

[Transcript] The Ezra Klein Show / The Most Amazing — and Dangerous — Technology in the World

I'm Ezra Klein, this is the Ezra Klein Show.

So you may have noticed at the beginning of the year that two themes are really dominating the show. China and AI. And obviously that's not an accident. I'm not going to try to rank order what matters most in the world, but these are two good contenders for the top five at least. When I imagine the history books getting written of our era, it is very hard for me not to imagine these being dominant themes. And these stories connect. They connect in obvious ways. There's a geopolitics of who controls AI, a race between the US and China to get the strongest and earliest AI capabilities, but they also connect in another, more tangible way. They are both stories driven by semiconductors and who controls them. In the same way that you couldn't understand geopolitics in the 20th century without understanding oil and other forms of energy, where it was and who had it and who needed it and what they would do to get it, you can't understand the major stories of the 21st century without understanding semiconductors. Whoever controls semiconductors controls the future. And it turns out for reasons I didn't really understand until I read Chris Miller's book, Chippor, that semiconductors really can be controlled. So Chippor, which is just amazingly timed given how deep it is, is a history of semiconductors as a technology, as an industry, and then it traces the way they have and are shaping geopolitics. It was a Financial Times's business book of the year in 2022 and having read it now, definitely going to be on my year-end list of the most important books I read in 2023. And there's a lot more in the book than I'm able to cover in the show. I really do recommend reading this one. But I do think the show is one of the more important we're going to do and important for understanding a lot of the other shows we're going to do, because this is getting in a material reality that is easy to miss, but is going to shape so many of the big stories we're living through in the coming years. As always, my email is reclinedshow at nytimes.com.

Chris Miller, welcome to the show.

Thanks for having me.

What timing on this book, man. I assume, when did you actually start it? Because I honestly cannot imagine a better moment for it to have come out.

I started researching it around 2015, 2016. Didn't start writing until 2020 and finished writing early 2022, just as the chip shortage was reaching its peak.

So let's talk a bit about why semiconductors end up mattering this much. You write that we rarely think about chips, yet they've created the modern world. Justify that for me.

Well, today, people like you and me can't live our lives without touching hundreds or thousands of chips, just going about the course of our daily lives. We think of chips as being in smartphones or being in PCs, but today, they're in almost any device with an on-off switch. So a new car will have a thousand chips inside of it, your refrigerator, your microwave, your dishwasher. All of our devices are full of chips that do computing, do sensing, increasingly do communication. And so the modern economy just can't function without lots and lots of chips.

I don't know if this will be a hard question or easy question for you, but like most people, and particularly before I read the book, I have only the haziest idea of what a semiconductor chip actually does. So you often describe it as providing the processing power of the

modern world. What is it actually doing?

So a chip is a piece of silicon with a lot of tiny circuits carved into it, and these circuits are either completed or interrupted via device called a transistor, which is a switch basically that turns them on or off. And when a circuit is on, it produces a one. When it's off, it produces a zero. And all of the ones and zeros that undergird all of software, all of data storage, it's just circuits turning on or off to produce the right digit. And today, we have lots of digits we require because we store and process lots of data. And so advanced semiconductors today have millions or often billions of these tiny circuits etched into them that provide the ones and zeros that modern computing requires. Tell me about that size. When you say you have billions of these circuits on a chip, how small are we talking? How is that possible to be etching or really doing anything at that scale?

Today, if you go to an Apple store, for example, and buy a new iPhone, just the primary chip in an iPhone will have around 15 billion transistors on it. And so each one of these tiny switches is smaller than the size of a virus. They're measured in a number of nanometers, which is a billionth of a meter. And so these are the smallest devices that humans have ever mass produced. And we produce more of them than we produced any other device in human history.

Tell me a bit about how quickly we've been able to shrink the scale at which we're working here and increase the density of the chips. I mean, these aren't a very old technology. As you point out, Silicon Valley, which has not been around forever, gets its name from the silicon of which these chips are made. So when this starts, what is a level of complexity? When is that? And what is the process by which we get to today?

The first chips were invented in the late 1950s. They first became commercially available in the early 1960s. And at the time, they would have had a handful of transistors on them. And the rate at which we were able to pack more transistors onto a chip, which was also the same as the rate that we were able to shrink transistors down to enable more of them to fit on a piece of silicon, has increased exponentially. So there's been basically a doubling of the number of transistors you can fit on a given size chip every two years since the 1960s. And that's come to be known as Moore's Law, named after Gordon Moore, who was one of the early engineers that created the industry and eventually went on to found Intel. And what that's meant is that the chip industry has produced improvements that have gone far beyond any other aspect of the economy. There's nowhere else in the economy we've had exponential growth rates persist for not only years, but half a century.

Let's talk for a minute here about Moore's Law because there's a, I think a misleading way in which it's called a law. It's not like the second law of thermodynamics or something. It isn't a law. It's an early observation that ends up being weirdly predictive. So what is he looking at, Gordon Moore, who actually recently just died? What is he looking at when he makes that observation? And then why in your view, does it not just come true, but come true beyond his own expectations for it?

