Russia	676	1 840	36.73
South–Korea	467	1 810	25.82
Brasil	520	1 650	31.53
Canada	819	2000	40.96

*** Source: NET46**

The data shows that the US has the highest revenue of all countries. My findings so far are further supported by the fact that the leading countries of the EU are more economically powerful than China and if we look at the data at the level of OECD countries without the US, we have to conclude that in terms of economic power, Germany, Italy, France, Japan, Canada, Spain, South Korea and the UK together are even more powerful than the US. China and Russia together are also up against a group of countries with four to five times as much public revenue in economic terms. I have not included the other European countries in Table 17 (Benelux, Austria, Switzerland, Sweden, etc.), but their economic strength would only widen the gap to China's disadvantage.

At the same time, China's economic recovery is leading the way for other Asian countries, notably India, which is projected to be a force of similar magnitude. Over the next 20 years, both China and India will achieve GDP output at domestic purchasing power parity (the value of domestic currency relative to the dollar, taking into account different prices between countries) that will already equal or exceed the amount of US GDP (John Hawksworth, Hannah Audino és Rob Clarry, 2017, p. 6).

Multinational enterprises

Thanks to the high GDP figures, China is the country most keen to take on the US in the economic race. Therefore, in the following subsection, I have analysed data typically related to China. There are many ways to look at the internal structure of an economy, in this case I focused on international companies, including multinationals, which have the international knowledge to make a country's economy more conducive to the pursuit of space activities. Due to the sensitivity of the topic, there is a paucity of literature available. This sensitivity was supported by the presentations made at Moody's Investor Service's webinar "Proposed Updates to Government-Related Issuers Methodology – Request for Comment" held on September 11, 2023 (NET47). In the presentation, countries were analyzed according to the government involvement of each company within the country. Only the methodology was presented, as the information is only available for a financial fee. By the way we have to put our focus at the age before Covid and the war in Ukraine to avoid the distortion.

First of all, it is worth clarifying what a multinational enterprise (hereinafter MNE) is (NET48). Exactly how many multinationals there are in the world varies according to different surveys. Depending on the analyst, the MNE designation may require a parent country to have an ownership stake of over 25% or 50% in the subsidiary in order to be defined as a national of that country. Multinational companies are expanding for a number of reasons. Their primary objective is to conquer the free markets in other countries. This not only increases their revenue side, but also allows them to learn about other countries' economic methods

and processes, as well as their legal systems. In particular, they can also attract the skilled labour force of those countries to their own ranks, which, if necessary, increases the strength of the parent company. Of course, knowledge transfer works both ways.

China really opened its doors in 2001 with its accession to the World Trade Organization (hereinafter WTO), which marked a turning point in its economy (Md. Salamun Rashidin, Sara Javed, Lingming Chen, and Wang Jian, 2020, p. 2). Comparing Chinese firms with their US competitors reveals a stark difference. China is selective in the countries to which it allows business companies to expand, and far from cooperatively. Chinese firms are reluctant to deal with foreign governments, unlike US firms (Md. Salamun Rashidin, Sara Javed, Lingming Chen , and Wang Jian, 2020, p. 15). China continues to send its multinationals abroad under the control of the central government, whereas the US creates companies that operate independently, are integrated into the economy of the country and maintain close links with the host government system. The primary objective of a country's government is survival and only secondarily development. In contrast, a civil capitalist enterprise is based on constant adaptation and dynamism. Thus, where such development exists, the government is able to constantly renew itself and does not confront its own economic elites.

Although China is very different from the US, it typically tries to integrate the rules of foreign companies. HR policies that are important for employees have been gradually adopted by Chinese companies, ensuring continuity of development and maintaining their competitiveness (Fabian Jintae Froese, Dylan Sutherland, Jeoung Yul Lee, Yipeng Liu, Yuan Pan, 2019, p. 8). As part of the learning process, the transfer of skilled labour from international firms to Chinese firms and the acquisition of knowledge and management methods through joint international firms as Chinese capital invested domestically started after 2010 (Fabian Jintae Froese, Dylan Sutherland, Jeoung Yul Lee, Yipeng Liu, Yuan Pan, 2019, p. 9). However, Chinese workers have a dual image. On the one hand, a significant proportion of them are located in foreign - typically Western - companies and, on the other hand, they find it difficult to tolerate or accept not being able to work independently. However, this is not a matter of creative freedom, but rather the opposite: they do not like to be monitored, held accountable or otherwise subjected to any form of monitoring of their performance (NET49).

