Global Economy Podcast – Episode 110

How Embracing New Technologies Defines Great Powers

Full Transcript

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Fredrik Erixon: Hello, everyone, and welcome to ECIPE's Global Economy podcast. My name is Fredrik Erixon, and today we are going to engage on a topic that has forced itself back into public discussion again, at least in the past decades, namely the rise and fall of great powers. And I am delighted to welcome to the podcast Jeffrey Ding, who is an assistant professor of political science at the George Washington University.

He has previously been at Oxford, Stanford, and Georgetown, among other universities. And he recently came out with a fascinating book, Technology and the Rise of Great Powers. And it's this book we're going to talk about today.

Jeffrey, welcome.

Jeffrey Ding: Thanks so much for having me.

Fredrik Erixon: I really liked reading your book.

And as the title reveals, it's a book about the role that technology plays in shaping the rise of new powers. And this theme, of course, connects with so many of the broad developments we have seen in recent times as well. The subtitle is How Diffusion Shapes Economic Competition.

And we are going to talk about that theme of diffusion because it's also very central to the way that you approach the issue of great powers. But why don't we start with a primer on the rise and fall of great powers and how this issue has been approached in the past? I suppose you wanted to research this theme and write this book because you felt something was missing or that others were getting things wrong.

So, what has been the common understanding of technology and the economy for rising great powers in the past?

Jeffrey Ding: Yeah, you're exactly right, Fredrik. I started out researching these past historical cases because I wanted to see if they could offer any lessons for great power competition in artificial intelligence and other emerging technologies today. But as I was going back through the first Industrial Revolution case, the second Industrial Revolution case, U.S.-Japan competition in information and communications technologies, all of the evidence from these cases was pointing to something that was very different from the standard story or the most common approach, which I call the leading sector or innovation-centric theory. The idea there is that the country that becomes the technological leader in these Industrial Revolutions is the one that monopolises cutting-edge innovations in some new industry, a really fast-growing industry that sometimes even becomes the country's largest industry. So that's what gives the label leading sector. So, think Britain and cotton textiles in the first Industrial Revolution, or Germany and the chemical sector in the second Industrial Revolution, the automobile sector or the consumer electronics sector in U.S.-Japan competition.

So, what I was finding going through all the historical data and relying very much on the work of historians of technology, economic historians, was finding was this process of diffusion was much more central. And you mentioned that diffusion, by my account, is the spread of a technology across a population of users. And diffusion points to the role of these general-purpose technologies, because for foundational transformations that have the effect to pervasively, that have the potential to pervasively spreading throughout the entire economy, the potential population of users for a GPT is essentially all the sectors of the economy. It's not contained in just one industry. That's what makes AI fundamentally distinct from electric vehicles or quantum. And so that's what I was finding in all this historical research, that the country that achieved technological leadership in these past revolutions was actually not necessarily the one that was the innovation leader, but it was always the country that led the way in terms of diffusion of a general-purpose technology throughout its own economy.

Fredrik Erixon: And I mean, as you pointed out, and we will come into this a little bit later too, I mean, the cotton textile sector in England in the first industrial revolution. So, we would hear then, if we say a more classic approach or a more past approach to it, we would be fascinated with some of the original innovators. And we would think that these innovators, even if they were technicians or if they were scientists, and perhaps sometimes they're more businesspeople, they're entrepreneurs.

I mean, classic Joseph Schumpeter type of personality. And we would say, well, look at the major achievements they accomplished. And as a result of that, England parachuted itself into enormous economic power.

And as a result of that, it also pressured down the Netherlands and achieved, if not global dominance, at least something which would be at that point akin to global dominance in technology and economy. And that's why it became a great power. So that's the leading sector theory, right, that you're talking about.

Jeffrey Ding: Yeah, I think that just very briefly, that is very much the leading sector theory and the emphasis on heroic inventors, and which country can create the most brilliant Silicon Valley or make sure its cutting-edge crown jewels don't leak to other countries. That's the focus of what the leading sector approach suggests in terms of institutional adaptations.