So he made this observation in 1965, which was just seven years after the first chip was invented. And he noticed that the number of transistors per chip was doubling every year or two. And he predicted, given the technology that he saw being developed at the time, it

would last for at least another decade through 1975. And that proved true. But as that was proven true, chips became more powerful, also cheaper, because you could get more computing power with a smaller and smaller chip. And they found more use cases across the economy. So the first chips were used primarily for defense systems. But as the cost of computing power fell, it became possible to apply them to more and more uses, to corporate computers, for example, then to pocket calculators, then to automobiles. And as the use cases proliferated, the investment dollars going into further shrinking transistors and further packing more computing power into chips also increased dramatically. And so there's been a sort of virtuous cycle between the cost of computing declining and even more investment dollars going into driving that down further, because people realize that there were a lot more uses for computing than anyone really imagined at the time that Gordon Moore first coined the concept of Moore's law.

Which direction does that causality run? Were there more uses for computing than anybody imagined? Or are there more uses for computing than anybody imagined because such computing is now possible?

You know, I think it's actually both in some ways. Gordon Moore himself wrote a couple of essays looking into the future of computing. And at the time, he predicted devices like what he called personal portable communications equipment, sort of like a smartphone, if you will. He envisioned home computers that would be networked together, sort of like the internet. So it was possible to envision some pretty futuristic uses. But I think even he was shocked by just the diversity of applications of computing and the ways in which they transformed society. He could predict portable communications devices, but I think even he was shocked by the iPhone when it first emerged a half century later.

I want to key in on an example of what it has taken to keep Moore's law going for as long as it has. Because I also think having this in people's minds is important for the geopolitics and the policy that's going to come in this conversation. So you spend some time that I would describe as somewhere between loving and odd, describing the development of EUV lithography. So tell me that story in some detail. What is it and how did it get from a hope to a reality?

One of the process steps in manufacturing chips is projecting a pattern onto the silicon, a pattern that describes where the transistors will be. And at first, you could actually do these patterns by hand because transistors were large enough to be carved out by hand. But as they've become smaller, you need to project them using sort of like a microscope backwards. Microscopes take optics to make something small like big, and we do the opposite to make a big pattern projected in a very small form onto a chip. And for a long time, the optics involved were pretty straightforward, and you could use visible light to project the patterns and interact with chemicals in specific ways to carve transistors onto chips. But as they've gotten smaller and smaller, the wavelength of visible light has gotten far too broad to actually carve transistors in the way that we want. So visible light has a wavelength of several hundred nanometers, depending on the color, whereas the transistors on your smartphone are far smaller than that in dimension. And so around three decades ago in the early 1990s, scientists began developing a new type of lithography more precise using smaller wavelength light in the ultraviolet spectrum. And this was necessary to get the

precision, but it was also extraordinarily complex to produce. And so today, there's just one company that is capable of producing the machines that are capable of providing this light at the scale and with the precision necessary. And these machines are the most complex machines humans have ever made. They require one of the most powerful lasers that has ever been deployed in a commercial device. They have an explosion happening inside of them at 40 or 50 times hotter than the surface of the sun. And because of all this precision, they require \$150 million per machine to produce, require multiple airplanes to move. They're sort of extraordinary accomplishments of human engineering, but also wildly complex. And that complexity has made modern shipmaking more and more difficult. But that's the only way to get the precision that we require.

They also, from the way you tell the story, represent remarkable accomplishments of supply chain management and to some degree globalization. So it's a Dutch company making these systems,

but they are a company that does a lot of sourcing. They don't just make the system in a factory somewhere. You talk about just the laser needed for the system, which comes from another company, which is called a slightly weirdly Trump with a PNF. And you say that the laser itself requires exactly 457,329 component parts, many of which need to be made by different players. So you're dealing with the sourcing when you then scale up to the entire machine of a number of parts that seems almost unimaginable.

Yeah, that's right. And the engineering doesn't simply happen on the machine itself. The supply chain itself is an engineered process carefully sculpted to select the suppliers that this company knows they can trust, suppliers that they know they can deliver on time, and suppliers that they know they can deliver high quality products. Because if you think, for example, of what it takes to keep a machine with hundreds of thousands of component parts operational, the mean time to failure of each of those parts has to be measured in the decades or else the machine never works. So that level of precision and reliability has been extraordinarily difficult to produce. And it's why there's just one company in the world that is capable of producing them.

So something you trace in your story is that for some time now, chips have been this hidden geopolitical force. You tell it in part through the changes in military power and what got called in the US, the offset strategy beginning sort of late in Vietnam as that war was failing. But then building into something that created an era of quite profound American military dominance, which was then noticed by everybody else and others are trying to match. Can you talk a bit about how these ended up changing, not just warfare, but America's military position vis-a-vis competitors?

Yeah, the US military was actually one of the early drivers of innovation in semiconductors. The first chips that were created were created for guidance computers in both space systems and in missile systems. And the Pentagon funded a lot of the early research in semiconductors and still is a major funder of a lot of cutting edge research today. The military was interested in semiconductors because it wanted to miniaturize computing power to distribute it across battlefields.