China's productivity is 30% of the world level and within this, the productivity of state-owned firms is lower than the contribution of the private sector. Domestic debt is 300% of GDP, but China is an ageing society, with the consequence that the active labour force will shrink by 20% by 2050. (NET50) In China, well after its accession to the WTO in 2008, the export exposure of foreign (Western) firms was 50%, a ratio that

includes the 80% foreign share of the more sophisticated IT sector. (NET51) The average foreign share was 58.3% in 2005, falling to 34.3% in 2021. Even Henry Kissinger in 2011 believed that the US should not allow China's economic and political expansion. It is fortunate, however, that all Chinese leaders are aware that China owes its rise to the economic and political environment provided by the US and Western Europe (NET52).

Looking at Chinese state revenues, it can be seen that China does not only live off the taxes it collects from domestic and international companies, but also owns 39% of state assets, 23% of its domestic business revenues and 18% of its industrial production revenues through companies under strong central government control (Chunlin Zhang, 2019, p. 10). The best deals in China are done, albeit indirectly, by the state.

As regards the role of multinationals, the data on economic linkages in a given country show that the US has 1 192, Germany 850, France 457, Japan 448, Switzerland 365, the UK 351 and the Netherlands 330 outward-looking linkages. These countries – all of them – account for 93% of outward linkages and are also home to the largest multinational companies (R S Wall, M J Burger, G A van der Knaap, 2011, p. 912-913). On the other hand, the host countries US, Canada, Germany, France, China, the Netherlands, Spain, Australia and Italy cover 50% of inward contacts. Other, potentially poorer countries also attract capital, but not to the same extent as the above countries. Of particular note is that 45% of international trade is covered by 1% of country pairs (bilateral relations), i.e. these countries trade the most with each other and have the largest share of international trade. These are Germany-USA, USA-Canada, USA-UK, Japan-USA and USA- Germany (R S Wall, M J Burger, G A van der Knaap, 2011, 912-913).

These figures are confirmed by the OECD survey, which shows that in 2014, 93% of multinational companies' production is controlled by OECD countries and 3% by BRICS countries. The OECD defines a multinational corporation as an international grouping where the ownership or voting share is equal to or above 50% – i.e. narrower than 25% – in a given company. (NET53) Based on the fact perhaps these details are expired, so I have to analyze other data about the international trade. If we study the top100 non financial companies around the world we can state, that BRICS countries are represented only by China with its 10 companies. Taiwan and Hong Kong are ont he list but I could not consider them as the part of BRICS. With an except of 2 out of 9 chinese companies take place in the last fifth of the list regarding the Transnationality Index (hereinafter TNI, examining asset, sale and employment proportions to foreign and in total) score (NET54). China has a share of 7% in foreign sale and of 8% in foreign assets. The substantial part of the foreign sale and asset belong to OECD and Hong Kong, Singapore, Saudi-Arabia and Taiwan. The higher TNI scores are particularly pos-

sessed by small western countries. Further narrowing the time gap, I analyzed the digital MNE companies. In 2022, the US leads the group with its share of 59% followed by other developed countries with a share of 32%. China owns its 4% and other developing countries contribute to it with their 5% (Claudia Trentini, Joao de Camargo Mainenteb and Amelia Santos-Paulin, 2022, p. 173). We can find that the development of BRICS during 10 years is slow. It is hard to make a comparison among the years because of the changing methodology. The consideration of the ownership or voting share of 25% or 50% in the MNE is changing and it is not decided sometimes. But we can follow the trends on it. We have to differ the control of production from the output in a case of a company or country. MNEs may produce their products for export or import, manufacturing or servicing, which are to be considered in comparison by you.

According to OECD data, multinational companies account for half of world exports, a quarter of employers and almost a third of GDP (In Song Kim & Helen V. Milner, (2019), p. 2). Let us now look at the top 2 000 multinationals (NET55). If we compare Table 18 with the previous ones, we can see that OECD countries have a much higher degree of control over the management of multinational companies.

Looking at the more than 2 000 multinational companies, the US, Japan and Western European countries are the most likely to be headquartered there (NET56).

Table 18: Space industry spending. Source: NET55

Headquarter	pcs	Ratio to total %
USA	719	33
Japan	264	12
China	219	10
UK	118	5
India	81	4
France	70	3
Australia	66	3
Canada	60	3
Germany	58	3
Switzerland	48	2
Other countries	487	22

Furthermore, taking into account the market value of multinational companies, it can be seen that in terms of value, US companies account for 44% and European companies for 22%, while Chinese companies account for around 10%, Japan for 7%, Canada and Switzerland for 3-3% and India for 2% (NET57). This figure also shows that China's competition is far from the US, but rather Canada, India, Japan and the EU.

