3 Takeaways Podcast Transcript
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Ep. 121: Chip War: the Fight for the World's Most Vital Technology and the Staggering Vulnerability of the U.S

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INTRO male voice: Welcome to the 3 Takeaways podcast, which features short memorable conversations with the world's best thinkers, business leaders, writers, politicians, scientists, and other newsmakers. Each episode ends with the three key takeaways that person has learned over their lives and their careers. And now your host and board member of schools at Harvard, Princeton, and Columbia, Lynn Thoman.

Lynn Thoman: Hi, everyone. It's Lynn Thoman. Welcome to another 3 Takeaways episode. Today I'm excited to be with Tufts professor and author of the Chip War, Chris Miller. I'm excited to learn about the fight for the world's most critical technology and the surprising vulnerability of both the US and China. Welcome, Chris. And thanks so much for our conversation today.

Chris Miller: Thank you for having me.

LT: Chris, why are chips so important?

CM: Well, today chips are found in almost all goods that we rely on, whether it's dishwashers or microwaves, as well as smartphones and computers. We can't have a functioning economy or society without them. And although we generally think of computing power as being something inside of computers, in reality, all sorts of devices today rely on computing. And as we project into the future, that's going to be increasingly true. So the typical person will touch hundreds of chips over the course of their daily lives, even though most people hardly ever see the chips inside of their devices.

LT: And even what I'm going to call are old kinds of devices like cars and airplanes that have existed for a long time, those are now dependent on chips as well. So it's not just the Internet, iPhones, but it's pretty much everything you're saying?

CM: That's right. And just to take the automobile, for example, a typical car today could have a couple hundred chips inside of it. Some of them quite simple, others quite advanced for autonomous driving features. And across devices, we're seeing more and more use of chips inside of them.

LT: And what actually is a chip?

CM: So a chip is a piece of semiconductor material, usually silicon, which has lots of little transistors carved inside of them. And a transistor is a circuit that either turns on or off. And when it's an on, it's a one, off it's a zero, and this produces all the ones and zeros undergirding all software and all computing. And so a chip, for example, on a new iPhone will have 15 billion transistors carved inside of it. Each of the transistors is the size of a virus. And so making chips today is the most advanced and precise manufacturing process ever invented.

LT: And how rapidly have these chips been advancing and what does it actually take to design and build the most advanced chips today?

CM: The first chips that were brought to market in the early 1960s had just four transistors on them. So there's been an extraordinary progression from four to 15 billion, which is the number of transistors on a chip in a new iPhone, for example. And so, there's been an exponential growth rate of the number of transistors per chip, which has also made an exponential growth in the amount of computing power a chip can provide. And that's known as Moore's Law, named after Gordon Moore, one of the co-founders of Intel who played a big role in building up the semiconductor industry. And because of that, the chip industry has changed almost more rapidly than any other part of the economy. If you think of most sectors of the economy, productivity improves by a couple of percentage points a year and that's considered a success. Whereas the chip industry, we expect a doubling of computing power every other year, and we've gotten that for the most of the past several decades. And anything less than that is considered a absolute failure, which is why improvements in chips vastly outstrip improvements in any other part of the economy.

LT: And what does it take to design and build the most advanced chips?

CM: To design a chip with billions of transistors inside of it requires ultra-specialized software that can lay out billions of transistors and other components on a chip. And that's hard to produce. There's just a couple of companies that produce that type of software. But even more complicated than that is the machine tooling needed to actually manufacture chips. And although we think of computing often as being something ethereal, in the Cloud, if you will, in fact, computing is a manufacturing problem. All computing power today stems from silicon chips that are made by machine tools.

CM: And there's a small number of companies that can produce the ultra-precise machine tools needed to make advanced chips because transistors on chips are so small. You need to be able to move materials at almost the atomic level to produce transistors with basically perfect accuracy as they're able to do. So the ability to set down layers of material, just a couple of atoms thick or carve canyons a couple of atoms wide into pieces of silicon is possibly using only these ultra-specialized tools. Without accessing tools from five companies in the world, three in California, one in Japan, one in the Netherlands, you simply can't make an advanced chip. So these tools undergird all computing that we rely on.

LT: And who designs and manufactures the most advanced chips and how much does it cost?

CM: So if you want to design an advanced chip, just to get the blueprint for the chip, that can cost several hundred millions of dollars. And it's largely US firms that design the most advanced chips, the type of chips you find in a PC or a smartphone or in a data center. But most of these chips are actually manufactured by different companies. There's a design process first and a manufacturing process second, and the world's most advanced manufacturer of chips is called the Taiwan Semiconductor Manufacturing Company based in Taiwan. And so, although the world's most advanced chips are designed in the US, largely in California, most of them can only be manufactured in Taiwan. So there's a deep interconnected relationship between US chip designers and fabrication capacity in Taiwan.