If you think back to the earliest computers in the 1940s or 1950s, they were the size of rooms far too large to be deployed in systems in the field. And so the military wanted to

find a miniaturization technique and chips were the answer. And over the course of the Cold War, the US military deployed chips in all manner of devices and in airplanes and satellites and missile guidance systems. And a lot of the precision that we take for granted today in military systems, the idea that you could launch a missile and have it hit a target hundreds of miles away with pretty close to perfect accuracy, is only possible because of lots and lots of semiconductors, chips in the missile that guide it, chips in the satellites that send signals as it identifies its location over the course of its flight, chips in the sensors that are collecting, targeting information, chips in the communication systems that are distributing this data across the battlefield. And so the US military was actually the first institution to show the ways that the distribution of computing and sensing that chips provide can transform how organizations work and can provide extraordinary value in terms of networking different devices together. And so that, that was important both in explaining why the US jumped ahead in military power during the late Cold War, but it also provided an example for the rest of the world to see not only how militaries but how all institutions could take advantage of semiconductors to provide new types of capabilities they previously hadn't imagined. A point you make towards the end of the book is that one reason Russia has struggled so badly in its effort to invade Ukraine is that they're using a lot of pretty technologically rudimentary military hardware that a surprising number of their munitions we're seeing are unguided. They're not sort of modern smart weapons. A lot of what we're giving and Europe is giving to Ukraine are more precision oriented like the javelin missiles that people have probably heard about. Can you talk a bit about how that's played out into the balance of military power and force there now as we speak? It's been hugely important in a number of different ways, partly as you say, because the Russians just have less sophisticated equipment than we're able to give to the Ukrainians. Partly because even in the relatively sophisticated equipment that the Russians have, they're using pirated or smuggled in version of Western microelectronics, Western chips, which are not custom-made for their defense systems in which Russia's never sure whether they're getting counterfeit versions or the real thing. So even when Russia's able to acquire more advanced Western chips from abroad, there's all sorts of issues it creates in their supply chain and their systems integration as a result. But then perhaps the most important is that Ukraine has benefited from all the intelligence gathering and processing capabilities that the US military has, which is largely today a question of signals intelligence, of satellite photos, of radio signals being gathered, decoded, processed. And this is intensely reliant on computing power, both to understand what's being said and then to dissect signal from noise and give the Ukrainians the useful information. So when you think about a Heimar's rocket, for example, the easy part of the computing is actually guiding the rocket towards its target. The hard part is identifying where the targets are in a rapid enough fashion so that the target hasn't moved by the time you want to fire it. And that is thanks to US intelligence gathering, which today is more dependent than ever on semiconductors. The next turn of this wheel, both militarily and more broadly economically, seems to be different forms of machine learning of artificial intelligence. And that's a story we tend to talk about in terms of data. You'll hear things like data is a new oil story we sometimes talk about in terms of training algorithms and theories like deep learning. And it's

a story that is very much grounded in semiconductors that if you're talking about training next generation artificial intelligence systems, you're talking about these chips. So can you talk a bit about the interrelationship there and what kinds of chips have become crucial for AI and the way that has also begun to play into different major countries' conceptions of what you need for geopolitical primacy?

If you want to train a sophisticated AI system, you do need lots of data to train it on. But that data is only possible to process and to remember by deploying lots of advanced chips. And so today, for training AI systems, there's a type of a chip called a GPU, a graphics processor unit, which was actually originally invented for computer graphics. But the math that the chip was capable of processing turned out to be useful for training as well. And so today, there's just a couple of companies that produce or design the most advanced AI chips. And in particular, a company called NVIDIA based in California produces the majority of the chips used for AI training in the world. And NVIDIA manufactures all of its leading chips at one company, TSMC in Taiwan. So underneath all of the AI training happening around the world, whether in the US or in Europe or in China, are chips produced by just a couple of companies. And that produces a level of political influence that the US in particular has tried to wield in recent years.

So you brought up Taiwan here, which is a helpful bridge for me because you spend a lot of the book focused on this one Taiwanese firm, TSMC, which produces 90% of the world's most advanced chips, 90%. And let's start here by talking about why. Why does TSMC have this hammerlock over the most advanced chips? I think the number you have in the book is they're producing or Taiwan is producing more than a third of new computing power every year. How?

So there are only three companies in the world that are anywhere close to being able to produce cutting edge processor chips, TSMC in Taiwan, Samsung in South Korea and Intel in the United States. And the complexity and the cost involved of cutting edge production means that these three firms will be the only three firms close to the cutting edge for at least the next half decade, probably longer. So there's just extraordinary concentration in the industry when you get close to the leading edge because of the expense and the sophisticated technology involved. TSMC is the leader of those three because when it was founded in 1987, it was founded with a unique business model. Morris Chang, the individual who founded the company, had a vision of not designing any chips, only manufacturing them. And before that point, almost all chip firms both designed chips and manufactured them in-house. But Morris Chang realized at the time that the complexity of both design and manufacturing was growing in a way that would require firms to specialize. And so he set up TSMC, promising never to design any chips, but only to manufacture them. And he was able as a result to serve many different customers. Today, he manufactures chips for Apple, for Nvidia, for AMD, for Qualcomm, many of the biggest chip design firms. But he doesn't compete with any of them because TSMC doesn't do any design itself. And so TSMC is now the world's largest chip maker. Because it's the world's largest chip maker, it has reaped extraordinary economies of scale, letting it drive down costs. And what's most important is that there's a pretty clear relationship between the number of chips you produce and your ability to hone your technology over time because you get data for each chip you develop. And so TSMC has

been able to develop the most advanced manufacturing technologies as a result of its scale. And so today, TSMC produces, as you said, 90% of the most advanced processors, the types of processors that go into smartphones, PCs, data centers. The other 10% are produced by Samsung of South Korea. And Intel right now is a generation or two behind what either of those firms are capable of producing.