Fredrik Erixon: Yeah, yeah. A couple of other theories that can be kicked around would be some, perhaps more institutionalist. They would focus on, well, there was a, let's say we go with the example of England again, there was an institutional environment that was susceptible to a new type of economic activity.

Others would point to, for instance, the role of geography. And you will still hear that association also, just to stick to the case of England again, I don't want to focus upon England, but just to stick with it, that they had a geographic position that was attractive, they became a sea nation, they were a little bit between different continents in terms of the time zones, they developed language, etc. So, how do you see your own work and your research, your theory, how does it fit with sort of these other forms of explanations that we've seen in the literature on why some countries become great powers?

Jeffrey Ding: Yeah, I think it's really important you're calling out these other very general explanations. I think we should be precise here in terms of this book not claiming to be the end-all be-all overarching explanation for why Britain became a great power. It's trying to ask and explain a much narrower question which is if technology played the driving role in Britain's rise, how did the technological advances of the First Industrial Revolution actually enable Britain to gain leadership?

And so, specifically, how did it enable Britain to become the economic leader in terms of productivity and economic efficiency, surpassing its other industrial rivals at that time, France and the Netherlands? And so, the title is a very broad title, but the actual endeavour at hand here is a little bit narrower. So, for some of those other explanations, I'm not engaging with as much, but there are people who argue, for example, that geography played a critical role in Britain being able to take advantage of iron-based machinery, which I see as one of the key general-purpose technologies at play here.

And the argument there is because of the wealth of coal resources and easy access to those coal reserves, Britain was able to leapfrog ahead here. And so, in the First Industrial Revolution case, I go back through and sort through that explanation and I find that it shouldn't have played a determinative role because at the time when iron-based machinery started to take off and diffuse throughout the British economy, the Netherlands already had cheap access to coal by that time. So, it doesn't explain why the Netherlands wasn't able to take as much advantage of it, and to a lesser extent, France as well.

And so, my explanation for why specifically Britain was able to adopt iron-based machinery throughout all different sectors of the economy was that it wasn't about the heroic innovators like James Watt. It was about this higher degree of average technical literacy, just more and more competent engineers with general applied mechanics knowledge, who were able to spread this general-purpose technology.

And so, that does interact with some of those other broader classes of explanations you mentioned. So, I've benefited a lot from Margaret Jacobs' work, where she finds that Britain's rise was very much connected to this intellectual curiosity, this openness to new general techniques like the scientific method. And I think that intersects with this idea of a broader pool of talent in applied mechanics. So, maybe my story there is just a little bit more specific, a distilled version of that story.

But for some of the other broader explanations, they might not be tackling my specific question of how this technological revolution leads to this economic growth differential between Britain and the Netherlands and France?

Fredrik Erixon: And in that context, it is, of course, important to note that, well, if we take a very long sweep of history, you can make the argument that technology always has played a role in terms of generating nations or regions that become economically powerful and that can use that power in order to achieve sometimes economic and sometimes non-economic objectives. And we can go back to Rome, at least, in order to sort of track that story. But what's important is, and I think you make this observation in the book as well, which is that the Industrial Revolution basically accelerates the role or re-emphasises the role of technology when it comes to global competition.

And suddenly, we begin to enter into a world where many of the other factors that historians or others perhaps would have stressed when they looked further back in history aren't becoming that important anymore. For instance, access to raw materials. Or we can go to the contemporary discussion now, and you're going to find a lot of people pointing to, for instance, access to energy, access to oil or access to gas.

And they're going to say, well, America is in a fantastic position with all its energy reserves in order to compete in the future and to be a powerful, great power in the world. But the important point here is the dissociation of many of these factors for understanding why some sort of nations or regions become very powerful over time. And it's much more connected to technology.

Jeffrey Ding: Yeah, you're exactly right. And that was one of the decisions I was making in terms of how far back in history I should go? Should I look at Portugal's rise and fall or the Dutch's rise and fall even before the first Industrial Revolution?

And to your point, I start with the first Industrial Revolution because that is when it does seem like technology is playing a much more significant role in shaping which countries rise and fall. To your point about energy security and contemporary applications of that, I'm not saying access to natural resources doesn't matter for some aspects of power. You might not want to be overly dependent, for example, on a single source for energy supplies.

