Are Microchips the New Oil?

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Microchips are the building blocks of the modern economy, but what are the geopolitical implications of this new power player? In this episode of The Active Share, Hugo speaks with Tufts University associate professor Chris Miller, author of the book Chip War: The Fight for the World's Most Critical Technology, about the decades-long, globe-spanning battle to control one of the world's most critical resources.

Comments are edited excerpts from our podcast, which you can listen to in full below.

Why did you decide to write a story about microchips now?

Chris Miller: I'm a Russian historian by training. I started out wanting to write a book about technological change in military power. It puzzled me that during the Cold War, the Soviet Union could produce atomic weapons and rockets, but they couldn't produce military technology that was changing the balance of power.

The more I dug into this shift in military technology, the more I realized that at the core of this change in global power was semiconductors, the tiny devices that let us miniaturize computing power.

During my research, I learned that the first semiconductors were created for missile guidance systems during the Cold War. They needed a small type of computing that could fit on the nose of a missile. Since then, there's been a deep relationship between the development of military power and the development of computing capabilities today, in the United States and globally.

Most people understand the connection between geopolitical power and the control of energy. Why are

microchips given less prominence than energy?

Miller: I would go so far to say that chips are more politically influential than oil is. If you look at the production process, there's more concentration in the chip industry than in the oil industry. Saudi Arabia produces 10% to 15% of the world's oil; Taiwan produces 90% of the world's most-advanced semiconductors.

In other parts of the chip supply chain, there's even more concentration, which gives rise to pricing power for companies and political power for the countries that can control them.

We haven't realized the extent to which chips provide the building blocks for the modern economy because most of us never see a chip, although we rely on them daily. Unless you take apart your smartphone or your dishwasher, you don't see the chips inside.

In the simplest form, what are chips?

Miller: A chip is a piece of silicon that has tiny circuits carved into it. You can measure a chip's computing power, roughly speaking, based on the number of transistors that are carved into it. The primary chip in an iPhone will have 15 billion transistors, each one the size of a virus. And these transistors turn on and off on a regular basis.

When they're on, they create a one. When they're off, they create a zero. These are the ones and zeros that undergird all computing systems. You couldn't have modern computing without the chips that are doing the computing for us.

What are the different types of chips?

Miller: You can divide chips into three main categories. There are the types of chips that process data, which are the main chip in your smartphone, and are often called central processing units (CPUs). There are types of chips that remember data and store it over short or long periods of time; you'll also find these in your phone and PC. The third category of chips are analogue chips, which take real world signals and convert them into ones and zeros.

What do you need to make chips?

Miller: To make an advanced chip with 15 billion transistors, you need precise manufacturing equipment.

First, you start with design, which you need ultra-precise software for. Then, you need manufacturing tools that take a circular piece of silicon called a wafer. You shine light at it in a certain pattern. The light reacts with chemicals to carve shapes in the silicon, and these shapes, after repeating this process multiple times, become your transistors. Then, you use these tools with ultra-specialized and purified chemicals to produce chips.

How did the chip industry come about and what were the motivations?

Miller: Before the first semiconductors were invented, the computers that existed were simplistic, and the capabilities relied on devices called vacuum tubes, which were like light bulbs.

But they regularly burnt out, they were impossible to miniaturize, and they had a fraction of the processing power of a contemporary iPhone. The military's push to find ways to shrink computing power so it could be put into weapons systems drove the initial funding for the first semiconductor firms.

If you look at the people who invented the first chips, you find that the real leaders married expertise in science with business thinking. You need brilliant scientists and engineers, but you also need people who understand where the market's going to go.

Bob Noyce, a founder of Fairchild Semiconductor and then Intel, was one of the people who invented the first semiconductor. His real expertise wasn't so much in science but in understanding the way the technology could develop and meet new markets. Similarly, at Texas Instruments, CEO Pat Haggerty realized that because chips had become smaller and more powerful, they could be used far beyond mainframe computers.

The chip industry has also shifted since the earliest days. When chips were first invented, the Pentagon was buying almost all of them. Today, only a percentage of chips made globally end up in defense uses; most go to civilian applications.

During the Cold War, the Soviet Union realized that it was falling behind militarily and needed to catch up. Why did it fail to replicate the U.S. chip industry? Why did Japan then succeed?

Miller: The failure of the Soviet Union is an interesting puzzle because the Soviets had brilliant physicists, an extraordinary educational system, a ton of capital investment, and a big military market, just like the United States.

But they didn't have a consumer market or an international supply chain.

U.S. firms could sell to Europe and Japan and acquire equipment and materials from the best companies across the industrialized world. Russia was trying to do it all on its own, a bad strategy given that the Soviet economy was a small share of global gross domestic product (GDP).