Tell me about the political economy of TSMC's birth and rise. Because when you tell a story of Intel, you have a bunch of scrappy young weirdos, they're one firm and then another and then they go to another or found another, I should say. And it's a very Silicon Valley story. And TSMC isn't like that. It's a sort of public-private hybrid institution. So tell me a bit of their story.

So TSMC was founded in 1987 by Morris Chang, who at the time had been a tech executive at Texas Instruments for almost three decades. He was passed over for the CEO job. And so I was looking for something else to do. And he was approached by the government of Taiwan, which wanted to create a chip industry that was moving up the value chain. At that time, Taiwan was a producer of relatively low value electronics and wanted to produce higher value semiconductors. And the government gave Morris Chang a sort of a blank check to set up a new firm. It provided half the capital for the company and got a number of Taiwanese business people to invest another 25% in the firm and was very supportive of the company's early development. And so in some ways, it was very much a public-private partnership. But in other ways, the company had to survive from day one by selling to the international market because the domestic market in Taiwan was far too small to sustain a semiconductor industry. So the firm had to sink or swim by selling manufacturing services to largely U.S. firms from day one. And so in a lot of ways, TSMC has grown up alongside a new set of semiconductor design firms that previously didn't exist because there weren't companies like TSMC that manufactured chips but have been able to thrive because they haven't had to worry about manufacturing. They've outsourced all that to TSMC and have designed chips instead. And so companies like Apple, which manufactures all of its key chips at TSMC or NVIDIA, the company that makes the chips that train AI systems, they've never had to build their own manufacturing facilities because TSMC handles all of the cost and understands all the manufacturing technology so they don't have to worry about it. And that's been a very effective business model both for TSMC but also for the U.S. chip design firms that have always been TSMC's largest customers.

Let's say I designed a computer virus tomorrow. What it did is it simply targeted every TSMC location worldwide and knocked out all their electronics. So effectively, the company ceases to in any way function tomorrow. And there's no real way to get it back online. What happens to the global economy after that?

We'd face an economic crisis globally akin to the disruptions that we saw during the Great Depression. It's not just tech devices like smartphones or PCs that would be catastrophically disrupted. And we certainly struggled to build a cell phone anywhere in the world for the next year or so. We'd have PC production fall easily by a third, maybe by half. Data center rollouts would grind to a halt to be hard to build a cell phone tower anywhere in the world because cell phone towers are just big metal poles with lots of chips on top of them. But it's also all other manufactured goods, so dishwashers and microwaves and

automobiles.

They don't necessarily need the most advanced chips, but Taiwan doesn't only produce the most advanced chips. They produce lots of less advanced chips as well. And the semiconductor shortage of the last couple of years illustrated that it's not only the tech sector that's reliant on chips. It's companies like car firms, too. During the chip shortage of 2020, 2021, the world's car industry faced an estimated \$200 billion worth of losses because they couldn't sell as many cars as they'd hoped because they couldn't get all the chips that they needed. And there's lots of different countries that produce chips in cars. But if you think of a typical new car having 1,000 chips inside and figure 10, 20, 30% of those chips generally come from Taiwan, replacing those would be an extraordinary challenge. And we'd see huge disruptions across the entire world's manufacturing sectors. And final point is that it's not just the U.S. that's reliant on chips from Taiwan. It's everyone. It's Europe. It's Japan. It's China. The entire world's manufacturing sector requires TSMC's chips.

And so there's TSMC's chips, but we also mentioned the Dutch manufacturer, lithography. This is a place you say where the oil metaphor misleads, but probably not in the direction that people would think. If I say chips like the new oil, you might think, that's great because we know that there's only oil in so many places and chips all you need is a manufacturing facility. But you write that unlike oil, which can be bought from many countries, our production of computing power depends fundamentally on a series of choke points, tools, chemicals and software that are often produced by a handful of companies and sometimes only one. So beyond TSMC, tell me a bit about the level of vulnerability and choke points here. Let every step in the production process of an advanced semiconductor, whether it's the software tools that are used to design them, the machine tools like the lithography systems that are used to manufacture them, the actual manufacturing often at TSMC, there's usually just a couple of companies that are capable of producing the most cutting edge capabilities. And that's just because it's very expensive and very hard to do so. And specialization has been critical to the industry. That's why we're able to produce semiconductors with 15 billion transistors on them at a price that all of us can afford. But it's also created risks and vulnerabilities, because in some cases, there's only a single source for certain types of materials or tools. And that creates single points of potential failure. And the world I think has done a reasonable job of managing many of these risks. We've made an error somewhat in putting a lot of our chip making capacity in seismically active zones like Silicon Valley in Japan and Taiwan. But actually, we've been able to manage that risk somewhat too. But obviously, the biggest risk hanging over the industry today is the concentration in the Taiwan Straits where compared to five or 10 years ago, there's far more concern that something might go wrong. And if it does, we're guaranteed to get vast disruptions in chip supply.