But for me, in the long term, if I could only pick one variable that the fate of the rise and fall of nations rested on, I would pick economic productivity because that is the key ingredient to long-term economic growth. And we've seen historically from great work by historians like Paul Kennedy, they've shown that countries achieve economic leadership first, and then they translate that into military and geopolitical influence. And so that's why the book focusses on economic productivity.

Fredrik Erixon: Yeah. So, let's go into economic productivity a bit more and especially to contrast these two different schools of thought that you work with. And then, of course, you focus on one of them.

But we have already talked about them already. But I think it would be useful just to lay them out a little bit more, and what they entail in terms of what factors we would look at in order to understand how one country can become a great power. So, the first theory is the leading sector theory.

And the second one is the diffusion theory, and the diffusion of general-purpose technology, more specifically. And in the first place, so perhaps just a terminology issue, would you agree if we say, when we say diffusion, we basically mean adoption, we basically mean widespread adoption of technologies, right?

Jeffrey Ding: Yes, exactly.

Fredrik Erixon: So, if we contrast these theories and we would start to categorise different themes that we would like to look at, factors to understand great power rises, how would you contrast these two different theories or these two different approaches against each other?

Jeffrey Ding: I think there are four main differences. And I'll group them into those that match differences in the technological trajectory. And then the last one is based on what that implies for the institutional and policy adaptations that countries should make. And so, the three differences on the technological trajectory side and the pathway side between leading sectors and my GPT diffusion theory are, first, the time frame when these technologies make their impact on the economy.

And for leading sectors, it's these fast-growing industries that have almost immediate impacts on shaping which country rises and which falls. And for general purpose technologies, we know they take a really long time to work their way throughout the economy because every single application sector has to develop some complementary innovations and re-shift processes to adapt to this new industry, right? The AI industry itself doesn't matter unless it gets the construction industry, the education industry to shift their practices and actually integrate AI.

Same thing with electricity, same thing with the steam engine. And so that process takes time. So, we know from these past examples of GPTs, sometimes that the process of diffusion into economy-wide productivity boosts takes four decades.

That was the case with the electric dynamo and the US's benefits from wide-scale electrification.

Fredrik Erixon: Just a question there, Jeff. So, has that period shrunk over time? Meaning, did it take a longer time for these general-purpose technologies to spread widely historically, and does it go faster now, do you think?

Jeffrey Ding: I think it has shrunk a little bit. Nicholas Crafts did some research on this point. But even with the computer, everyone assumed, Oh, now we're in the information age, things are going to spread very quickly. You don't need to build a lot of new infrastructure to enable the spread of computerisation.

But still, there was Solow's productivity paradox. You see the computer everywhere, except in the productivity statistics. And it took decades for information and communications technologies to eventually make their mark.

And it's a big flashpoint now with AI, right? That's one of the points of pushback that people tell me is, can we really take so much from the lessons of history if technology spreads so fast nowadays? But I think there are still lessons to be gained here.

Fredrik Erixon: No, I agree with you. And I'm just going to labour on this point a little bit more, and then you can get back to the explanation that you started. So, I think many people are sort of pretty flippant about the time issue that you're talking about.

I mean, you sometimes see memes coming out today to say, well, Instagram managed to do in one year what Christianity took six centuries to achieve in terms of having X adherents or X subscribers or whatever it is. And of course, it's easy to say because getting a social media app or something else is basically cost-free. It doesn't really commit you to do anything.

It's an adoption, which is very general. It doesn't come with an intensity dimension to it in the sense that that type of adoption requires something that needs to change. And what I'm curious about is, in the first place, I mean, taking an economic approach to innovation and technological shifts, they do require a lot of organisational change.

And they do require a lot of destruction of existing capital in order to make space for something new. And of course, that's not a process that has necessarily become easier over time. Simply because, I mean, if you think about, for instance, you want to revolutionise healthcare with technology.

One thing you need to bear in mind is that we have invested more and more human capital into the organisation of healthcare. And technology can have the impact that you need to destroy some of that human capital in order to make space for something new. So, if human capital is one of the production factors that become more important when you add more technology to something or when you are in a technological shift, it doesn't necessarily, it may even be the result that this period is going to take a longer time.

