

5G: The Next Generation of Connectivity

Disruptive Forces in Investing

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Anu Rajakumar: Welcome to *Disruptive Forces*, a podcast from Neuberger Berman where we discuss innovations and insights in investing. I'm your host, Anu Rajakumar, and in today's episode we'll be discussing 5G, the next stage of high speed Internet and mobile connectivity, which will pave the way for a number of exciting technological advancements. To discuss 5G and the next era of connectivity, I'm joined by Dan Flax and Y.T. Boon, who are both members of Neuberger Berman's global equity research department and portfolio managers for the global thematic portfolio that invests in a basket of 5G exposed companies and next generation connectivity. A special welcome to Y.T., who is visiting New York from Neuberger Berman's Hong Kong office. Welcome, guys, good to have you here.

Dan Flax: Great to be here. Thanks, Anu.

Anu: So when I think of 4G or 5G, the first thing that pops into my head is the top left corner of my mobile phone and the strength of my signal. But it's about much more than mobile technology. Would you give us an overview on what 5G is and explain how it's different to 3G or 4G?

Y.T. Boon.: Well, technically 5G is a combination of a lot of newer technologies that enables a faster network. These include massive MIMO technology.

Anu: What is massive MIMO?

Y.T.: Massive MIMO stands for Multiple Input and Multiple Output, which basically means a massive array of data transmissions. 5G is also different because it runs on what we call sub-6 gigahertz, a different set of frequency spectrum from 3G or 4G, and it also in addition to that, 5G would also run on a very high frequency network, which we call millimeter waves, because it literally is a frequency range of between 20 to 30 even up to 40 gigahertz. That's the high frequency of, um, you know, high, that enable high speed 5G.

Dan: I think, first off, there are a number of improvements around the speed, lower latency, just having a much faster experience on your device. So as consumers, if we think about it, you'll be able to download a movie in seconds as opposed to minutes or hours. So if you think back to the 3G or even the 4G world that we're in now, it would take you and I and all of us as consumers a long time to do that. So those kinds of things, I think, you'll see will be a lot faster. I think what's a bigger shift, if you will, in terms of where 5G and next generation connectivity takes us is to a world where the Internet of Things, or I.O.T., becomes pervasive. What that means is that more and more devices, billions of devices, will be infused with intelligence, software, semiconductor content, which is going to enable them to transmit data. And so I think they'll be significant ramifications in other areas. The industrial world, factories, a lot of parts of our infrastructure that are in place today but don't have the intelligence. And by giving them or infusing them with more intelligence relative to the world we're in now, let alone the 3G world, you're going to be able to deliver a whole wave of new services. And so this is really a critical jumping off point for where we see things evolving over the next several years.

Anu: That's great. And Y.T., you've said that 5G would change the way we live in unimaginable ways. What are some of the most interesting and unique use case for the 5G technology?

Y.T.: Well, the way I think about 5G is that 3G is basically like walking. 4G probably feels like biking. And 5G is basically space travel.

Anu: Wow.

Y.T.: It's completely different. It will enable very different experiences, very interesting business models. If you think about future of factories, if you think about future autonomous vehicles, if you think about remote surgeries, if you think about all these innovations that's enabling these new applications, the robotics, the artificial intelligence, these newer innovations, they all need to be connected and 5G is the cornerstone, basically that connects all these future innovations and technologies. As I mentioned, in China, they've already

demonstrated remote surgery, remote healthcare, with the 5G technologies. A surgeon sitting in Beijing did a remote surgery on someone that sits a thousand miles away. And that's possible only because of 5G technology. Autonomous vehicles, for example, today relies on sensors. But in the future, with 5G technologies, cars can communicate with cars, allowing better safety, better advanced technologies, improve the driverless Uber type of business model. So I think that's 5G in enabling unimaginable ways of technologies.

Dan: Yeah, I mean what I was going to just add, Anu, is that I think what Y.T. and I are trying to get across is that people should really think a lot more broadly about how this is going to transform all elements of society. So was consumers, as individuals, if we're not able to watch a video at the, you know, speed that we like, you know, some will be unhappy about that.

Anu: Instant gratification is a key.

Dan: Yes, to, to put it that way, I think that's right. So that should all get solved in many cases in 5G. But I think what we are excited about is that if you think about surgery, as Y.T. mentioned, or autonomous vehicles, or really new business models, this is really going to change how all elements of our society, industries, factories, travel, new services, all these things are going to be fundamentally reimaged. And so we see tremendous opportunity as a result of these changes, of these shifts, of these developments. And that's going to have enormous ramifications for several industries and companies. And so that's really what we're spending a lot of our time trying to uncover, interesting opportunities.

Anu: And you mentioned autonomous vehicles and these remote surgeries, which are fascinating use cases. But I imagine that one of the challenges must be the rollout of 5G, right? We're going to go across not just urban city areas but also rural areas where perhaps there is not very much connectivity at all at the moment. Can you talk to some of those challenges, with just getting this technology in places where there is currently no connectivity?