To fully understand the above, we need to know which countries China trades the most with. This is necessary because, in addition to technology transfer, these countries or regions have the greatest influence on the Chinese economy (NET58 and NET59).

Of course, as Table 19 shows, there is also evidence of China's dependence on the US and the EU for economic purchases – as China's largest trading partners –

Table 19: China's foreign trade 2020 and 2021. Source: author's own editing based on data from the National Bank of China and OECD cited in the text

Country vs. regional / in billion dollar	Export		Import	
	2020	2021	2020	2021
USA	418	530	122	151
EU	383	473*	202	223**
Hong Kong	279	323	90	138 ***
Japan	143	168	171	153
South–Korea	110	140	173	158

*** in 2022: 626 (NET60)**
**** in 2022: 230**
***** Ausztrália**

but it is important for all countries to maintain relations with China. At the same time, each country acts more as a buyer than a seller, so it is reasonable to conclude that China is in a vulnerable position.

The disruption of trade relations with China by the US and the EU could lead to a sharp decline in China's GDP and irrecoverable losses in the medium term. This will not happen because of the exposure of other countries until China's position can be replaced by Asian countries or possibly European countries with similar (labour and productivity) capabilities. In addition to the countries of South East Asia, this could include Ukraine. These countries are not yet able to develop the Chinese manufacturing capabilities, but a parallel economy can be built in the medium term.

To give an example, Apple Inc. in the US used to manufacture 85% of its products in China, but due to the COVID-19 treatment in China and other internal governance issues, Vietnam and Thailand are also targets for new manufacturing relocation. This was confirmed at the NIKKEI FORUM webinar "Untold Story of Chip War" held on 20 July 2023, where the role of these two countries was highlighted and the relocation of Apple Inc. factories has already begun. However, the long-term plan of Apple Inc. is to manufacture 40-45% of its products in manufacturing facilities in India. Further, on 16 August 2023, the Economist Intelligence Unit in its "Business Environment rankings 2023-2027", looked at countries from a business perspective and clearly North America and Western Europe were the best places to invest. Several South American and Asian countries were ahead of Russia and China. Vietnam and Thailand made the most significant improvements, coming in first and China lagging the furthest behind (NET61).

China's GDP also includes a large proportion of data that is necessarily generated in China but is not actually produced in China. To use Apple's example, China is not the sole producer of the devices, but there are over 200 sourcing points for accessories and other accessories, but the supply chain ends in China. The significance of this is that while China earns around $8.5 – 3.6% of the cost of the Taiwanese company Foxconn, which sells Apple products in the country – on a $650 Apple device, South Korea earns double that, while Taiwan earns six times as much, the US and Japan eight times as much and Apple itself 30 times as much (NET62). Apple exports to the US account for 5%

of the value of Chinese exports. The products increase Chinese exports at the border and account for $650 of the country's GDP, up from $8.5. Similarly to the above example, looking at a specific Chinese brand, we can say that after WTO entry, the Chinese Lenovo laptop brand was developed with the joint help of US Microsoft and IBM following the establishment of foreign firms in the IT industry (NET63). The Taiwanese company Foxconn, which also sells Apple products, accounts for 3.9% of China's exports (NET64).

The above data is supported by the OECD's regularly published Global Innovation Index (GII), which looks at the drivers of development in a country and ranks the top 20 countries as follows: (Soumitra Dutta, Bruno Lanvin, Lorena Rivera León and Sacha Wunsch-Vincent, 2023, p. 19): 1. Switzerland 2. Sweden 3. USA 4. UK 5. Singapore 6. Finland 7. Netherlands 8. Germany 9. Denmark 10. South Korea 11. France 12. China 13. Japan 14. Israel 15. Canada 16. Estonia 17. Hong Kong 18. Austria 19. Norway 20. Iceland. However, it is worth looking at the calculation of the 2022 index, in which the OECD includes the Chinese subsidiary of Taiwan-based TSMC among the largest intangible asset holders in the definition of Chinese innovation (NET65). So the index also looks at firms that include innovations from foreign-owned firms. This is supported by my research using an additional index in Table 20 on the complexity of countries' economies. This index is the US Economy Complexity Index (ECI), which measures the complexity of a country's economy through trade, technology and scientific research (NET66; see Table 20).