LT: So, for example, Apple, would it design its own chips but TSMC would manufacture them?

CM: That's right. Apple designs chips with a few designers in California and Israel and then sends all of its chip designs to TSMC in Taiwan, which produces all of the key chips in iPhones, iPads, Apple computers, other types of Apple devices.

LT: How important are TSMC's chips for both the US And China?

CM: Well, they're important for everyone. TSMC produces one-third of the additional computing power the world adds each year in a small number of facilities arrayed along the western coast of the Taiwan Straits. And if TSMC were to disappear for some reason, it would send the world into a horrifically costly recession because TSMC is the only company that can produce advanced chips for Apple, produces around a third of all PC processors every year, critical chips for data centers, telecom's infrastructure, as well as many of the chips that go into autos and microwaves and dishwashers. So it's the most important company, I think you can argue, in the entire world. And its capabilities simply couldn't be replaced in anything less than half a decade's time if they were somehow to disappear. And although most people have never heard of TSMC, in fact, almost everyone in the United States relies on TSMC products every single day, although they never see them. They're packaged inside of the electronics that they couldn't live without.

LT: Are TSMC chips also used by, for example, the American military?

CM: They are. They're used, in fact, by almost all of the world's militaries. One of the interesting conclusions of the Russia-Ukraine war thus far is that when you begin to break apart Russian guidance computers and the missiles, for example, you'll find that Russian missiles are full of chips from the US, from Japan, from Taiwan and from Korea. So, in fact, the world's most advanced chip companies, knowingly or not, provide chips for all the world's militaries, including the Russian military and the Chinese military. And the US efforts to control and limit the ability of other countries, adversaries, militaries, to access chips is a key challenge right now. And it's never going to be perfectly possible to cut them off but there are a number of limits that are currently in place.

LT: That's amazing. Many people look at Germany and wonder how they could have been so foolish, at least in retrospect, to be so dependent on Russian gas with the Nord Stream pipeline. Are the US, China and the rest of the world in a similar position with chips? Is it a staggering vulnerability?

CM: Well, I think it is. And I think it's been an error of really historic proportions to let the military balance in East Asia shift in such a dramatic direction in China's favor, such that it's now widely discussed that China might try to pressure Taiwan militarily or even to move on Taiwan. This wouldn't be a concern if the US military had the advantages over the Chinese military that it had two decades ago. But since that time, the Chinese military has been building up its forces dramatically, whereas the US has been focused on other regions and let its edge slip.

CM: And so right now, there's real uncertainty about whether the US would be willing to come to Taiwan's aid in a crisis, given the costs that a war would involve for the United States in simply military terms. This uncertainty creates risk that Xi Jinping might decide to roll the dice and try to accomplish the goal that he's stated of asserting control over Taiwan. And because Taiwan is not simply a country that's been a longstanding US Partner, but also a critical supplier of US

technology, such a move by China would be disastrous for the entire world economy, not only for the United States.

LT: What could China do if they wanted to undermine or disrupt TSMC's supply of chips being sent to the US or if China wanted to pressure TSMC into giving Beijing preferential access to their chips?

CM: Well, China could certainly try to impose a blockade around Taiwan, which would prevent the export of chips. And if you look at the military exercises that China undertook after Nancy Pelosi's visit earlier this year, it looked a lot like planning for what a blockade might entail. So I think that's certainly a risk that must be considered, given that the Chinese military is actively planning for it.

CM: In terms of pressuring Taiwan, I think the key question is to what extent do China and Taiwan think that US defense commitments are credible? And the problem is that as China's military power grows and as US military power doesn't, US defense commitments become ever less credible no matter how much the US says it's going to defend Taiwan. And President Biden has repeatedly over the past year said he would defend Taiwan, and that's somewhat of a shift from prior US policy, the reality is that he's being more declaratory in his policy, but actually the US military is still falling in relative terms behind where it used to be vis-a-vis China because China's building up its military and the US is not taking comparable steps. So I worry a lot that the US is relying too much on trying to declare its commitment to defend Taiwan and not nearly enough on developing the capabilities you need to very straightforwardly do so.

LT: What impact would a disruption of the supply of the most advanced TSMC chips have on the US?