And if we talk about, and that leads me to my voice, which was my sort of question, which I'm curious about, which is basically, so when we talk about the AI revolution right now, do we really mean AI as we think about it now or as we have thought about it over the last five years? Isn't it more appropriate to think about this as a broad wave of data science application revolutions, which started a long, sort of long before the arrival of large language models and the applications of AI as we see today?

Jeffrey Ding: Yeah, so let me touch on two things that you mentioned before I return to that last question. I completely agree that when it comes to adoption, we throw around really flimsy statistics today. I don't, it's very important to separate out the costless adoption examples you mentioned from, and I like this word you used, the intensive adoption that you'd need for a GPT.

And so it's not enough for one employee at a company to play around the ChatGPT or businesses to say, hey, we're going to adopt AI or Chinese hospitals to say, hey, look, we've integrated DeepSeek, when it's really just a publicity stunt. And so that intensive adoption does take organisational change. It takes human capital upgrading.

It sometimes requires getting rid of vested interests and established interests. The organisational change, I'll give an example from electricity. You had less intensive adoption of electricity in factories in the U.S. when you shifted away from the central shaft and belt system, where you had a central steam engine and all the different machines in the factory were powered by a system of shafts and belts. Initially, electricity was adopted through something called a group drive system, where now you have different generators and different electric dynamos, and they're powering groups of machines instead of just one centrally based system. But electrification didn't become intensively adopted in factories until they figured out, we need to completely restructure the organisational layout to be a very decentralised one in which each individual machine can now be powered by electricity. And so that was known as the unit drive system. And so these are organisational changes that take time and take work, take trial and error to come to fruition.

On your specific question, where do we date the start of this general-purpose technology of artificial intelligence? You could go back to the 1960s statistical approaches to artificial intelligence.

In the book, I dated it to 2012 with the AlexNet submission to Stanford's ImageNet competition that proved this approach of deep learning was going to outperform these past approaches, these older versions of AI. And so, with that submission, it really kicked off this whole paradigm of deep learning, on top of which all these new breakthroughs in AI are being built. And so that's where I date it.

And so, by that account, it's already been almost a decade and a half since this new paradigm was incubated. And so, if historical trends hold up, for my purposes, I don't see AI making a huge impact on economic productivity, even in the earliest adopting country before 2030.

Fredrik Erixon: Hmm, very good. So let us go back to where I interrupted you, Jeff. So, you were talking about the four dimensions that you prefer to look at when you contrast the diffusion theory with the leading sector theory, and the first category we discussed was time.

So, the other three, what are they?

Jeffrey Ding: Yes, so the impact time frame is first. Second is the phase of technological change determines relative advantage. And so, for leading sector theory, that phase is innovation, which country can have the frontier firm or the frontier university or that heroic inventor that generates this new breakthrough or that first commercialises a new product or process innovation.

On the other side, GPT diffusion theory says it's about that phase of diffusion, the phase in which a technology spreads across a population of users. There, it's more about which country is the leader and has that comparative advantage in diffusing the general-purpose technology across its entire economy.

The third phase is the breadth of economic growth and technological change. Is that concentrated in just one or two great sectors, the leading sectors? Or if it is a general-purpose technology at work, we should see broad-based technological change and broad-based productivity growth, not just concentrated in a few sectors. And so those three show a very different technological pathway for the GPT diffusion story versus the conventional story.

And once you have a sense of how these technology pathways differ, that's going to suggest very different institutional factors that are going to be the most salient for countries trying to compete in these industrial revolutions. And so, we could talk about a wide set of institutional adaptations just for the purposes of the argument in the book. I focus on skill formation institutions, just in part because I think human capital permeates every other institutional aspect and is one of the biggest bottlenecks to technology adoption.

And so, in the leading sector theory, it's about you cultivating the best and the brightest and deepening this pool of talents, protecting those inventions coming out of the heroic innovators from leaking out. For GPT diffusion theory, the key institutional ingredient is education and training systems that widen the base of engineering skills associated with a GPT, because that helps standardise and systematise the knowledge associated with a GPT and allows a broad pool of talent that can implement and adopt a GPT across all different sectors of the economy. And so those are the four key differences between the two theories.