Table 20: ECI indicator. Source: NET84

n	ECI Trade	ECI Technology	ECI scientific research
1.	Japan	Sweden	USA
2.	Switzerland	Germany	UK
3.	Taiwan	Austria	Canada
4.	South–Korea	Finnland	Australia
5.	Germany	Italy	Netherlands
6.	Singapore	Norvegia	Switzerland
7.	Czechia	France	Sweden
8.	Sweden	Turkey	Germany
9.	Austria	Spain	Belgium
10.	USA	Switzerland	Israel
11.	UK	Canada	Italy
12.	Slovenia	Brasil	France
13.	Finnland	Australia	Spain
14.	Hungary	UK	Norvegia
15.	France	Belgium	Denmark
16.	Slovakia	Netherlands	New–Zeeland
17.	Ireland	Russia	Finnland
18.	Belgium	Czechia	Ireland
19.	Italy	Denmark	Austria
20.	Israel	Poland	Brasil
21.	Hong Kong	Japan	South–Afrika
22.	Netherlands	India	Hong Kong
23.	Mexico	Saudi–Arabia	Chíle
24.	Malajsia	south–Afrika	Jamaica
25.	China	USA	Turkey

The main finding of the application of the index, created a decade ago by professors at Harvard University and MIT, is that a country that is ahead in trade and behind in the other two indices - technology and scientific research - explains why most innovation in products for export is not the domestic result of the exporting country. However, this does not prevent a country from achieving economic growth, i.e. the size of trade can mask technological disadvantages (NET67). The superiority of the OECD countries is clear, and Table 20, which rates the Hungarian economy as

superior in complexity, suggests that, given Hungary's economy is economically based on foreign working capital, China is the world's supplier, not the world's economic engine. Not ignoring, of course, the fact that if China inadvertently (COVID-19) or deliberately puts the brakes on its economy, the world economy will slow down with it. But this is a quantitative and not a qualitative constraint, which can be mitigated by diversification. Just as any small country has the leeway to create geopolitical conflicts, a country with a much larger economy and population as China has enough space for manoeuvre on the world geopolitical map.

The above gives a clearer picture of why it is so important for China to acquire Taiwan, which is one of the world's leading chipmakers alongside South Korea, Japan and Singapore. However, if we look at the background of the management team at Taiwan's TSMC, one of the world's most sophisticated companies, we notice that only 8 out of 32 managers have a non-OECD background (NET68). On 22 June 2023, I participated in the Economist Intetlligence Unit's webinar "ASEAN", where the above was confirmed by Dexter Thillien and analyst Laveena Iyer on China, that firms in China are looking for a new "home" and that the Chinese technology gap with the US is significant (NET69). Furthermore, it was clearly stated that the Association of Southeast Asian Nations (hereinafter ASEAN) countries are also dependent on Taiwanese chip production and would be significantly affected by any Chinese aggression (ASEAN countries: Vietnam, Philippines, Malaysia, Thailand, Brunei, Myanmar, Laos, Cambodia, Singapore and Indonesia). The ASEAN countries' trade balance with China is almost identical to the EU's, which also underlines the Chinese exposure and the uncertainty of how each country would react to Chinese export-import relations in the event of a conflict (NET70). On 19 September 2023, the ASEAN countries held their first autonomous military exercise in the South China Sea, several times with the participation of the US (NET71).

The particularity of ISO

The ISO (hereinafter International Organization for Standardization) system is a key element of the world's economic engine. As a result, there is a trade in products, processes and methods that are created and disseminated according to the same principles. This common point helps a country to disseminate its results to other countries and economic operators through the use of the product, process or method it has developed. It is undoubtedly a sign of economic dominance, which I also referred to in the previous subsection "Multinational companies" in the analysis of the ECI indicator exports. Participation in the international recognition of the ISO standard is a clear indicator of a country's high-tech development, which is also in direct proportion to its space industry development. Of course, I have focused my analysis on China, but I have also identified other countries that have made significant progress.

