DBS Flash

Kopi Time E180: Tech wave with Bain's Ravi Vijayaraghavan

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- *180th episode of Kopi time, a podcast series on markets and economies from DBS Group Research.*
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Welcome to Kopi Time, a podcast series on markets and economies from DBS Group Research. I'm Taimur Baig, Chief economist, welcoming you to our 180th episode.

Today we will discuss the astonishing tech wave we are encountering presently. Our guest Ravi Vijayaraghavan is the head of APAC technology and Cloud services practice at Bain and Company. He's also a member of Bain's global PE and M&A practices. Ravi focuses on global strategy, transformation, due diligence, profitability turnaround, and growth blueprint for technology and telecom clients.

Ravi, welcome to Kopi Time.

Ravi Vijayaraghavan

Thank you, Taimur. Pleasure to be here.

Taimur Baig

It's so great to have you. Ravi, you've had an extensive career dealing with all sorts of clients across geographies on the tech area. So, let's use your experience to cast a comparative lens on the current tech wave, the exuberance that we're seeing with the one, say, the dot com boom.

Ravi Vijayaraghavan

I've been in tech for almost 40 years. I guess I'm dating myself by saying that. But I cannot honestly remember a time that feels quite like the present time. And if I roll the clock back to that day in whatever November of 2022, I think it was when ChatGPT entered our vocabularies for the first time. In some ways it felt like, yes, this is exciting and this is fun, and look, I'm a geek and I studied AI in grad school many, many moons ago. And so, it was exciting and it was fun, and you expected, or I expected, we would see what we've seen till now, which is every one of these tech waves that seems to be on steroids compared to the previous one. If you think about how fast Instagram grew relative to Facebook and how fast TikTok grew relative to, they've all kind of compounded, if you will. So, if you go back to that point in time, I said, this is going to be bigger and faster, and sure it's been bigger and faster. Within a couple of months, 100 million users on ChatGPT. And then the amount of spending that started perking up right then, which again you said, it's going to be bigger and faster than before. That maybe isn't as much of a surprise. What I think is different is, I'd say maybe three things. The first is that this is truly pervasive, if you will, as a technology, what we're seeing now. You know, when you look back at the internet, it changed commerce, it's changed information, how we got information, how we collected information, and so forth. If you look at the mobility that came a decade or so after that, it changed, access and communications and connectivity. But this one changes seemingly everything. The ability of this technology to do everything from searching for data to analyzing to synthesizing to reasoning to acting. It's extraordinary. And so, what you're seeing now is it's just as useful for a radiologist as it is for a banker. It's just as useful for a software developer as it is for a student, for a journalist, for an artist. And so, I think the pervasiveness of this technology is actually truly different. We haven't quite seen the same. The second, and I'm sure we'll get into this some more, is the fact that it is actually self-improving. Again, human beings had to go and make Instagram better the next time around but this thing makes itself better on its own to some degree, every single time that any time you give it. That is quite truly unique. We have not seen quite the same thing. The third and I'm just back from a few days in Silicon Valley. You see a lot of excitement, you see some paranoia, but you see a lot of anxiety as well. And in a way, maybe anxiety with new technology is not new, going back to the Luddites of two centuries ago but you would say that most of the concerns were by people or groups of people who felt somehow, they are going to be harmed or hurt or left behind by it. But this time you're also seeing some of the most successful people who are benefiting from it, like the CEOs of OpenAI and Anthropic saying we need regulation. That's new.

Taimur Baig

Absolutely. And Ravi, as you know, a few weeks ago, a co-author of mine and I

collaborated on an article, and you and I have had some interesting exchanges around that.

Ravi Vijayaraghavan

And then you see Trump saying something to that effect, which is astonishing.

Taimur Baig

Indeed. So, the alarm of being disintermediated or dealing with something that is sort of out of control. I think it is rather unique in this wave because we never thought the internet for all its good and bad was sort of running away from us.

Ravi Vijayaraghavan

We never felt we were losing control. And I think there's a sense that we may lose control.

Taimur Baig

So, Ravi, let's talk a little bit about your last week's visit to Silicon Valley. Some of these numbers on CapEx, it's been going on for about a year or two. They just get bigger and bigger. I mean, tens, if not hundreds of billions of dollars. And if you add it up in the whole world's investment in the trillions. Isn't it a bit risky to have so much money going into one sector?

Ravi Vijayaraghavan

It is mind-boggling sums of money. We throw around one trillion these days like, honestly, like it's nothing. Everything is one trillion. It is unfathomable. A billion is a lot of money and a trillion is truly something. So, take two or three aspects of it. So, yes, it is, I don't like to use the word too often because I see it everywhere, unprecedented, but this is something we haven't seen before. So even at the height of the internet fiber build out, we were talking about USD100 billion a year, which in today's dollars equates to a little less than USD200bn, let's say. And now you're just saying the big four, the MAMAs, as I'd like to call them, Microsoft, Alphabet, Meta, and Amazon. They alone have committed to about USD700bn this year, and projections by analysts and so forth say it might be close to USD1trn next year. Now, you peel that apart a little bit. So as of this point, there is a demand for the service that they're not yet able to fulfill and hence the frenzied build out of data centers and stuffing them with GPUs and so on and so forth. So, the age-old question is fine, if you build all of this, will the business come? And so that is a question that they're dealing with. And you see all of the arguments on both sides. On the one hand, there are folks who would say, look at their backlogs, and just between Amazon, Google, and Microsoft and Oracle, they have a backlog of about USD2trn. And so, I said, wow, ok, so they've already got commitments for what they're doing, so it doesn't feel quite as risky. But about half of that is to companies, to customers who at this point do not have that money to spend. Right now, they may get that. So, there is a lot of froth and, of course, they're getting the money because some of these companies are investing in them. So, there's that element of circularity and all of that as well. So, I think there is certainly a risk to it, but I would say two things. First is many of these players, especially the Googles and the Microsofts, Metas and so forth, have enormously profitable and scale-based businesses. You know, Meta has by various estimates spent some tens of billions on AR/VR and that hasn't quite paid off, but they're fine. They're here to spend the next on the next wave. So, they have great businesses, unlike some of the companies that try to extend themselves or extended themselves in the dot com. I think that's clearly one thing. And the second thing is, look, maybe some of this is a bit frenzied and so forth, but in the end, society probably still gets a productive asset. The risk may be on the part of the individual companies. And I think some of the risk is just a timing risk because unlike railroads which last decades and fiber optics, which also lasts a few decades, GPUs have a shelf life of a few years.