Fredrik Erixon: If we take a historical example then, and we've already covered one historical example that you go into the book, which is first industrial revolution in England, but let's talk about Germany and United States, because that's another epoch and we're now sort of in a second industrial industrialisation phase, so we're basically talking about late 19th century. And I find this, it's a fascinating chapter in your book, and it touches upon some of the issues that I observed when I was reading it and what you were talking about now. So, coming into that era, you can make the argument that Germany was the birthplace of modern science, where you started to have the first universities, the first categorisations of scientific endeavours, especially in subjects like chemistry.

So, Germany becomes this hotbed of university-based talents with lots of, I mean, these are some of the names that everyone is going to recognise if we talk about them, that come out of Germany. And of course, there are economic and firm-specific examples that speak to that nature as well for Germany. But you make the argument in the book that, well, that may be true, but hang on here, we shouldn't put too much emphasis on that particular fact and we need to understand that something else was happening in America with a connection to chemistry, but it was with different forms of applications that came from it and that became much more powerful in understanding how do you use this particular science in order to have a more widespread impact on the economy. So, can you sort of walk through that particular episode and talk about it?

Jeffrey Ding: Yeah, Fredrik, you gave a much better explanation than I could have given. It's a great summary. I think the thing that I would add here is an important point of background for the second industrial revolution case, which is discussing the 1870 to 1913 timeframe, when we see the relative decline of Great Britain in terms of economic strength and the rise of the US and Germany.

A really important piece of background, and it's connected to our earlier discussion of productivity and what is important for economic leadership. Germany never surpasses Britain in terms of economic productivity, total factor productivity, whereas the US does. In many ways, what we saw with World War I and World War II was the US leveraging that productive base of its economy to translate it into military strength, and so it's a really important outcome that the US becomes the preeminent economic power here.

So, the key, as you were saying, is to understand how the US took advantage of all these innovations that were coming out of the second industrial revolution to become the preeminent economic power, not Germany? Even though in the most advanced, most science-based sector of that time, the great leading sector, the chemical sector, Germany was dominant in terms of exports, global production of synthetic dye stuffs, which are a key product here, and the US was sending its best and brightest to study for PhDs in chemistries at German universities. And I think what the US is doing in the field of chemical engineering is really instructive here, because it does follow that GPT pathway, where the US is not monopolising new innovations in one sector, the chemical sector, but it is on the frontier of institutionalising chemical engineering practises at different schools like MIT.

And there, the impact of chemicals is not through exports or a single industry that monopolises innovation. There, the impact is through who can adopt this general set of practises, chemicalization processes, like titration, crystallisation, and integrate them into this chemical engineering discipline that then spreads to affect not just synthetic dye stuffs as just one industry, one application sector, but food preservation, petroleum, all these other different sectors that use chemicalization processes. And so, I think that's a good distinction that shows you don't necessarily, it's not a necessary component, leading sector, that leading sector's story, that leading sector mechanism is not necessary. It wasn't necessary in the US case in terms of rising to economic leadership.

It was the GPT diffusion mechanism that was more at work here.

Fredrik Erixon: Indeed. Taking that parallel into more modern times, then, and going to sort of give one supporting example, and then I'm going to play a little bit of devil's advocate when we think about where we are right now in a technological cycle. So, the supporting part of it would be if we think about some things that have changed, compared, for instance, to the late 19th century and the second industrialisation phase that you just talked about, is, of course, cross-border connectivity right now.

So, if we talk about the ideas economy, the generation of ideas, I mean, the cost of creating new ideas may have gone up, but the cost of adopting ideas that others have created has certainly gone down. I mean, the easiness right now that you can access lectures, seminars at top universities in the world just online, if you actually want to be part of an understanding of where frontier science is, it's so much easier to do that today. So, transaction costs for accessing new ideas have gone down.