So this to me has been a very undernoticed part of America's commitment to Taiwan and America's concern about China potentially taking Taiwan. I think most people hear this and they think, in reality, why would we really care that much about Taiwan? I mean, we don't want China becoming territorially expansionist. Taiwan is our friend. But why do we really like real politic care about Taiwan? And one reason seems to be that you lose Taiwan and

you lose semiconductor industry that Taiwan is a point of vulnerability for the entire world. And that really raises the stakes on this. So can you talk a bit about the ways in which the geopolitics around Taiwan have become merged with the dependence we all have on semiconductors?

If you ask the Taiwanese government, what they'll tell you is that Taiwan's position in the chip industry creates what they call the silicon shield. The idea being that it would be too expensive for anyone to disrupt the chip supply coming out of Taiwan and therefore no one will be willing to do so. And I think that might be true, but I'm not sure about it. It's also the case that Taiwan's chip production guarantees that the U.S. is interested in ensuring ongoing good relations between the U.S. and Taiwan and peace between China and Taiwan. And that dynamic is certainly true as well. I also think it's probably an oversimplification

to argue that semiconductors are the primary reason or a primary reason that either China or the U.S. are interested in Taiwan, because of course both countries have been involved in the Taiwan question since 1949 before the first chips were invented. And so in some ways we have semiconductors sitting at the center of the competition in the Asia region between the U.S. and China. But in other ways, the competition is largely driven by political and military factors that intersect with chips but are far from guaranteed to ensure that their supply is uninterrupted. And so I do worry that actually chips don't provide a deterrence against conflict or don't guarantee that conflict won't happen, but actually they would be the first disruption and the first most dramatic disruption that we face if in case conflict does materialize. So as a result, I finished my study of the chip industry in the ways it intersects with the China-U.S. relationship, much more worried, thinking that perhaps it's stabilizing, but perhaps it's not. And if it's not stabilizing, we're in a very vulnerable position.

Tell me a bit about the chip's question from China's perspective. You make the point that China now spends more money importing chips and it spends importing oil, which is a striking fact. How does this look to them?

Well, for China's leaders, it's an extraordinary vulnerability, both because they're well aware that in case of a crisis, they're likely to lose access to the most advanced chips produced in Taiwan, also in Korea, Japan, and the United States. They also see it as an economic vulnerability because for China's electronics industry, moving up the value chain requires producing semiconductors. If you look, for example, at a smartphone, most of the world's smartphones are assembled in China, but most of the high value components of a smartphone are semiconductors. And so even in Chinese branded smartphones assembled in China, most of the bill of materials ends up going to Taiwanese, to Japanese, Korean firms because they're producing the chips inside of these phones. And so if China wants to progress technologically, economically, they believe they've got to domesticate production of semiconductors. And the challenge they face is that the Chinese government has been struggling to do so. They've been spending billions of dollars a year since 2014 to try to produce cutting-edge chips domestically. They've made some progress in a number of spheres, but in aggregate, they still remain fundamentally

dependent, not only on importing chips, but also the chips that China does produce domestically

are produced almost exclusively using imported machine tools like the lithography tools that I described. And so although China is a manufacturing powerhouse, it's actually a small player when it comes to the production of semiconductors, especially when we're talking about cutting-edge semiconductors.

Can you talk about the idea of weaponized interdependence?

Well, this is a phrase that was popularized by two political scientists several years ago who noted that in theory, many people had thought that interdependence would produce peace. It would increase the incentive for political actors to cooperate because they had economic incentives to do so. But in reality, what we were seeing in the world was that interdependence was not only relevant in terms of building bridges between countries, but it was also a sphere of competition. In that countries, we're using their privileged position in certain networks to try to cut out or to punish their competitors. And we've seen this in cyber networks, for example, where the US has a unique capability to conduct cyber espionage because a lot of the world's key data centers and cables transfer through the US. We see it in financial networks with the US also has a unique position. We also see it increasingly in semiconductors because the US sits at the center of many of the world's semiconductor supply chains and the other key nodes are close US allies like Taiwan or like Japan. And what that's meant is that the US government over the past 10 years or so has been able to surgically cut China out of certain parts of the chip industry while keeping China dependent on many other types of chips. And so whether it's cutting edge tools, cutting edge software or certain types of chips like the chips used to train AI systems, the US is able to say China can't have access and it's able to force the world's chip firms to basically comply.

I think the political history of our policies here is interesting. There's a pretty sharp discontinuity between Obama and Trump and quite a bit of continuity on this from Trump to Biden. So first can we talk about the Obama to Trump change? What is the Obama administration's

perspective on semiconductor competition dominance particularly around China? What do they do about it? And then how does the Trump administration change that? What do they actually do differently than the Obama administration had done?