So, can they afford it? Yes, they can. Are they really stretching themselves? And if you look at how much they're borrowing or issuing more stock and so on and so forth, they are stretching themselves. But they also have enormously profitable and stable core businesses.

Taimur Baig

Right. Ravi, I think the systemic risk or the conjunctural risk that we talked about, I think independent of other things that we will discuss today in terms of the promise and the potential of this technology, I think, almost like an additional issue. Because one is the truly exciting aspect of this, and we'll talk more about this. And the other is that, could we be getting ahead of ourselves to some extent? And are there some systemic risks? So, I will share with you one or two concerns that I've found on myself. One is the interest rate issue that the US economy is running very hot. Long term interest rates are going up. And there is a degree of leverage with the VCs, the sovereign wealth funds, or the other asset managers who are pouring money into the OpenAI and Anthropic of the world, who are then generating massive demand for the services and hardware from TSMC to Nvidia and so on. And would then significantly higher interest rates spoil that or not. You could also argue that to some extent, that was the pin that pricked the 2001 dot com bubble, the likelihood of rates going up. So that's one thing I worry a little bit. Second, and again, I suppose this can only become clear with hindsight, winners versus losers. That maybe there are three winners and five losers, but each of them have hundreds of billions of outlays. So, then who's on the receiving side of the losers versus the winners. But I suppose you've seen this in other cycles as well.

Ravi Vijayaraghavan

So, on the first one on the interest rates, it remains to be seen how much rates go up and how much that impacts what they're doing. And it was interesting that Google obviously chose to issue more stock (USD85bn), I think they raised it by five because there was good demand for it, I think. So yeah, and I just read a report that Meta is also considering something like that. So, I think that was, I think, quite interesting because and I'm sure some of the concerns that you just pointed out might have underlay their decision to do that. My sense is probably what pricks this bubble is demand not materializing in the way they're expecting. And what do I mean by that? So, if you look at some of the demand projections and so forth, ultimately, it's assuming that there will be enough customers who want the frontier model and they will pay for it. Because the frontier model costs a lot more, if you will, on a unit basis, cost per token or a million tokens, whatever, much more than the trailing models. And the only thing I would point out is, today, most users are still in the early stages and they're saying like, what can this technology do for me? And whether that's software companies that are using the technology in turn to give it to their customers, or its companies using it for themselves, we're tending to use a lot of the frontier model. I mean, I have to check myself every so often when I'm playing around and something, it's like, this doesn't really need a frontier model, but I'm just using it. So, I think when things start to stabilize, I think companies will find that a lot can be done with or without frontier models. That changes the monetization equation quite significantly. So, I think my sense is that the bubble will probably be most influenced by what we see as the demand pattern and less so on the interest rates, obviously, again, there's a threshold, if interest rates climb extraordinarily from where they are today, that would change. But my sense it's more demand.

Taimur Baig

And it's a fascinating subject, Ravi. I'm thinking about it a lot because lately, Vivian Balakrishnan, Singapore's foreign minister, when he gave that speech where he said that in the context of foreign policy and government security, but it applies to banks like mine or a company like yours where we have to deal with client data and worry about opening these things up to external models. And his point was that I don't need a frontier model. I'm trying to organize certain notes and certain insights, a model that is open source and can be hosted in my MacBook is probably almost as good, sufficient for my work, and I will use that. And then of course the need for playing monthly subscription to the frontier model goes down.

Ravi Vijayaraghavan

Correct. And I was actually reading something, when you fly to the US and back, I'm sure you have the same thing. You catch up on an enormous amount of reading. And, by one of the startup CEOs and an AI native startup, and it's well known, and I can't recall the name right now, who's making the point that it's not economically viable for his company to use a branded model, let me say versus open source, to be able to do offer their software on a at a competitive price to customers. That you have to get the open source and then essentially rent out space on a GPU farm to run it because that was the only way that he figured that he could get that to be competitive. Look, its early days, and I would say this cuts both ways, meaning, I'm not convinced that the pricing for tokens yet reflects actual cost of producing the tokens. Subsidized, it's a land grab, and everybody knows that. And that's part of the reason to the extent there's an overspend. It's an overspend because it's a land grab. At the same time, I think on the other side, the token cost optimization, if you want to call it, I don't think has really happened at all, right? We're not yet thinking about how can I get this same work done at the lowest cost in terms of tokens. Right now, we're still, ok, how can I get this work done really well and can it get done even better and, so forth, and that's where we are.

Taimur Baig

Yes, I mean, at least the previous tech waves show that the marginal cost of producing that new value added will be going down, and that would be the source of profitability. We're certainly not there yet. Now it's just a question of build out.

Ravi Vijayaraghavan

It's interesting the pricing for frontier versus non-frontier, you can see the price curves, if you will, and how they've gone down right the moment something ceases to be frontier. But I think the flip side has been that most users, companies as well as individuals have still opted for the frontier because you like the whiz bang stuff that you get and token usage has gone up. So, more token usage at the frontier model obviously means a lot of spent.

Taimur Baig

Ravi, in the last couple of years, we've seen the OpenAIs of the world sort of looking for consumer centric solution and Anthropics of the world go for enterprise solution. And it seems like the market is more impressed with those looking for enterprise solutions. So, share with us your thoughts on this consumer centric versus enterprise centric solutions from the AI companies.

Ravi Vijayaraghavan

It's an excellent point. Again, I think we should recognize that these are early days and probably be careful about drawing too many lessons from the early days. If you step back and look at the technology timer, as we've been talking about, this is so general purpose and so widely applicable that in the longer run as it becomes kind of the way we do things in in both our personal and work lives, and you and I are probably not unique in that we use this for work, we use this outside of work, and it's become natural to do both of those. And so, I think over the longer term, it will be both, without a doubt. What I think we are seeing right now is that the enterprise offerings, are much more monetizable than the consumer direct to consumer offerings. I'll clarify that in a moment. And even within the enterprise, what is quite clear is that the coding tools are probably the tip of the spear as it were in terms of ability to monetize. And that's maybe not entirely surprising as a one-time programmer myself. A coding tool has an enormous code base from which to learn, lots of code repositories. Programmers don't need a lot of handholding to use something new. And any good programmer is very structured in their thinking and very specific in the instructions. So, in a sense, they're well primed to make most use of the technology like what we have here. And then the last is the moment you develop code, the ability to validate it and test it is very good. So, you know that it works as opposed to if you're using it to write a piece. I mean, like there is no litmus test for whether this works or not

and programming that very much is. So, you can see why that is strong and why that's taken off. But I think from an enterprise perspective, and when I worked with my clients as well, you can see how workflows can be so dramatically reimagined with this technology, it's still a lot of pilots and experimentation and so forth. But you're starting to see them transition to more production and company-wide scale up and so forth. So, I think the monetization at this point is much easier in the enterprise side than the consumer side. The only thing I would say is, look, the big consumer players, the ByteDance and the Googles and the Metas are seeing a lot of value in incorporating this in their consumer-facing offerings. And that is already a big market. Whether that improves their ability to, as you know, in Google, you get excellent results, because it gives you an answer as opposed to just a set of links. Enormously valuable being able to target advertisements and so on and so forth. So, there's a lot of benefits, I think, but the direct-to-consumer revenue is still a bit slower.