And I think that's important also when we think about where we go from here right now, which is that leading sectors and thinking through that first category in terms of time frames that, you know, birthplaces of different things don't really matter that much probably. And sort of it perhaps even matters much less than it did in the past, as well, because it's so easy to copy good ideas right now. It's so easy to transfer skills, transfer organisational knowledge, leadership know-how, management theories for how do you how do you build organisations that can work with new knowledge and with new technology.

The contrasting theory, the contrasting idea that you can hear sometimes, and I wonder to what extent you would and how you would reason around this fact of today, is that some people will say, well, that's all true. On the other hand, it's also the case that the human capital intensity with new technology has gone up. So, it's not as easy to think about skills formation today as it may have been in previous technological shifts because the degree or the time you need to spend in a school or university in order to have the knowledge required in order to understand what you can do with all this is has gone up. It's much higher than it used to be. And that means you're probably going to find a pattern of development where you see more economic activity and also more productivity being generated from university environments that you will see that there is not necessarily limitation for the distance it can spread from university, but just significance of places of deep learning, places of high reputation when it comes to deep learning will play an increasing significance. And that significance is also going to be cross-sectoral. So, even if you say, well, Silicon Valley or MIT, you have lots of talent, lots of new ideas, lots of new technology that comes out, but it can be applied in many other different sectors, not just tech or pharma or whatever we're talking about.

So, how would you reason around that issue when we think about technological shifts today?

Jeffrey Ding: So, a few things. One is on your first point, which is accelerated globalisation, some might say that makes diffusion maybe not matter so much because ideas just spread so quickly now. And so, it is still more about who's first and who can protect and marshal all the innovations within their own borders. What was really interesting as I was doing this research is the fact that cross-national studies, especially this Andrews et al study, I think it is Andrews, Criscuolo, and Gal, 2015.

They find that, yes, there's been a reduction in the gap between networks of global multinational firms and frontier firms and universities and all these different countries adopting new innovations, that the gap is shrinking, less time for these innovations to travel across borders. But the gap within each country, the gap between those multinationals or their frontier firms and intensive adoption by the entire economy, that gap has actually only increased in recent years. And so, that might point to the added importance of GPT diffusion when it comes to how this current era differs from past eras.

Your point about how education and skill infrastructure are changing throughout time is a really important one because we've seen in the past, in the first industrial revolution, that skill infrastructure is not in universities. That is sometimes in mechanics institutes, that's sometimes in just like evening lectures held by different societies that are just trying to transmit and share applied mechanics knowledge.

In the second industrial revolution, which evolved into these land-grant institutions in the US and these emerging schools like Cornell and MIT at that time, but there were also other technological institutes like Stevens. And so, there's still a mix, even though it's becoming more and more formalised.

And then in the third industrial revolution and today, as you were saying, we see a lot of this education being formalised in universities, this engineering education. I think what's hard to predict, but still interesting to speculate with in terms of AI, is that, on some level, I do think it will still, like universities will play the central role, but the open question is to what extent will there be more lifelong learning that needs to occur?

And are there alternative pathways to getting that learning through certificate programmes sponsored by companies, or to what extent can open-source software communities of practice help facilitate that type of learning as well? So, those are the questions that are still on the table here.

Fredrik Erixon: Let me just take this to the close and try to bind this together, and coming back to great powers. So, I mean, one interpretation then could be that a country that wants to, or a condition for a country that in modern times would like to rise to great power status or maintain, it would be to have networks probably centred around universities that are of very, very high global standing. So, they attract talent from across the world and from different sectors, and there is a sort of spillover coming from these environments into the economy.

So, that's obviously one factor to think about, but if we go a little bit further and perhaps start with how you would characterise great power competition today? I mean, I think simplistic perhaps, but a pretty common view would be to say that, well,

America is, it has all these fascinating tech firms, but it's a development which is highly concentrated in a few sectors. So, that will sort of confirm your diagnostic here of sort of being careful about leading sector theories because productivity development in other sectors, then basically tech and pharma, hasn't been that very impressive in America. But obviously, there is a development within these two sectors that is impressive, and they create capabilities for a great power status.

China has its own problems, but it's on the rise. It's on the rise even more with AI, and going into quantum, we're probably going to see technological developments that speak to the characteristics of the Chinese economy, perhaps even more. I'm not saying I believe this myself, but I think it's a pretty common view out there.