Since the 2020s, China has been continuously increasing its performance in the field of standardization and is trying to switch from abandoning Western standards to developing its own standards (You-hong Yang, ping Gao és Haimei Zhou, 2023, p. 2). With China's accession to the WTO in 2001, it adopted all the legislation that facilitated the development of international standards requirements in the country. In its comprehensive plan for national standards from 2016 to 2020, China specifically highlighted the need to encourage domestic companies to co-operate with foreign companies and be key players in the development of national and international standards (You-hong Yang, ping Gao és Haimei Zhou, 2023, p. 3). However, until 2015, China continued to adopt Western standards and develop similar standards. After that, a significant independent development of Chinese standards began under the Intellectual Property Rights (IPR) as its own intellectual property. The Chinese government subsequently relaxed state regulation and is now more permissive in allowing Chinese companies to rely on the benefits of their own technological and organizational development rather than state control (You-hong Yang, ping Gao and Haimei Zhou, 2023, p. 12).

ISO has established thousands of technical bodies, known as International Standards Developing Organizations (hereinafter SDOs), to decide on the introduction of new standards. These are made up of experts from all over the world. Of the 39 technical SDOs, the US holds at least 50% of the votes in 11. However, the participation of 9 countries (US, Germany, Japan, Canada, UK, France, Italy, South Korea and China) is the most significant (Giulia Neaher, David A. Bray, Julian Mueller-Kaler és Benjamin Schatz, 2021, p. 10-11). ISO currently has 168 member countries (NET72). The US, Western Europe and Japan develop the most international standards. (NET73) In 2022, there were 24,000 international standards in force, of which 95% were from the three countries and regions mentioned above and less than 0.7% from China. (NET74) However, China uses the most international standards (NET75).

In Table 21, I have taken the two most important standards and their spread as a basis (NET76).

Table 21: Use of international standards ISO 9001 and ISO 14001 by country. Source: NET76

Countr	ISO 9001 Quality Management Systems (pcs)	Countr	ISO 14001 Environmental Management System (pcs)
China	426 716	China	217 592
Italy	92 664	Japan	21 976
Germany	49 298	Italy	18 135
Japan	40 834	UK	17 378
UK	39 682	Spain	14 122
India	36 505	India	9 275
Spain	31 318	Germany	9 256
USA	25 561	South–Korea	6 886
France	21 918	France	6 392
Brasil	16 268	Romania	6 174

Based on Table 21 and this sub-chapter, I have found that China uses standards from Western developed countries for its

products and processes and does not yet have autonomy in setting international standards. The functioning of the established international practice is exemplified by China's attempt to take the lead in 3G technology deployment prior to the 2010s. With state funding and strong commercial support, TS-SCDMA was intended to take the lead from other international telephone networks. However, it soon realised that it could not exclude other international networks, otherwise its own network would not function properly outside the country. The TS-SCDMA system was developed by the German company Siemens. végezte. (NET77) It was also the period when the Western smart phones appeared and the telecommunications sector took off. However, China has adapted well and today has developed world-class 5G technology.

Findings

It can be concluded from the above that there is no current or foreseeable situation that could make a country independent of the global supply chain. Only regions or groups of countries - closely linked - where both the raw materials and the human and technical resources are available, would be able to do so. However, it also needs the right political establishment to cooperate and to distribute goods, forces, tools and technologies in a proportionate way. All these conditions are difficult to achieve within a single region.

As far as minerals are concerned, it is in the interest of every country to share its mineral wealth with others, as no country is clearly self-sufficient in this area. Everyone needs to import some kind of mineral, being it for the space industry or any other industry (NET78). At the same time, it should be stressed that it is not the existence of minerals that is desirable, but their availability in the right way, i.e. the continuous supply of minerals. The data show that, in addition to mineral reserves, human knowledge, i.e. the understanding and development of technology and management principles, plays a more important role. It is also necessary to distinguish, for each country, that mineral extraction is not the same as available mineral reserves or unexploited reserves. I have shown that even the country with the largest reserves does not automatically achieve "autarchy", as the need for minerals used may not even reach the reserves available for use. We do not need as many resources as we have.

It has been confirmed that it will not be and cannot be vulnerable to China, the main rival of the US, which currently leads the space industry, in terms of EEE components and rare earths. In the event of a possible disruption of the supply chain, countries that import and export large quantities of these materials will be at a disadvantage, according to their specific characteristics, based on the principle of feedback. The current disruption of supply chains is not an unique phenomenon and not the first time it has been faced at global level. China is still far behind the technological development that would allow it to become fully self-sufficient, combining its mineral reserves with technological

sophistication. The distribution of mineral resources presented does not make China a major influencing factor, as other countries have enough mineral resources to sustain their space industries. At the same time, the technological superiority to ensure the continued development of the space industry is fully available in the Western federal system. Neither India, nor China, nor Russia can be independent of this if they wish to secure the highest level of development in the space industry.