Taimur Baig

And the fact that as of this week, OpenAI is going to be offering a broader set of suites, which includes Kodak. So, even the differentiation that I was making earlier, that OpenAI more consumer facing and Anthropic more enterprise, that is also beginning to dilute a bit.

Ravi Vijayaraghavan

I think and I just wonder if some of that is just a reflection or a recognition that in order to IPO, which obviously they're rumored to try and attempt and so forth, that's just the more monetizable part of the landscape at this point in time and I think it's quite easy to understand that if you can't do this and if you can't kind of IPO, do you kind of fall behind in the race and so forth. So, there's a little bit of a competitive dynamic there.

Taimur Baig

Absolutely. And even going just back to that opening example, a year ago there was so much fanfare around Sora being released.

Ravi Vijayaraghavan

It's gone. And again, when you read about it and kind of saying what happened, and it is a recognition as well to the point that we touched on earlier, that GPU capacity is still limited. So, if you're using it for a GPU hog, with image generation tends to be and that's not very monetizable, then you're taking the most valuable, constrained asset and using it for something that is simply not yielding the return that you want. So, I think it was a bold decision to say it was very popular and people liked it, but it was a bold decision, I think, to say, thank you, but no more.

Taimur Baig

Indeed. Although in the case of China, for example, we're seeing that these web-based mini soap operas that they used to have, they're like fully AI produced right now. They're churning out more content and seems like they're monetizable there at least.

Ravi Vijayaraghavan

Yeah, it does seem so. And this is again another fascinating element of this is the learning curve. You'll recall back in the day, the learning curve was a central reason why the market share leader in automobiles or automotive or so forth, stole a lead over the next, because they could just produce more, learn, and go down that curve. And you have that same thing again, in tech, which you have not had. Software has been a scale business, but not a learning business as much. And now, so I was reading this article, I think in the FT or somewhere, which said, because of exactly what you were pointing out. The video editing tools in China are actually better than the ones in the US because they have this massive learning curve that they have been through.

Taimur Baig

Just a bigger consumer database.

Ravi Vijayaraghavan

Much bigger consumer database and a lot of it again, I think points to me to the value of a free or a premium model because you get a lot of usage. And usage makes you better,

which is again, wasn't quite how much of software has actually worked.

Taimur Baig

Right. So, since you've used the word software a couple of times, I want to talk about that a bit. So, we've discussed enterprise versus consumer. But then when I look at the stock market performance, the hardware manufacturers, whether it's GPU or CPU, all the rage, and software companies under a lot of pressure that it'll be the Salesforces of the world. So, let's talk a little bit about these markets being very much in love with the hardware ecosystem and not at all with the software ecosystem.

Ravi Vijayaraghavan

Which is a reversal of what has been true for quite some time, actually, for years. So let me try to maybe peel that into the two questions because I think they're slightly different. So, on the hardware side. At the core of it, it's very straightforward. It's a picks and shovels play. We may not know whether OpenAI is going to come out on top of Anthropic or vice versa and, you know, Google versus Amazon or and so on and so forth. But we do know they're all going to need GPUs, they're all going to need CPUs, they're all going to need memory, they're all going to need hard drives. So, let's kind of go into that and plow in. And at this point, demand is certainly outstripping supply in many of those. So, pricing has responded correspondingly and that's why you're seeing these enormous profits and whether you call them windfall or you call them something else, enormous profits that are being churned out. I mean, you saw this stuff in South Korea.

Taimur Baig

Two companies now with one trillion valuation.

Ravi Vijayaraghavan

One trillion and Samsung had to strike a deal with its employees to share some of that. Because they were like, we need a part of it. We have kind of helped you get there. But I think there's an underlying element which is useful to touch on, which is over the past two-ish decades, in most of the hardware sectors and semiconductor sectors. It's come down to really a tied oligopoly, two, three, four players basically. So, you look at DRAM, there are three players. Samsung, SK Hynix and Micron. You look at SSDs; there's one more which is Kioxia in essence. You look at hard drives, it's Western Digital, Seagate, and Toshiba. But it goes all the way down when you look at lithography, as you know, there's only a couple of players of whom only one does the EUV, which is ASML. And it's true for the chemicals, it's true for the gases, it's true for the equipment. And so, what happens in times of demand outstripping supply is that they all do very well. So, in some senses, it's also reflective of the fact that there's been a lot of consolidation in these sectors because you go back over time, whenever these things happened, you go back to the dot com, there were still enough memory suppliers that during a downturn, one or two will say, you know what, I should use this to gain share and come out ahead.

Taimur Baig

There'll be brutal.

Ravi Vijayaraghavan

Exactly, brutal price war. Some will go out of business as a result. But once that happens enough times, you're left with where you are now, that everybody's careful about adding capacity, even if you add capacity, it doesn't come on anytime soon. So, I think hardware is reflecting the supply demand equation and the fact that it's an oligopoly. And until the demand pattern changes, I think it's going to be what it's going to be.

Taimur Baig

Ravi, before you go to the software, I just want to ask you a supplemental question. I was in Washington DC in April, and my colleagues at the IMF were telling me, somebody on the procurement side that laptop prices have gone up by 20% in the last one year. So, this demand that you're talking about is feeding into this frenzy of price increases for a wide range of electronics products. So, to what extent that's helping

the Hynix of the world and is there a risk that it could sort of eat itself because the prices are going so far up?

Ravi Vijayaraghavan

Yeah, I think what you're seeing is actually a result of most of the hardware players and semiconductor makers diverting capacity to serve the AI segment because it is so lucrative. So, high bandwidth memory, as you know, has been super important for AI and well, if I have some capacity that I can direct to make DRAM or high bandwidth at this point in time, what's more lucrative. So, I think what's happening with the laptop prices and so forth is reflecting a shift in the manufacturing capacity to serve the AI data centers over consumer applications. And so therefore, again, supply demand, there's not enough of it and that's what you see.