And then we have Europe, and Europe will be sort of more looked at as a sorrow case than an optimistic case for a lot of people. It's a region in relative decline. It hasn't really managed to keep up with the pace of change which has happened in the last say 15 to 20 years. It was a tech leader until the beginning of the noughties, but has ever since then declined. So, if these are the propositions people would come to you with, what would you respond to them?

Jeffrey Ding: Yes. So, my conclusion in the book and the last chapter is all about drawing out the lessons learned from this discussion of theory and historical examples, to the question of whether AI will lead to a shift in power with the US and China as the two main great powers vying for leadership. And my conclusion is that I still think the US is very well positioned to be the leader in adopting AI at scale.

One of the things I focus on is oftentimes, we think of strategic industrial policy or strategic technology policy as protecting key sectors or export controls or funnelling a lot of R&D into an industry. For me, education policy is a strategic industrial policy for a general-purpose technology. And so, to me, it's not about the US's elite universities.

It's more about the US having a wider bench of universities that can train average AI engineering talent. By one of the metrics I collected data for, the US has 159 of those universities that meet a very low-quality baseline for training average AI engineers. China has 29 of those universities.

And so, I think there's still a big gap here. Some of it is also how strong the linkages are between different parts of your science and technology ecosystem. Do your universities collaborate with your industry players? Do the implementers talk to the innovators? And one indicator of that is hybrid publications in AI. How many publications have at least one co-author from industry and one co-author from academia? The US leads the world on that metric. China's pretty middling on that front.

And so, those are some of the things I draw on to make this case that the US is very well positioned to win the AI race, at least how I conceptualise it.

I have to admit, I haven't looked at all the data for Europe, but in terms of this GPT diffusion story, I think it's a pretty optimistic case for Europe as well. At least, if you're only maximising or optimising for this economic productivity outcome that I care about. Of course, Europe, with Eurostack and concerns about the reliability of the US as a partner, has to also balance these things with technological autonomy and sovereignty concerns.

But if you're only maximising for economic productivity, for Europe, it doesn't matter that they don't have the technology giants. As long as Europe can diffuse faster and adopt AI at a more intensive scale, Europe still has a chance to be in this competition. And so, the thing I'll end on here is that the timeline here really matters because if you think of AI adoption as this marathon, not a sprint, then maybe prudent regulation is going to lead to more trust in these systems over the long run.

Whereas a lack of regulation in China and the US could lead to accidents or a severe loss of trust in these types of systems in those countries. And so, there are still a lot of avenues for Europe to compete here as well.

Fredrik Erixon: Yes, and I would entirely agree with you on that point, that pessimism about Europe, even if I can be pessimistic at times, it's not so much about the potential, it's much more about understanding that things are changing and just being accepting of change and that type of mentality. And I'm more concerned to see that we have school systems and teachers and politicians who want to protect children from working with modern technology or using modern technology, it's sort of that type of cultural expression I have more problem with than other things. You can even make the case, and this would contrast with, for instance, Mario Draghi and many others, which is, and I agree with you, which is sort of the bigness of companies is not the point here.

It may even be that Europe has a strength in the sense that it has a very decentralised network of companies that are pretty sizable, they're pretty capable, they do invest in R&D, and they can move a lot faster than big companies can. And if you can utilise that strength, that can certainly play to your advantage. But Europe, just as America, has that fundamental condition, which I think is basically societies where you can organise around new ideas, and you can organise around new technologies.

And that is a pretty unique quality when you take a historical view and combine cultural, institutional, market issues, social policy issues, just to understand what it entails of actually having an economy where you are skilled at organising yourself and the way you produce around ideas. So, in that sense, I think optimism is called for as well.

Jeffrey, I think we are going to close here. I would have loved to continue talking to you because this was a fascinating conversation, and I enjoyed reading your book very, very much. And let me remind listeners that the book is called Technology and the Rise of Great Powers: How Diffusion Shapes Economic Competition by Jeffrey Ding, and it was published by Princeton University Press. Jeffrey, thank you so much for taking the time.

Jeffrey Ding: Thanks so much for having me on and engaging so deeply with the book.