CM: Well, it would be disastrous. There would be huge delays for not only the production of smartphones, PCs, data centers, but also for all sorts of the simpler devices that use lower-end chips because even though Taiwan produces almost all of the world's most advanced processors, it also produces a huge number of less advanced processors. And so, dishwashers and automobiles would face massive delays from a disruption of Taiwanese supply, the cost to be measured in the trillions of dollars just in the first year. And the cost wouldn't go away after year one because it would take a long time to rebuild the chip-making capacity that we lose in Taiwan, probably half a decade if not longer.

LT: The US Congress has just passed the so-called CHIPS Act, which provides about $300 billion or so of funding. Will that solve the problem?

CM: Well, it's not going to solve the problem. It will, on the margin, increase the manufacturing capacity for chips in the United States. But the reality is that moving the chip supply chain is a very, very expensive task, and the US Congress has not appropriated nearly the amount money you need to completely shift where supply chains are located. So we're going to be quite reliant on chips produced in Taiwan for some time to come, which is why the defense of Taiwan is important not only for geopolitical reasons but also for straightforwardly, economic reasons. Even if you don't care about Taiwan, if you care about your iPhone, you ought to support the defense of Taiwan.

LT: Are any of the most advanced chips in the world produced in the US or anywhere outside of Taiwan?

CM: There's different ways you can categorize which chips are the most advanced and which are the least advanced. What I would say is there are capabilities that Taiwan has that nobody else has and there's capacity for production that Taiwan has that nobody else can replicate. And so, there's no way that that could be straightforwardly set up in a crisis outside of Taiwan. It could be set up, but it would take years, and in the interim, that delay would cause massive and hugely costly disruptions.

LT: So to be clear, neither Intel, for example, nor Samsung have the advanced capabilities that TSMC does?

CM: Samsung is not far behind TSMC in terms of fabrication capabilities, but it's far behind in terms of fabrication capacity for logic chips. So TSMC has a lot more capacity than Samsung does, and it is slightly ahead in terms of its technological capabilities. But if you were to lose access to the TSMC, you couldn't ramp up at Samsung because they're already pretty close to capacity, and their capacity is far less than what TSMC has.

LT: If US chip supplies from TSMC are disrupted, what is the timing to design and build the most advanced chips fabrication plants and to produce chips at scale? How many years are we talking?

CM: It's hard to be certain because there would certainly be a major national push to devote any resources necessary to build up chip capacity, but I think you'd be looking at many years, three, four or five years before you even began to make a real dent in the problem because the challenge is not just building the buildings that chips must be made, and it's also acquiring these ultra-precise machine tools. And right now, the production capacity for these machine tools is already booked out into next year. And so, scaling up the production of these tools is not something that can happen overnight. It would take a long time to build both the tooling and the fabrication facilities that would be needed to replicate what's in Taiwan. Remember one-third of production capacity of logic chips is currently in Taiwan. So you'd be talking about a massive relocation, which isn't something that could be done quickly.

LT: Before I ask for the three takeaways you'd like to leave the audience with today, Chris, is there anything else you'd like to mention? What should I have asked you that I didn't?

CM: Well, I think the other key dynamic is that the US is trying to cut off more effectively China's access to advanced chips and chip-making tools, precisely to hold back China's ability to apply these technologies to its military. And so, the US strategy over the longer run to defend Taiwan more effectively is to grow the gap in computing power between what the US can access and what China can access and then apply that gap to military systems. And so, chips aren't only a key reason why the US is defending Taiwan. They're also the tool by which the US hopes that it will retain its military advantage in the future and thereby able to deter the Chinese military more effectively.

LT: And how successful do you think China would be in developing its own very advanced chips comparable to TSMC's?

CM: It's going to take a long time and a lot of money for China to get close, and it may never succeed. I would guess that China is going to make progress in a number of different spheres, but in a time horizon measured in multiple years, perhaps in decades time, for China to really make

meaningful strides in a sense.

LT: What are the three takeaways you'd like to leave the audience with today?

CM: First, although most of us never think about semiconductors, in fact, semiconductors are critical to all of our lives. And if you think about all of the devices you touch with an on and off switch, they've got a semiconductor inside. Second, semiconductors aren't just a tool that makes technology possible. They're a manufactured good that requires ultra-precise tools to produce. And unless we've got the supply of tools we need, we're not going to have the supply of computing power we need. And third, you can't understand the chip industry today without putting the US-China rivalry and the Chinese threat to Taiwan at the center of your analysis because the Chinese threat to Taiwan is the biggest risk factor hanging over the chip industry today and it's also the biggest impetus for US government policy to reshape how supply chains are structured.

LT: Chris, this has been great. Thank you so much. I really enjoyed your book the Chip War.

CM: Well, thanks so much for having me, Lynn.

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