Taimur Baig

So, the rising tide is lifting all the stockholders' boats, but it's also raising the price of our pocketbook.

Ravi Vijayaraghavan

I mean, phones, again, because it's all the same elements. I mean, TSMC capacity is finite. Everybody wants to use that because they have 80% or 90% of the smallest node capacity. So, again, that can only do so many things.

Taimur Baig

So, we might have to settle with a 7 nanometer chips for our phones for a while, given that all the 3 nanometers are going to the data centers.

Ravi Vijayaraghavan

Indeed. So that's hardware. So, I think it's reflecting just the supply demand, the tight oligopolies in most sectors. And until demand pattern actually changes, it's probably what it is because supply takes a long time to come on. And look, if you're a hardware player, you want to be careful not to add supply, and if the demand then kind of softens, then you're stuck with a situation where, again it's feast or famine.

Taimur Baig

We've seen this in the past with DRAM in particular.

Ravi Vijayaraghavan

With memory in particular, correct. We've seen this in the past. So, they're being very careful, rightly so. Software is actually quite a different one, and I think after many years where software was a was a darling sector, if you will, of investors, I think the concern right now is twofold. You think it's threefold, meaning there are new AI native software providers, and will they usurp the franchises of the incumbents? But that's a game we see playing all through and I don't think that's a new game. What is new is twofold. First is, with all these technologies and vibe coding becoming popular and all of that becoming popular, can enterprise customers do more on their own and essentially not have to rely on some of the software vendors that you mentioned for what they want. So, look, I still need an ERP system, but some of the reports and so forth that I need to generate from it, rather than paying my ERP vendor, can I roll my own. Because I can use some agentic technology, I can use some of these coding tools. Can I do my own? So that's one part. But I think the more fundamental question they have is, how far will the AI labs, the language model providers go in terms of functionality that takes over what today we rely on these other software vendors to do for us.

Taimur Baig

Especially SaaS.

Ravi Vijayaraghavan

Yes, and SaaS is obviously I think a broad term and I think that if you separate application software from more infrastructure software and so forth or tools like databases and stuff. I think it's true across the sector really is how much more would the language labs do, AI labs do, which take over the franchises of the Workdays or whoever else in the world. My personal view on that is evolving and I think this is where I am. You know, fundamentally if you step

back, what this software is doing, application software in particular, is enabling workflows. That can be a general ledger workflow in the case of an ERP, it can be supply chain planning in a factory context. It's enabling workflows or vertical workflows. I mean, medical transcription and project management in the construction sector and so forth. It's enabling workflows. These workflows, as we talked earlier, are I think going to change quite dramatically because of AI. You can think of a workflow today and say, you know what, I can get away with, do away with some of those steps. I can consolidate those others. This can be completely automated. This can be 80% automated with only a human in the loop to approve or do something. And the technology is so capable that previously you needed a guy sitting. If I had to approve an invoice, sometimes I had to look at four different systems, you know, four windows on my screen and say yes, ok, now I can hit the pay button on a fifth application. Yeah, I can do all of that. It can pull data from all of them, it can synthesize, it can reason, if it's straightforward, it follows the rules that you've said, you say fine, let's approve it and go. If it's not, it'll say you need to kind of review this and check in particular for X and Y and go forward. But that knowledge, that ability to understand the workflow, that nuance is really more with the application software vendors because closing the accounts in a company, there's lots of company specific elements. There are compliance elements, there's regulatory elements, and it's all not neatly coded somewhere on a sheet that you can just give it to the LLM and say learn from this. Some of it is the way you've configured your ERP system and what it does. Some of it is what people do and say, yeah, I know it's going to do that and I'm going to reverse it, and this is a, you know, all of these kludges, if you want to call them, that we have. So, there's lots of knowledge that's not just necessarily neatly captured in any format. And so, the application software providers really have that. So, in many ways, they should be primed to prosper, but their own applications now have to be very different. It has to be, in a sense, always on and watching, looking at what signals are coming in, take those signals, synthesize them, decide what action is needed, either execute that action or prompt for that action. But they also have to be continuously learning, continuously getting better. That means that it's not just about grafting on some AI capabilities onto your existing application, it is reimagining the application software from scratch. The ones that do that, I think, will actually do really well. And when I look at it in one way, I was just playing around last week, with using Claude and OpenAI and I try to use them to cross-check each other sometimes, but software spend in the S&P 500, and that's a crude proxy for S&P 500 because as you know, the components change over time. But sort of the 500 largest companies of America. So, IT spend over the last four decades has tripled from about 2% of revenue to 6%. Software spend has grown twice as fast, it's almost sixfold from 0.3% of revenue to 2% of revenue. And this I found fascinating, and again, I haven't fully validated it, but what do you think spent on people has been in the S&P 500 over that time? How has it trended? It's been roughly flat at 25. It's been in the range of 23% to 25% over that entire period. So, we've used software, we've gotten things better, things work better, I'm able to do more, I'm able to do it better, and all of that. But I'm not necessarily able to do it in one way of looking at it more efficiently. And I think with what AI brings, I can now break through the barriers of human ability and competence and competence. I can break through the rigidity of systems and like, you know, System A won't talk to System B and the organizational boundaries and actually change some of that. So, it's viewed one way. There's a lot of potential, but it requires a rethinking of the software itself.

Taimur Baig

Right, unless we solve for organizational rigidity, we're not going to be able to have these silos written down by software alone.

Ravi Vijayaraghavan

It is, and you know what we're talking about this in a somewhat dispassionate sense, Taimur. What this means is possibly fewer

people. And so, the societal impact is non-trivial. I know we're just talking about it how work gets done in a technology sense, but there's a societal element to this.

Taimur Baig

Absolutely. Although there, I try to be optimistic, which is that human capability of generating jobs for humans is substantial. You know, we have all sorts of jobs today, which would only exist in the internet world. And we probably could not have envisioned when the internet was coming to fruition.

Ravi Vijayaraghavan

Exactly. And I think there's two elements to that. And what I keep thinking about is, I too am an optimist, and I think we just don't know what we don't know and human ingenuity is always one. But what I think scares me a little bit on one side is just the speed at which some of this is coming, and to me the speed is probably the biggest change vector, if you will, compared to the past. And, you know, I do a lot of work in software and with software companies and the pressure to move faster and adopt this technology, become leaner, do more, and really when you think about it, slimming down is easier than speeding up when it comes to an organization. And the only way you really speed up an organization is remove the human in the loop in many things because inevitably humans are going to slow some of these things down. And again, in a dispassionate sense that sounds logical and so on and so forth. But the question is whether some of the slimming down will happen much faster than some of those new jobs arise. And that again is another challenge to deal with.

