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BULLETIN

A Technological Arms Race: Chip Manufacturing

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The supply gap in the chip market caused by the COVID-19 pandemic has highlighted the chips' growing role in the global economy, as well as in international relations. Countries where chipmakers are headquartered are restricting exports of this good, and the competition for access to these products has opened a new phase in the technology race between China and the U.S. Currently, the U.S. is emerging victorious, significantly limiting China's ability to modernise. The European Union plans to cooperate with Taiwan and the U.S. on chip supplies and is working on production technology.

Chip Manufacturing. Semiconductor chips are materials that, depending on their use, have the properties of an insulator or a conductor (most often made of silicon, germanium, or gallium arsenide). They are widely used in the economy in computers, transmitters, and other electronic devices. With the development of the Internet of Things (IoT) and the computerisation of things, chips have become indispensable in the manufacture of cars, home appliances, production machinery, as well as modern military equipment.

Chip manufacturing requires specific standards of precision and sterility, as well as an extraordinary level of automation. Therefore, chip factories are highly capital intensive, with the cost of the most advanced plants about $15-20 billion. As well, construction time is several years and the break-even point is at the level of sales of hundreds of millions of units per year. Moreover, the factories must be located near large water reservoirs, since the production processes require the use of tens of millions of litres of specially treated water per day.

Most of the chips are purchased by American technology companies, but production takes place mainly in Asia—as much as 83% of the market is held by Taiwanese firms (including 54% for just one, TSMC) and South Korea (mainly Samsung), while American (Global Foundries) and Chinese (SMIC) companies have only a few percent market share. In the case of the EU, it is around 10%, but it is spread over many smaller companies. Only TSMC can produce chips with 3 nm technology (in 2025 it plans 2 nm), the most advanced (logic) chips used in, for example, devices with artificial intelligence (AI). South Korean companies are leading the production of simpler (memory) chips in 5 and 10/7 nm technology, also produced by the U.S. and EU. China, on the other hand, produces older generation 22/20 and 16/14 nm chips. However, each manufacturer uses equipment, including lithography machines, produced by U.S., European, and Japanese companies. Companies from these countries are also responsible for most of the processor designs used in the factories.

With each passing year, global demand for semiconductors is growing faster than production capacity. This trend accelerated as a result of the COVID-19 pandemic and its aftermath, such as increased demand for electronic communications equipment, disrupted supply chains, limited transportation and factory operations, rising prices for silicon, which is also used in the production of vaccine vials, and the rapid recovery of the automotive industry. In addition, this situation coincided with the worst drought in Taiwan in 56 years. The chip shortage that followed cost the global economy hundreds of billions of dollars and highlighted existing interdependencies between countries, including Taiwan's role.

US-China Rivalry. The beginning of the U.S.-China rivalry in the technology sphere took place in 2017 with the launch of a campaign targeting Huawei and the company's 5G systems. The aim of the Trump administration's protectionist measures was to cut off the Chinese company from high-tech chips and Western markets. In June this year, President Joe Biden, continuing the policy of his predecessor, banned U.S. entities from investing in 59 Chinese companies, including the manufacturer of SMIC chips, previously already subject to

sanctions. At the same time, the U.S. is putting pressure on allies to take similar action.

In China, for which technological independence is a main goal, chip production is underdeveloped. It meets only about 30% of demand. In the case of more advanced chips, the country remains entirely dependent on technology from foreign manufacturers, and will remain so for at least a decade because it will probably take that long to develop their own production technology in 3 nm. If supply problems persist, the development of projects such as "Made In China 2025", "China Standards 2035", or the Digital Silk Road will be threatened. Therefore, in response to the situation, China has announced that it will allocate additional resources ($200 billion) to domestic production.

When it comes to semiconductors, however, the U.S. and China are closely linked. Mainland China accounts for more than half of the world's silicon and germanium production and is the main location of factories of manufacturers from other countries. On the other hand, U.S. technology companies' opportunities for further growth are closely tied to expansion into the Chinese market. For this reason, these companies put pressure on the U.S. administration, which often results in relaxed regulations or exemptions. Some companies circumvent the restrictions by establishing joint ventures with Chinese partners.

Other Actors. Key to the U.S.-China rivalry remains technological leader Taiwan. Pressure from the U.S. to restrict chip exports to China is yielding moderate results. TSMC has decided to build a new processor factory in Arizona, as well as to relocate some factories from China to other countries, including the U.S. despite the lack of a rational economic basis for this action. Opportunities to reduce China's dependence on Taiwan are limited. TSMC's factories in China produce only less-advanced chips, making nationalisation unprofitable. Economic pressure could lead to restrictions on chip exports, and military action could lead to a complete cut-off of China and the rest of the world from the most advanced chips. China is therefore left mainly to attract human capital, particularly TSMC engineers, by offering them many times higher wages.

In the competition for semiconductor production, South Korea is active, planning to allocate $450 billion for its development over the next 10 years. It is particularly tied to the Chinese market, which accounts for about 30% of its exports, making it unlikely that the U.S. will persuade it to restrict chip exports to China. At the same time, like Taiwan, South Korea plans to invest in semiconductor production in the U.S.

The United States can also count on the support of some EU allies, such as the United Kingdom, and Japan. Already in the past, at the request of the U.S., the U.K. applied restrictions to Chinese companies working on 5G technology, while the Netherlands blocked exports to China of lithography machines used in chip manufacturing.

Efforts to develop the EU's own manufacturing are also being stepped up. The goal is to increase the Union's share of the global chip market to 20% and to develop 2nm production technologies in cooperation with Member States. Initiatives such as KDT (Key Digital Technologies), EuroHPC (a network of European supercomputers) or the European Processor Initiative (aiming to build an advanced-generation processor) are to serve this purpose, and the funds will come from, among others, the European Reconstruction Fund, from which at least €160 billion will be allocated to technological projects. Internal Market Commissioner Thierry Breton is also in talks with Intel and TSMC to prepare for the construction of chip factories in the EU in exchange for subsidies.

Conclusions and Outlook. In the coming years, Taiwan and South Korea will continue to lead the technological race in semiconductor manufacturing. Actions taken by the United States and its allies point to better prospects for industry development in the U.S. than in China. This is evidenced by, among other things, the relocation of chip factories and technological cooperation with Taiwan and South Korea. In the short to medium term, these actions will significantly limit the potential of China's technology sector, while China to accelerate its development in order to become independent of Western technology.

The EU, which has relatively few resources at its disposal compared to its competitors, relies on cooperation with Taiwan and the U.S. From Poland's perspective, it would be desirable to support these activities and persuade the EU partners to select Poland as a location for European chip factories (e.g., in areas of western Poland that facilitate geographic centralisation and transport) or related manufacturing, due to the high quality of human capital and positive external effects (e.g., an impulse to develop the local economy).