I think the Obama administration in their final year or two in office was beginning to actually trend in the direction that the Trump administration eventually took things, but it certainly was the Trump administration that was first willing to disrupt supply chains, first willing to take costly measures, and first willing to characterize tech competition as more zero sum than positive sum when it came to China. And so as a result of this new worldview, the Trump administration took a variety of steps in the semiconductor space to cut off China and to punish China for efforts to steal technology from Western firms. So for example, the U.S. put out of business a company called Fujian Jinhua, which had been found to be stealing technology from a U.S. chip maker called Micron by banning this firm from accessing machine tools that are made in the United States without which it's impossible to produce semiconductors. And so overnight this company went out of business because it couldn't get the requisite tools. And this was a really dramatic step. It was very different from the prior U.S. strategy of starting WTO cases, for example, or trying legal measures. This

was just an executive measure that said this Chinese firm can't access the tools anymore. And that began to illustrate the power that the U.S. regulators had to determine who got access to chips and chip making tools and who didn't. Another example is Huawei, the Chinese telecoms firm, the U.S. banned Huawei from accessing certain types of chips and forced Huawei to divest entire business lines. And that again illustrated that even China's leading tech firms were producing technology that required foreign semiconductors, U.S., Taiwanese, Japanese, Korean inside. And U.S. policy makers, I think, were impressed and in some ways even surprised by the power that this demonstrated. And that explains why the Biden administration has somewhat different ways, but in a large sense carried on the weaponization of semiconductor supply chains that the Trump administration started. Let's talk about the Fujian Jinwa story in more detail because the way it sounds there, it's like me in America comes in and puts out the business is Chinese company. But you told story in some detail in your book. And what was happening before that, which was in some ways, I don't want to exactly call it normal, but a common complaint of American businesses dealing with China, which then the Trump administration decides they're not going to stand for anymore. It is pretty interesting at getting, I think, at the other side of the frustrations here. So can you walk through that a little bit more slowly?

So there's a U.S. firm called Micron, which produces memory chips and had a facility in Taiwan actually. And a number of the engineers there began stealing internal documents with the aim of quitting the firm and then bringing this inside information to the Chinese firm, Fujian Jinwa, which was trying to ramp up production of the exact same type of chips in China. And this is a type of chip that Chinese firms have never produced at the cutting edge before. And this was quickly discovered by the company. Legal cases were brought. There's very clear evidence, for example, of some of the employees in question typing into their computers, delete Google search records, for example, to try to cover their tracks. So there wasn't much ambiguity as to what top flight espionage, how to delete your records.

Exactly. So there wasn't much ambiguity as to what was going on. And I think in prior instances, this would have produced a legal dispute or diplomatic discussions. But the legal mechanism simply didn't work. Micron brought a suit against Fujian Jinwa for stealing intellectual property in China. But in Chinese courts, they actually ruled in favor of the Chinese company against Micron, alleging that Micron had stolen the Chinese company's intellectual property, which was, of course, a bogus ruling. But for Micron, China was a critical market because China is the world's largest consumer of chips. And so getting locked out of the Chinese market was a real risk for any chip firm. And it had made them all hesitant to actually take on Chinese companies or the Chinese government when they faced legal issues.

And the Trump administration saw this, believed that the previous strategy hadn't really worked, hadn't changed China's behavior. And so had real little faith in any sort of legal or diplomatic mechanism and said, we're going to put Fujian Jinwa out of business. And via executive order, that's exactly what they did.

Do you think they were right?

I think they were right. I think that the track record had been that the legal mechanisms

had failed to address intellectual property theft. The fact that Chinese courts, despite all the evidence had intervened on behalf of the Chinese firm, suggested that there was really not much hope for legal mechanisms working. And the alternative was just to let intellectual property that stuff like this keep happening, which doesn't seem to me like a very viable alternative strategy.

So you can look at that case as a case of reprisal. We are going to punish you for doing something wrong. And I think that it's a pretty clear cut case that something was being done wrong by China repeatedly there.

Then you have Huawei, which is more about not wanting a Chinese company to build the backbone of 5G internet and a lot of telecommunications fears that on the one hand there were security

risks that couldn't be addressed. And even if you could address that, that the dependence on China was a kind of dependence we didn't want. And you can tell me if you think that's an unfair characterization of it.

And then under Biden, there's another pretty big step up in these export controls on semiconductor chips, which isn't just that we don't want to be dependent on you, but we actually want to slow down your advance. We don't want you to have a semiconductor industry moving towards equality with ours to say nothing of getting beyond ours. And we're going to weaponize the supply chain to stop that from happening.

So can you talk a bit about that change to the Biden administration? Where did they go that the Trump administration had not and why?