Taimur Baig

Right, I think Ravi, that frictional risk is substantial, and which is why I think even among the AI vanguards, just in the last couple of weeks, we have heard calls for slowing things down or equity partnership with a sovereign wealth fund to give some of the upside to the population. So, that article that Tony and I wrote seemed kind of a maverick thing to write, but whether it's Bernie Sanders or Sam Altman, people are now sort of joining the band.

Ravi Vijayaraghavan

Exactly, when I saw Trump's statement on that. But also, I think the statement, I mean, the pronouncements in Singapore about importance of protecting people as opposed to just the jobs. I think those are very important policy directions because you can see this technology and you can see that some jobs that we do today can actually do better. And we're not going to turn down progress. We just have to figure out how to absorb it.

Taimur Baig

Absolutely. Let's travel back to last week again, to your trip to Silicon Valley. You hear from all the tech visionaries this relentless quest for AGI. You don't really hear that when you go to Beijing or Shanghai. So, China's AI visionaries seem to be trying to crack climate change or population related issues, whereas the American entrepreneurs are very much about this all in kumbaya of an AGI. You like to sort of compare and contrast these two seemingly distinct approaches?

Ravi Vijayaraghavan

Do you think we're hearing less of AGI now that all the attention is on the IPOs of these companies and so on and so forth?

Taimur Baig

It seems a little bit of the hype has softened but it still pops up in the West Coast more than in China.

Ravi Vijayaraghavan

That's my sense as well, and inevitably I think one thing that has happened is that the commercial success of the current generation of technology and the push to capture the opportunity there and the race. I mean, these are all companies racing against each other has I think to some extent also refocused attention on the here and now and the improvements of today's model versus AGI. As you know, the whole question of AGI revolves on what is AGI really? I've read lots

of stuff. I don't still fully claim to have an understanding, and depending on your definition, you can say it's here now or it's going to be in three years or it's a decade or two out. Depending on whatever your definition is, whether it's, you know, as well as a human on certain cognitive tasks or self-improving and moving the frontier of scientific research, those are two very different definitions of what that can be. My take on China is actually a little different, which is that, think of where China is. They realized this is a transformative technology. One, they cannot fall behind, and yet they have their hands shackled in some ways. They don't get the best GPUs; they don't get the equipment to make the GPUs that they do make as powerful as they can be. So, they have some shackles and, in many ways, I think a lot of attention has gone to saying to how do we make the best of the constraints that we've got and still succeed. And you know, that's why I think some of the successes of the DeepSeek, which as you know, took the whole American technology world by surprise, whatever it was last January or something, when it when it came out, it is so important. And we can all argue whether, you know, it was truly five million to train it or a little bit more, a little bit less, but it was innovative. And they use different techniques to get performance levels much closer than anybody thought could be possible without throwing more and more GPU capacity at it. And so, I think China is at this point or the Chinese companies are more focused on not falling behind in what's possible with today's technology, as opposed to kind of what's the holy grail that we're trying to reach for. But I will say this, look and I know you have studied China for a long time. There's an explicit policy goal, intent of not falling behind, not lagging in the technologies that matter. And they've done an amazing job of that since they said that original policy, but a little more than a decade ago. And so, I cannot believe that they will think that is something that they don't care about doing. I just think you're hearing less about it, so much of the focus needs to be rightly on the here and now. And I think there's also some element of just being discreet about what you do and not necessarily shouting about it. But I would think many people are still putting some resources towards that because if that's going to be the next game changer, how would you not?

Taimur Baig

Ravi, I was in Shanghai two weeks ago. It was a semiconductor conference, which is something that I don't get to attend typically, but so it was a real eye opener for me. And the week that I was there was when Huawei announced the Kirin chips, new developments and how they've not sort of solved for lithography, but they're coming up alternative ways of reusing nodes without necessarily having to access to EUVs or UEVs. And that I thought was fascinating because this is exactly what Jensen Huang kept on warning the Trump administration about that by depriving China of the best-in-class lithography technology, sooner or later, they will be forced to come up with workarounds, which, I have, you know, talked to sort of some of these prominent authors of tech books in recent years, Chris Miller, Dan Wang, and so on. And even two or three years ago, the view was this was not possible by the Chinese. They just would not be able to find a workaround. But now it seems like they are pretty getting pretty close and pretty good.

Ravi Vijayaraghavan

Yeah, I think there's a lot of literature on that and look, they are, smart, capable, have lots of very, very well-trained engineers, and they're going at it hammer and tong because in some ways they view it as existential to be able to do this. Otherwise, how do you keep up with America and the West? So, I think they've made great strides. It's still not entirely clear, the economics of some of this is quite challenging because the yields they get often from these things are quite low. And as the chip size gets bigger and bigger, the yield becomes bigger and bigger issue. Because one small flaw in a 2 square centimeter chip still dooms the chip, and if it's a 0.1 square centimeter chip, it's fine. You get lots of chips per wafer. It's ok, I can deal with that. But if the 2 square centimeter, oh

my God, like that's a problem. So, it gets harder. I think the latest what I was reading is the sense is that it's going to prove hard for them to catch up because the West is also advancing. It's not as if things are standing still. So, the West is also advancing, but I think it's really important to note that a lot of the advances are not purely semiconductor based. I mean there is a lot that's on top of that. Whether it's the hardware subsystems and how you connect all of them together, the software and all of that. So, there's lots of other elements. China is a formidable competitor to the US, period. I don't think that changes. Like, is this forcing them to be more innovative and practical and stuff, yes. Will they entirely catch up? I think it's still quite difficult.

Taimur Baig

But just on your point of that developments being critical beyond the integrated circuit level, it's the whole issue around packaging, which is now science fiction territory. So, packaging itself is also sophisticated now.

Ravi Vijayaraghavan

Well, it's packaging, then it's how do you connect the different chips in a system at the fastest speed because, that's optical networking and photonics and all of that, so forth. So, it's lots of stuff and that's just at the system level. Then it's the programming architecture that sits on top of it. And then it's all the things that DeepSeek, for example, did, which has nothing to do with hardware. It is purely in software. So, there's lots of places you can innovate. So, I don't think that we should for a minute think that just because they don't have the most powerful CPUs, the end outcome, they're able to get will be severely restricted.