The data analysed show that the main rival, China, is far from competing with the US, but rather with the "smaller" countries of Asia and Western Europe. Accepting the fact that the use of mineral resources is based on economic considerations, China receives substantial help in technology imports from developed countries in exchange for cheap raw materials. It is precisely the export of raw materials that makes it more dependent on Western countries and unlikely to become self-sufficient in the coming decades to the point where it can reach the minimum level necessary to maintain competition. If it were to become self-sufficient and continue to operate solely with its own technology, we would have to conclude that it would have to expect a less developed space industry, which would not be in line with the goals it is pursuing and has already announced. Furthermore, we must not forget that the seabed is home to an invaluable reserve of raw materials, the extraction of which is regulated by the UN Convention on the Law of the Sea and Article 11 of the Convention (No 24/2008 (10.II.) on the proclamation of the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea) and the International Seabed Authority is responsible for the legal tasks associated with this (Pászka, 2014, p.205). However, if necessary, any major or regional power could, presumably arbitrarily, start extraction.

I have shown that China's role in the space industry is very far from that of the US, but its size means that it can keep up for a long time. Presumably, the reason for the continued US attention is more to do with China's unity and unpredictability. China's emergence under one overall administration is more of a threat than a competitor. In the future GDP comparisons, both China and India will be significant forces on an internal purchasing power parity basis, both exceeding the sum of US GDP. However, domestic purchasing power only provides the necessary economic advantage if a country can produce the goods it needs. If it engages in international trade and purchases foreign goods, its internal purchasing power becomes a handicap and the foreign currency becomes the benchmark again. However, internal purchasing power parity does not matter if only local goods are cheaper and quality foreign goods remain expensive, and the price of local quality goods is brought on a par with foreign goods.

Thanks to its opening-up policy, China was able to engage in international trade and has been dependent on Western countries ever since. China's exposure to

the EU and US still implies that it is not an economically independent country. It is much harder for China to find solvent countries for its products than it is for the US or European markets, which are even more comfortable with the current situation, to find a source of supply similar to China. At the same time, this economic dependence offers China the opportunity to avoid facing any future crises on its own and to continue its development. Western countries will also use their full economic strength to help China maintain their own markets.

The clear conclusion from economic data and the number of educational institutions is that China and other countries cannot compete with the main European countries, including the UK. The competition is not really the US, but individual countries in Europe that, individually or together with their regional neighbours, have the quantity and quality of knowledge that puts them above China or other non-OECD countries. Knowledge transfer is also a one-way street, with Chinese citizens taking knowledge home from universities in Western countries. Nevertheless, China's capacity for development is not negligible, but without adequate US and European support it will be difficult to sustain. The opening up of China's markets, the emergence of Western standards and the transfer of technology to the country have given China the opportunity to use its geopolitical position to follow the path of the developed countries, but at the same time it is limited in its development by the need to remain within a complex economic system.

The appearence of Chinese standards is a clear sign of progress. But China still has competition from some European countries or Japan before it can match the US. At the same time, despite the fact that state pressure on private companies is still considerable, the emerge of private companies' research incentives and of their own standards, alongside state control, are clear signs of democratic relaxation. A similar situation was seen in the second half of the 20th century, when Japan further developed its democratic institutions and promoted the development of entrepreneurial freedom. This was a prerequisite for progress above a certain level. At the same time, the examples of Russia, Iran and North Korea suggest that, with state control, any country may be able to organise space activities, but that above a certain level, economic underdevelopment prevents its development or, if it does develop, it has to draw the necessary funding from other parts of society. The space industry and space science are more diverse than the construction of a satellite or a rocket to bring any country up to the level of advanced space-faring countries. The weakness of the economic background hinders the performance of space activities at a certain point – country-specific – and prevents the widespread exploitation of the results achieved in space activities. At the same time, space exploration has created a new economic area which, alongside the 'traditional' economy, offers all countries new contacts

and new investments, while at the same time helping to turn unnecessary conflicts into economic competition.

Since the space industry involves costly development by the private sector and funding from the public budget, I have shown that China's economic base for its space industry is significantly below that of the US and could be more in competition with the EU, but has not yet been able to reach this level. The number of countries on Earth is large enough, and the size of their territories also provides ample opportunity for any economically expanding entity to increase its trade relations. In the 21st century, an area is not necessarily covered exclusively by one power without leaving room for another.

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