Well, as you have this escalation in US policy, you also have technology trends developing in important ways that I think are key to understand. And the key shift here is the training of artificial intelligence systems and the realization that training the most advanced AI systems will increasingly require vast volumes of data that grow every single year and therefore cutting edge chips. And so the Biden administration, I think, not only had the concerns of the Trump administration when it came to IP theft or came to China's role in telecom networks, but it was also looking at the future of AI and realizing that it was going to be US chips that were going to be training the world's AI systems over the subsequent decade and that AI systems are going to be even more powerful than people had thought five or 10 years earlier. And so it was hard to predict for them how AI systems would develop, but it seemed inconceivable that they wouldn't have, in addition to transformative economic ramifications, also vast military and intelligence uses. And so given the tremendous growth in AI plus the reality that training AI required US hardware, to them, I think this looked like a risky moment, actually. If AI was unleashed and the chips that could train AI were unleashed to the entire world, the results would be unpredictable. And so I think in addition to the Trump administration's concerns, they were also looking at these trends saying, we want to have some control over how US chips are used to train AI systems. And that explains why last year, they rolled out two different prongs of a new export control regime, the first which limited the transfer of certain AI training chips to China, made it illegal to transfer NVIDIA GPUs above a certain threshold to China, and then also said because these chips are so important, we want to make sure that China can't produce them domestically. And so to do that restricted the transfer of any advanced machine tools

to China as well. And so this is a very zero sum view of the world that takes all of the national security advisor outlined when these controls were announced. But it's a zero sum view of the world that I think is informed by a lot of concern and uncertainty about how AI systems will be deployed by other countries for military uses and for intelligence gathering. These export rules were announced six months ago. What has their effect been so far in China?

We know the effect of the machine tool restrictions, which have caused pretty substantial challenges for Chinese firms at the cutting edge or close to the cutting edge in production because all of China's leading edge production has required tools from the US, from Japan, from the Netherlands, and those three countries are all implementing roughly similar controls right now. It's harder to say what the impact of the ban on AI chips has been because China still has a large stock of existing AI chips that had imported before the ban was in place. And so these controls won't begin to have an impact for a couple of years when the rest of the world builds next generation data centers or the generation after that and China's unable to. And at that point, we will begin, I think, to see some differential open up in terms of the ease of training AI systems in the US or in Europe or in Japan and the comparative difficulty of doing so with less advanced chips in China.

The other side of the Biden administration's thinking on semiconductors has been to build or rebuild American semiconductor manufacturing. So tell me about the Chips and Sciences Act. What does it want? What is it trying to achieve? And what does it actually do?

So there's two major facets of the Chips and Sciences Act. The first puts around \$10 billion to R&D spending, which is intended to increase innovation in the chip industry and keep the US at the cutting edge in many different spheres. The second is to provide incentives for firms that open up new manufacturing facilities in the US. And here the goal is to address the fact that it's more expensive to build chip making facilities in the US than it is abroad. 20 or so percent more expensive than in Taiwan or in Korea, which over the last several decades has been one of several factors encouraging companies to build more facilities in other countries rather than in the US. And so the \$39 billion in incentives is intended to help companies defray the cost differential and thereby encourage them to build more capacity in the US.

Do you think it is likely to succeed in doing that?

Well, I think there's no doubt that it will succeed in the short run. If you pay companies to build factories, they're going to build them. That's straightforward. I think the harder challenge is to have an impact after we've spent these first \$39 billion of subsidies.

I'm skeptical that there will be a second round of Chips Act spending to defer cost differentials in the future. And so I think the real challenge is to say, can we get the chip industry investing more in the US over the long run even after we're no longer subsidizing them? And I hope the answer is yes, because I don't think subsidies indefinitely into the future are likely, but it's going to be much more challenging because a lot of the drivers of the cost differential still exist, that labor costs are higher in the US. It's more difficult because of environmental permits, for example, to build facilities in the US. And so we've got to produce an environment that does address some of the cost differential, but also make sure we've got other assets, more productive workers, for example, or closer integration between chips and the software firms that they're serving that make up for the cost differential. And that's

ambitious goal. I think it's a worthwhile goal, but it's far from guaranteed that we're going to achieve it. I've been spending a lot of time looking at the Chips Act for a big story that I guess will probably be out by the time this publishes. And you and I spoke for this piece. And something that looking through the Notice of Funding Opportunity, which is the publication that explains how the US government is going to evaluate applications for this money. And I think I'm prepared to say now, having spent more time with the document and talking to people

that this does not lower the cost differential. It is subsidies and it has a lot of, I think, good ideas. But aside from funding R&D to try to create innovative breakthroughs, it doesn't lower the cost of what it takes to build or operate fabs or labor or through immigration, bringing in more technicians. It really just doesn't do much to change what it costs to run one of these in America. And in some cases, very arguably, will make it higher. They add on a lot of standards. People have talked a lot about insisting that there's high quality childcare in the fabs. But even beyond that, there's just a lot of language about creating pathways for marginalized workers and trying to increase the representation of women in the construction industry. And a lot of these ideas might be good ideas. But if you start from the perspective that US chip manufacturing fell behind, because it's very costly to build and operate factories here, it is very, very, very hard for me to look at this document and say what they are trying to address is a cost differential. They're subsidizing on one side. They're adding a certain number of regulations and standards on the other. But if you're starting from a place where you're already non-competitive on cost, I mean, I'm curious if you think I'm being too harsh on this. It's just knowing a little bit more now about what has been the problem for American semiconductor manufacturing. It doesn't really look like it has a solution to that problem.