Taimur Baig

And some of this stuff is just so frontier. Ravi, one of the things that I saw in Shanghai, so there was this lady presenting, she was from actually Japan, but it works for a Cambridge University based company. And it was a very sort of frontier level of thinking on silicon photonics. So, electron age is almost over, can't really push many more electrons through those ICs. So, what about light? And then, and what are the challenges around that and what are the solutions around that? All the Chinese in the conference was fiercely taking their notes. It was absolutely fascinating. Since we talked about China, let's talk a little bit about the region to some extent. North Asia, we've talked a lot about Korea, but there's also Japan and Taiwan in that mix. Characterize for us, you know, where they stand in this tech wave right now.

Ravi Vijayaraghavan

They're essential to all of what we're seeing happening. Well, we know how important this region is, North Asia, but also Southeast Asia in particular, in terms of the supply chain for everything. Like all of those hardware things that you're talking about and, Taimur, you do this for a living, you look at these economies and they're all benefiting from the high demand for the electronics that they are making. I mean that has been an important part, I think, as you look at how well they have fared in the days since Liberation Day, I think you believe that this has been actually one of the elements. It's held up quite well. So, it's a critically important supply chain. But if you go beyond that, between what TSMC does in Taiwan, and it's not just the chip side, packaging is also very advanced in Taiwan. Between what the Koreans have in terms of the lock on some of the most, on memory and so forth. You know, the frontier in semiconductors has typically traditionally been three companies, TSMC, Intel, and Samsung. So, Samsung is right up there with them. But then there are many companies in Japan, and you've heard of the bigger ones like Tokyo Electron and so forth, but many smaller ones as well, which play crucial roles across the semiconductor value chain. Whether it's in equipment or it's in the materials, gases and chemicals and so on and so forth. Highly specialized, not too many alternatives at all. So, I think it's been the wave, if you will, has been good for many of these companies and businesses. I mean, again, we've got, until recently, America was the sole domain of USD1trn companies. Not anymore. And guess what? I mean, the first two outside of them were in Asia, not in Europe. So, it's been a central cog in that

whole semiconductor ecosystem. So, it's not just the manufacturing, but it's also technology and the product know-how and knowledge and the R&D and so forth. All of that has been crucial. So, I think when you look at these supply chains, they don't relocate very easily. But they don't relocate very easily because you're making typically very long-term decisions and so tariffs, you know, changing this way or that way. It's hard to kind of change in a in a jiffy and ultimately the cost will be borne somewhere, but ultimately the end user, I suppose, but cost will be borne somewhere. And also, many of these places have ecosystems that that that you need for all of this. Malaysia over the years has built very nice ecosystem in Penang across all of electronics supply chain, and it's just very hard to replicate that somewhere else. Yeah, so I think it's here and it's here to stay. And it's a nice time to benefit from all of those that hard work and investments over many, many decades.

Taimur Baig

By all means, Ravi, and it's not just since the reciprocal tariff days when we've had this new shock in the last three months with the Iran war and when the war began, the view was that we were going to have a massive supply shock that's going to hurt. Economic growth and overall policy stability in this region, we have done pretty well in the last three or four months. And the key driver in my view, is the fact that the tech wave is keeping the exports engine humming in this region.
Ravi, what about the Singapore, Vietnams of the world? We're not necessarily manufacturing 3 nanometer chips, but we are a pretty important part of the supply chain. And what's your sense of the prospect for Malaysia, Singapore, and Vietnam, which are not at the frontier like the Korea, Taiwan but still seems pretty relevant.

Ravi Vijayaraghavan

Look, I think you need all of them, all of the above. I think to some extent maybe some of the profit concentration is a little bit more in the leading edges because again, capacity constraints, TSMC's 7 nanometer and below is the most capacity constrained part of fabs right now. And so of course they're realizing a premium from that because of that. But the importance of all of the other elements doesn't go away at all. You need all of these to come together, and Singapore has some pretty, I mean between Micron and GlobalFoundries and UMC and Infineon, it's got quite a bit of its own, and Malaysia has a lot of packaging, which as you pointed out is actually emerging and packaging used to be a sleepy afterthought in semiconductors. It was all in the chips. It was real men owned fabs. I mean, everybody else did packaging or whatever else. Not anymore. A lot of high bandwidth memory and stuff is more about packaging technology than it is about the wafer or the or the chip itself. So, Malaysia has a lot of capabilities in that area. And Thailand, for example, is one of the largest centers for production of hard drives. And that's a very, very big industry, that sector is doing really well. So, I don't think it's fundamentally just about the leading edge or not. I think you hear a lot more about the leading edge because that's where the attention gets naturally focused and to some extent in a supply demand situation as we are now, the profits are accruing a little bit more disproportionately to that segment.

Taimur Baig

Ravi, one country that is not part of this wave, but certainly has the aspiration to do so is India. Over the last five years, it has given billions of dollars of production like incentives. You hear large Indian conglomerates announcing desire plans to build fabs and so on. What's your sense of India's outlook?

Ravi Vijayaraghavan

It's hard to answer in an aggregate sense. And what I mean is, if you peel that apart, at least there's three big segments. There are the fabs, making the chips themselves, there's all of the assembly and tests and so forth. The packaging as we've talked about. And then there's electronics assembly, which is, as you know, what the Foxconn and the like, the iPhone being made in India, and so forth. And while all of them seem similar

there as, you know, the dynamics are quite different. So I think if you work from the bottom up, for the electronics manufacturing, India should be a very good alternative to China and the Vietnam. Because unlike every country other than China, it also has a huge domestic market which is salivating for many of the manufacturers of the device makers. So, it actually has a large market as well. And the technologies needed for that are not quite as, sophisticated or leading edge or scarce. And so, I think now in iPhones, for example, I think India has got quite a lot of Apple's global capacity. And I think that makes sense, and I'm a little disappointed we don't see more of that. You would think that there's more of that, as you know, a lot of that is still been concentrated in Tamil Nadu and then and in that part of India, and Karnataka neighboring but you would see more of that. I think if you go at the other end, I'm a little less clear on whether India has a great long-term play. Now, it may still be a good thing to say, look, as you know, post-Covid, there was this whole strategic kind of rebalancing that both companies sought to do and countries sought to do. It's like if I don't have anything, then I'm going to be a little bit left in the cold when disruptions happen.

Taimur Baig

Even if that means redundant supply chain.