From the earliest stages, the Soviets tried to copy chips, an ineffective strategy in an industry where progress improves at an exponential rate. Because of the increase in processing power, the Soviets' copied chips were technologically years behind, and they were never able to build a viable chip industry.

But Japanese firms succeeded because they were able to acquire the best equipment from the United States and Europe. They sold to global markets and showed that it's possible to catch up. But it's only possible when you're deeply integrated with global markets rather than trying to do it domestically.

How did Taiwan rise as a microchip power?

Miller: Although it's far from Silicon Valley, the two locations were deeply intertwined. There were dozens of influential Taiwanese technology executives in Silicon Valley and many Taiwanese students studying at Stanford and UC Berkeley throughout the 1960s, 1970s, and 1980s.

This connection explains why the Taiwanese government began to form new companies in the chip industry. It offered Morris Chang, a businessman who spent his career at Texas Instruments in the 1950s, 1960s, and 1970s, money to start a new semiconductor firm. Chang created Taiwan Semiconductor Manufacturing Company (TSMC), which is now the world's largest chip maker.

Before TSMC's founding, almost all companies designed and manufactured chips in-house, but Chang wanted to split the two processes. He said, "I'll focus on the ultraprecise manufacturing processes. Then, I can sell these services to different chip companies that will only have to design chips."

As a result, chip design start-ups didn't need to purchase expensive equipment. They could just hire a couple of designers and take their designs to TSMC for fabrication. This shift in business model proved remarkably successful.

We know chips are strategically important, but why is it hard to break into the industry?

Miller: When it comes to chip fabrication and tool manufacturing, the capital investment is massive.

Personnel are also critical, and you need people who understand how the processes work. The companies that play a big role in the industry were almost all founded by people who cut their teeth for several decades.

You also need to find a niche in a very complex supply chain, which makes it difficult for new firms; companies in the semiconductor supply chain are planning their research and development (R&D) over 5 or 10 years.

And they're planning their R&D already knowing who their customers will be because there's a small number of firms in the industry.

If you're a toolmaker, you must make sure your tools fit Intel's, TSMC's, or Samsung's fabrications, because they're going to be your biggest customers. The toolmakers and the chip manufacturers essentially co-develop their technology.

The same is true for chip designers. They're deeply interlinked, which makes it hard for a new firm to jump in because they don't have any credibility or existing relationships.

We've established that building a chip industry from scratch is difficult. Why does China want to try?

Miller: China has a couple of advantages. It's going to spend a lot of money. It has a substantial electronics industry. A lot of smartphones and PCs are assembled in China, which means that China acquires many chips in the process.

But while it produces a fair number of chips, they're almost all low value and low capability.

You also can't produce a cutting-edge chip exclusively using Chinese products, so it's going to be hard for China to reach anything close to self-sufficiency.

Just look at the United States, which is the world's biggest player in the chip industry but incapable of producing cutting-edge chips all the way through. If the United States can't do it, it's hard to imagine the Chinese will succeed.

How is Taiwan's production capability impacted by the power competition between the United States and

China?

Miller: This is the big question tearing apart the chip and electronics industries right now. Recently, the United States has taken steps to restrict the transfer of chipmaking technology to China, and several big U.S. electronics firms are reducing their reliance on Chinese production. The challenge that Taiwan faces is if political tension turns into military tension.

A disruption to Taiwan's ability to export chips would have serious consequences.

Miller: You'd see smartphone production fall globally to almost zero. It would also impact all sorts of electronic and manufactured goods such as automobiles, dishwashers, microwaves, coffeemakers, and airplanes.

While all these chips don't need to be produced in Taiwan, the country produces nearly all the most advanced processor chips and more than one-third of the computing power the world adds each year.

If we lost access to a third of that computing power, it could result in the worst decline in global manufacturing since the Great Depression.

Will we see certain economic blocks try to generate as much as they can within their geographic borders?

Miller: When you dig into the changing investment patterns of technology companies, they're moving to almost anywhere else besides China.

I think "de-China-ization" is what the tech industry is doing. We're having a bifurcation of supply chains, one focused on China, and one focused on the rest of the world.

I think the economic block that United States is trying to put together also includes Europe, Japan, South Korea, India, and other parts of Southeast Asia.

For China, it's a real challenge. If Chinese tech firms can only operate in China and a small number of other emerging markets, it's not a very attractive future for them.

In 10 years, will we still marvel at how much more chips are capable of than they were 10 years ago?

Miller: We're in the early stages of a revolutionary moment in chip design.

In the artificial intelligence (AI) space, we've seen algorithms shift away from traditional CPUs and datacenters toward graphics processing units (GPUs), which are structured and designed differently. It's not that they have more transistors; it's that they use the transistors in a smarter way.

I think we're only beginning to understand what the future architecture of chip design looks like.

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