Well, I think I would say a couple things in response. I think you're right that in any program like this, there's a risk that it loses focus and that multiple different political interest groups manage to make an imprint on it. And I think keeping focus on the cost differential is going to be a key determinant of success or failure in the long run. I think if you look at what the Commerce Department has said about a lot of the preferences around childcare, for example, or around profit sharing that have been controversial, I think a lot of these end up being preferences rather than requirements. And the Commerce Department, I think, has signaled a willingness to be flexible on some of them. So we'll have to see how exactly they're implemented and how firms decide to deal with them. I think on the permitting question, which I think is really quite important, this is a tricky issue because it's not just about the federal government. It's also about state and local governments. And so I know the Commerce Department is aware of the importance of this issue, but it's also about making sure that the Arizona state government and the Portland, Oregon City Council all agree that they're going to approve permits rapidly rather than slow them down because of NIMBYism concerns. And this is a challenge in Taiwan. TSMC is the island's most prestigious employer. It's the country's largest exporter. And so when it has a request, its request is quickly granted. Whereas in the US, semiconductors are one important industry among many. And so they just get less political priority as a result. And when they face problems, they're solved less quickly for that reason. And so I think we still have a lot more work to do, as you say, to make sure that we're actually taking steps that are addressing

the cost differential issues, both at the federal level, but also a lot at state and local levels. And one thing I should say on this is when I spoke with Secretary Gina Armando, who runs commerce,

and when we talked about the environmental permitting and talked about the immigration side, she said very clearly on the record, and it'll be in my piece, she would love that. She would love Congress to come to her and do streamlined environmental permitting. She would love Congress to come to her and work with her on easing immigration status for semiconductor technicians. And she also said that she has made clear to governors that if they want a FAB, that a grant application from a company where they've partnered with the governor or the mayors or whatever to have permitting sped through will affect what commerce does. So if you're a governor

and you want this to happen in your state and you're able to give a company assurances that they can take the commerce that it will and that you will have this the speedway, they will take that into account. That gets me to one of my final questions here because I know we're running quite out of time, which is when I read the history of the semiconductor industry in your book, what it seems to me was one of the single most effective things we did was have a fairly open immigration policy during a bunch of these periods that a lot of the industry has its roots in high skilled immigrants to this country, particularly coming out of World War II. And it raises a question as to whether or not one of the best things we can do for this industry and others is actually high skilled immigration or targeted immigration because labor, is it such a shortage in sort of skilled semiconductor manufacturing in America? How do you just think about immigration as a technological competitiveness policy? Well, I think that's right. And if you look at the individuals who founded the chip industry in the U.S., a disproportionate number of them were foreign born, whether it's Andy Grove, the longtime CEO of Intel, born in Hungary, or Morris Chang, who I mentioned, who built up chip making in Texas Instruments before he moved to Taiwan. He was

born in mainland China. You can go through a lot of the key CEOs and founders of the early chip firms or the CEOs of today's biggest U.S. chip firms, and you'll find a disproportionate number of immigrants there as well. So I think Secretary Armando is right that we ought to have more pathways to have firms bring in the talented engineers that they need. The fact that the industry has a really internationalized supply chain today allows a lot of efficiency. But from the U.S. perspective, it would be even better to have a less internationalized supply chain if more of those people could move to the U.S. and many of them would like to. They just can't get the visas or the work permits that they need. I think that is a good place to end.

Always a final question. What are three books you'd recommend to the audience?

Well, I'd start with *The World for Sale*, which is an extraordinary account of commodity traders who play an unseen role in the middle of the networks that deliver oil and minerals and metals that we require. It's sort of an eye-opening view as to how all the world's raw materials get shipped around the world. A second book I'd recommend, which picks up on a lot of the discussions we've had about networks, is a book called *Nexus* by Jonathan Winkler, which is a study of telegraph cables during the early 20th century. And what's striking about it is the extent to which all of the world's governments saw telegraph cables as not only economically important, but also important

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for military and intelligence uses. And when I think about Huawei today, I think back to the telegraph cables debates of 100 years ago. And in some ways, not much has changed. And then a third book, which was published last year, which I strongly recommend, is a book on decision-making

in China called *Prestige, Manipulation, and Coercion*, which is an extraordinary account of high politics in China over the last half century that illustrates with just a really exceptional archival documentation how Chinese politics has shifted in the key drivers in it. And so in my efforts to understand Chinese decision-making around semiconductors, I found the framework that he set out very, very useful to understand how it is that Chinese leaders make decisions. Chris Miller, thank you very much. Thank you.

This episode of The Ezra Klein Show is produced by Andy Galvin, Emma Fagahou, Jeff Geld, Roshy Karma,

and Kristin Lin. Fact-checking by Michelle Harris, mixing by Jeff Geld, original music by Isaac Jones, audience strategy by Shannon Busta. The executive producer of New York Times, appending audio, is Andy Rose Strasser, and special thanks to Pat McCusker and Christina Samueluski.