Ravi Vijayaraghavan

Even if that means redundant or not entirely the lowest cost or the best economics and so forth. Yes, right. And I think companies have also come around to that view that, yeah, China may be the lowest cost, but I cannot put everything in China because I need some resilience in my network. And so, when I look at the fab side of things, I'm a little perplexed because I can see why they would want to have some and so forth. But the leading-edge technology is incredibly hard to get. Very few people have it. And you know, TSMC is already committed to building the America production facilities, Japan, they've had dialogue in Europe. I don't know where that went. And so forth. Samsung is building something in the US and the US is such a large market. So naturally they're going to want to put something in the US, especially with the more tariff orientation of the administration that we're seeing now. And so, India cannot get that part. When you look outside of the leading edge, China's putting up a lot of capacity in that area. And you know, when China makes an economic policy to do something, they get it done. I mean, whether that's solar or batteries or EVs, they'll do it. And humanoid robotics is one of the next frontiers. And so, China's putting up a lot of capacity and has been doing for years. So, they're very well down that learning curve compared to in India. And the last is fabs take a lot of investment, but a lot of that investment is equipment, which comes from somewhere else. It's not necessarily buying local stuff, and they don't employ that many people. So, I find that a little perplexing. Other than maybe for security and strategic reasons, maybe. I don't know that. I think assembly and test is more interesting because it does favor having a large educated, productive workforce and technology, yes, still again the leading edge of packaging is getting somewhere, but a lot of semiconductor chips don't require the leading-edge packaging. So, I think that seems more interesting to me. So, if I had to peel apart your question, I'd say the assembly absolutely should be doing much more. The testing and packaging, certainly I see the opportunity to do more. Fabs, I'm a little less clear where it can go, given, given the dynamics of that market.

Taimur Baig

So, Ravi, the Indian stock market has been under pressure the last few years, and one of the sectors of which I see that has underperformed pretty badly the last six months in particular is the software giants of India, and so on. Is your assessment that the whole AI/LLM revolution is really going to disintermediate the whole outsourcing industry?

Ravi Vijayaraghavan

So, I'll set aside the stock market performance, not my area of expertise. I wouldn't claim it to be. As you rightly pointed out, the IT services has been under pressure

for some time. After that post-Covid kind of spurt. It's been low growth and margins under pressure for probably two or three years before all of this AI thing really perked up. So, this is coming on top of what has already been, I think, a little bit of a tougher time for them. So viewed one way, you can see the compressing effect of AI, a little bit like software that we talked about a bit earlier, which is that previously if I said, look, to essentially update that application and make it conform to new regulations would be 10 engineers of this seniority for four months. Now, again, all using Claude code or Codex and so forth, is it what, five engineers for two months? Like what is it? There are certainly some compression effects. So, like you're saying, do I need the same number and in a time and material, classic time and material business, I probably don't. So, you can see the compressing effect of that. And you also see some of the customers choose to do a little bit more on their own versus rely on the IT outsourcers. There's an interesting element here which is IT has become more strategic to many more companies than ever used to be, which in a way is also pushing, should I be doing more of this myself versus should I outsource. If it starts to become central to your business, should you be doing more of it yourself versus outsource it? And I think that's reflected a bit in the number of GCCs, the global capability centers you're seeing. And India's cornered a huge share of that, very nicely, and that is essentially saying, yes, I need to do it in a lower cost location for economics and others. Yeah, but I needed to be inside my four walls because it's actually important for my business. This is not less strategic, where I'm settling for best cost versus best capability and whatever. So, I think that is one part of it and the GCC will, I think, continue to do well for India. But the list that we discussed, players, so that's what they're facing. You cannot expect the same pricing for what you used to do, and two, you have this thing about GCCs as well. But I think you look at the other side. Almost every business I would argue these days is either a tech business or a tech enabled business. I mean a bank is like technology is the center of it. There's not much left, if you can't get the technology to work. Yes, you have to manage risk, and you have to manage many more things. I'm simplifying. Whether it's a bank or it's an insurance company or a logistics provider or a film production studio, whatever, technology is the center of it. And we were talking about AI. Experimenting with AI is easy. Piloting AI with AI is a little harder, rolling it out at scale, and transforming the way you do business, which means you've got to transform how the work gets done, the workflow. You have to transform how the people do it, the workforce, and then you have to transform the technology and data underpinnings which they're both going to rely on, with both of those are going to rely on. That's quite hard. There's a lot of work involved in getting that and that's why not that many companies still have fully scaled AI. And that's the challenge that many are facing in the US as well, not just outside the US and maybe even more so outside. But that's the challenge many are facing. And so, they need more help. So, in some ways you would say all of this means they need more help of the kind that these IT companies provide. And you're seeing the immediate demand. I mean, I go to any client, it's like, ok, we need to do all of this stuff with our data architecture is completely not what is needed. We grew through six acquisitions, and we have six ERP systems, and they don't talk to each other. You take the example, like a lot of mainframes still run COBOL code. Whether that's airlines, that's utilities, that's banks, that's insurance companies, all run COBOL code. But it's been phenomenally expensive and risky to change that. Now you have tools that make it much easier. Doesn't take away the risk. I mean, it takes away some of the effort, at least makes it more possible. Again, great, this was the Y2K, or, going back to the Y2K. So, there's a lot of work to be done. Again, like that software example I gave, but what the IT companies have to reckon with is, in order to do all this, I need to change my business model. I need to be able to price on an outcome as opposed to time and material. Time and material is not going to work in my favor as much. That also means that I need to have a different set of skills in my team. Using a code generator to rewrite the COBOL, and how do you validate

it? How do you test it? How do you rebuild the test suite, all of that different set of skills, and a different talent and a people pyramid and all of that. So, it's a very different company in some ways. Even though the core proposition is somewhat the same, it's a very different company.

Taimur Baig

So, Ravi, that really is my hope that if indeed there's going to be a full-bodied embracing of AI related capabilities, that transition would actually enhance employment. And down the road, it would be capital augmenting, labor augmenting, and maybe labor replacing as well. But hopefully that transition period gives us some time to think about what are the other areas people can gainfully employed.

Ravi, you were there last week. I was in Washington DC in April, and DC is a very political town. You pick up a lot of political vibe. One thing that I picked up was that there's a bit of an AI backlash taking place. Not just the Bernie Sanders of the world demanding that there is some equity from AI to be shared by the population, but not in my backyard for data centers. I saw Virginia while I was there, you know, passing legislation where local bodies would have far more say whether the data centers can be built in the back yard or not. So, could 2026 also be the year of AI backlash?

Ravi Vijayaraghavan

It's interesting because it has certainly become a political wedge issue. And interestingly, more so at the local and state level, if you will, than at the federal level. But at the local and state level, I think it has become more visible and if I could digress for a moment, as I said, I was in California last week, and in some ways, there's lots of excitement. But I'm seeing anxiety much more than maybe I've not been as observant, but I'm certainly seeing it, and it's more palpable than it has been in the past. And so, I kind of started trying to think about it and talk to a few people. Now, look, this is all anecdotal. I was there for three days, so, how many people did I meet? And there's a lot of anxiety. I think it's very interesting. Look, you're talking about the one place on Earth which is the biggest beneficiary from all of this, where the greatest amount of wealth creation is happening because of AI. I don't know, an order of magnitude, maybe even two orders of magnitude, who knows? And yet you see so much palpable anxiety. And so, I was like, what is this? And I think it's three things. It's one thing that we talked about earlier. The velocity. I don't know if you feel, Taimur. I suddenly feel everything is speeding up. Like, keeping up is harder and harder and harder, even with all the tools that I use and that you, I'm sure use as well, to synthesize and this and the other. It is harder, and I think change is coming at people at a pace that they are struggling to process. It's like we're all human. We only take change so far, so much and so much grace and then and I think it's just been coming and coming and coming. You look at what these models can do. Every three months, they come out with a new one. First of all, it used to be six, then it became four months, and, you know, whatever. But they're dramatically better than what preceded it. So, it's the time between has shrunk and the capability leap has been even greater. So, one, I think it's too much coming at it. Second, and tech may be the leading edge of this, there's just a lot more anxiety about job security. Because what you're seeing is the biggest companies that used to be very stable. And the most successful companies making lots of money, still letting go of people and saying, I have to find ways to fund my AI investment or because of AI these things are no longer a priority or whatever it is that they're saying. But I think it's dented the notion that if you're working for a big successful company, and look, I cannot, in any scenario, Taimur, think that Google and Amazons and the Microsofts will not be a winner in AI.

Taimur Baig

And still, they may be leaner.

Ravi Vijayaraghavan

They may be leaner companies, at least that's the direction at this point that we're seeing. So, I think it's shaken people's confidence. I

think that's a second source of anxiety and the third one, which is very interesting when I talk to people, it's because things are moving so fast, you're making decisions and choices, and you have no confidence that they are the right decisions and choices. You think about someone, for example, who came out of Berkeley, which where I went to as well, and four years ago, and you had this, pre November 22, let's say, four years ago, and you had this small unproven company called Anthropic making you an offer, and a Salesforce or an Oracle making you an offer. You would be reasonable to say, look, I think, I'm more leaning towards that, and roll forward the clock four years later, what a dramatic difference that's made. So, I think people are like, even now saying, I'm making these choices, but I have no idea how this is gonna play out. And I think that's very legitimate and that's very stressful.

Taimur Baig

Right, and Ravi, I guess this is where the public sector's role comes in that while companies may be bewildered, maybe in hindsight make the right or the wrong decision, that anxiety has to be addressed head on by the policymakers. Because like you said, it is a bit of a unique moment and that anxiety can manifest in all sorts of ways. I mean, it could be a big Luddite movement where we reject all AI and that'll set us back, or there could be some serious social instability.

Ravi Vijayaraghavan

You're right. And to the point you were making on the political. Maybe this November election could be swayed as much by some of these factors as by the cost of gasoline and, you know, whatever else.

Taimur Baig

I fully agree. We have talked about the promise of technology, and of course, the here and the now. I think, you know, there's decent data, decent evidence that it is tantalizing and it's exciting. But there's also a lot of frontier stuff being discussed all the time. Mr. Musk is talking about data centers in space, and then colonies and Mars and that sort of stuff. So, what's your sense about this super frontier stuff that is also being priced in for the next round of IPOs or the next round of fundraising?

Ravi Vijayaraghavan

Well, that's what makes tech so exciting. Some of this is, as you said, tantalizing, it may never evolve, I mean, may never come to fruition and some of that might, and it will be very different and so forth. Think about it though, Taimur. I mean, I'd heard of OpenAI, going back seven, eight years. But I was hardly prepared for what they came out with when ChatGPT launched. Again, you'd heard that AGI and all of that stuff and so forth, but it all felt like maybe it's somewhere out there. And then suddenly they launch something and it changes the world as we know it in some ways. So, look, I think that dreaming is absolutely part of it. I would say some aspects of these, so take quantum, which is an area where there is, I think, a lot of excitement. IBM's making advancements, Google's making advancements. Everybody's trying to go after the same thing, which is, can I get more and more QBITS without increasing the error rate. That's the holy grail, that's what we're pursuing. Different estimates as to how long it'll be before we see commercial systems and so forth, fine. But as of now, we think that will probably dramatically change cryptography. That we know. Probably dramatically change drug discovery. And probably change a few other things. I think there are some interesting applications in portfolio allocation and stuff like that in a fund management, but in those domains, it's probably going to be disruptive and transformative, but not as broadly so, at least in the early days. So that may take a while, unlike what we're seeing now, which is even its early days have been quite disruptive in a wide range of areas, not just in a narrow sense. So, I think when you take all of these, you go, which ones are going to be truly world changing. And which ones are important advancements. So, you know, data centers in space is a good example. You can see the logic. Power in, you know, here on planet Earth is increasingly hard to get. And if you imagine a future where we're using more and more AI for everything, maybe the

power needs just get to a point that we cannot do it while also, limiting fossil fuels and this, that and the other. And this could be a neat solution for that. But I mean it's strewn with hurdles. I mean, getting the stuff up there, dealing with the latency and lag effects that you have when something is in space, lots of you know whether components that work on Earth don't necessarily or are not necessarily going to work quite the same way there. You have all of these things; how much space debris will we be causing. Like there are lots of considerations. And so that one I put in the category of it's possible that when it is as in proven as a technology and proven to be commercially viable as an option, that if the world does get to a point where we can't do it anymore on the planet Earth, then that may be a lifesaver at that point in time. But I think it's really hard to say that that is at this point, that is going to be one at this point in time. So, you have this whole range of things that people dream of, but that's the fun part though.

Taimur Baig

Yes, and I really appreciate your distinction between the general-purpose nature of some of these technologies and the specific nature and the narrower disruption that they may have.

Ravi, what a tour de force of a conversation. Thank you so much.

Ravi Vijayaraghavan

It's been a pleasure and thank you, Taimur. I've learned a lot when we talk. So, this has been great for me as well. Thank you.

Taimur Baig

Benefit is entirely mine and thanks to our listeners as well.

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