Y.T.: Yeah. I think you're right about the time and also effort it takes to deploy the technology across different geographies. At first we need frequency spectrum available. We need to put in network infrastructure. We need to put in newer technologies such as massive MIMO that enables multiple input and multiple outputs. There's a lot of, new ingredients that needs to be put in. Which is why we think 5G is very different from 3G or 4G. When we did 3G or 4G it took, I would say, a, short amount of time to get things built out. 3G took about four to five years, similar to 4G. What's interesting about 5G is that this is a much longer cycle because of its use cases and because of the breadth of technology and also 5G runs on mid to low frequencies and also high frequencies, what we call millimeter waves. So the build out of the 5G infrastructure will take five to 10 years which is a very long period and given that the contents that goes in there is very different. We're looking at a massive content growth there. So it's not only a longer cycle, it's also a much bigger content opportunity.

Anu: Now in April 2019, President Trump spoke about 5G deployment in the U.S. and said the race to 5G is a race America must win. Japan will be showcasing 5G at the 2020 Olympics, and China has made this a national imperative. Can you explain and contrast the advancements from a global regional perspective?

Dan: Sure. So if we think about the U.S., and we think about China, these two nations, these two economies are the biggest and China is clearly, or likely to become the largest over the course of this century. The reason the race is so important for 5G is because the winners of the race are going to control and own a lot of the intellectual property that's going to enable economies, industries, really the fabric of our societies to engage, learn, interact, grow and evolve in many, many new ways. And what we've seen with the 4G or the 3G cycle is that companies or countries that are able to harness a lot of this technology are able to deliver the benefits to their citizens, their factories, their businesses, and really leverage the ownership of this technology to grow in some of the markets overseas. And so everyone has seen what has happened in past cycles and so the appreciation for just how important 5G is, is spurring President Trump's comments recently, certainly the Chinese and other nations are very, very focused. And so there are global implications. We don't think that there's a single winner here. What we've seen in 4G is that you have new business models but these business models can grow and evolve in one country and then spread rapidly to other countries. Ride sharing is a good example. It's not just in one place. And so it's a race and we've seen from some of the political jockeying some of the trade friction that nations are going to use, practically any tools at their disposal to try and get an edge or an advantage in this race for 5G.

Y.T.: And also what's interesting is that if you think about the 5G race itself, it's not just a technological race. I see it as an economical as well, because whoever has the best technology will innovate faster and enable a bigger economy. Just like what we have experienced in the 4G era. Because of 4G, we now have better smartphones, we have better social media, a lot of these use cases have evolved and created newer economies, bigger economies, much more efficient. So I think this is why, this is a race that, the U.S. needs to win, because the U.S. stands at the forefront of technology and the U.S. needs to continue to maintain this position. China, obviously wants to leapfrog. So I think of this race as actually a very positive thing for the greater society, as we experience all these newer innovations.

Anu: It's probably safe to say that many companies, particularly the big telecom companies, are heavily investing in infrastructure to capitalize on what was 4G and now 5G. How do you think about the investment opportunity set and can you discuss how companies have already adapted or may adapt their business models in the future to benefit from the 5G technologies?

Dan: I think, Anu, the big telecom companies who've built out networks for prior generations such as 3G and 4G, they are actively investing in working with vendors to build out the 5G networks. What's also a little different this time around is that you have the big Cloud companies or the Web giants who are enormous, they're global in many respects, and they have enormous amounts of money and intellectual property, and they're also competing in this new race. And so relative to past cycles, you have new entrants, if you will, and the reason they too are building out highways is because we've seen in the last several years, and I think we all appreciate in the coming years, that the ability to harness data, draw insights, and make decisions or invest in new areas is ultimately what's going to help create a lot of value. So certainly they're the physical networks that we're talking about that the telecom companies, that the Cloud companies are building. There is all the software and semi-conductor content that's going to find its way into many of the new devices. We often talk about the Internet of Things or I.O.T., and that's really the notion that every single object is going to have a level of intelligence and is going to be able to share or exchange data with the network –

Anu: The one I've heard is, you know, in the kitchen, when you run out of an ingredient, it all just automatically ordered the grocery items that we'll just show up at your doorstep when you're out of eggs, immediately, right?

Dan: Delivered by a drone, right?

Anu: Delivered by a drone.

Dan: So, so that's, so yes. But I mean, so that is going to fundamentally change how we all cook, and what are expectations are when we're in the kitchen. And then maybe to that point, so there are going to be new companies who are able to ride or leverage all of this new infrastructure to deliver services in new ways, and that's going to create value for their customers and ultimately the company.

Anu: One of the biggest risks of 5G appears to be security, and we've seen several countries take a stand against companies based on specific security concerns. So Y.T., could you give us a brief explanation of what's going on and a little bit of your assessment about how that's playing out globally?

Y.T.: Well, first of all, I think security is not a new thing. It's always been the key concern. So to me it's not a major risk. To me it is a opportunity. We've seen certain Chinese companies being banned, from getting U.S. technology or intellectual properties. This is obviously causing some short to medium term issues to the supply chain. We think that all these impacts, are obviously detrimental to some of the short term technological innovations. But longer term, we believe that these issues, geopolitical issues, if you may call it, or security issues, will resolve itself. We focus more on the opportunities down the line. When there is a market share shift, whenever there is a change, this is something that we do not fear, this is something that we try to look for new opportunities.

Anu: You mentioned different opportunities in companies. When investors think about this, this is obviously a long term trend that's going to take some, some years to play out. How do you think about investing in 5G technology in the short term as well as the longer term?

Dan: We look at a few different areas Anu. Part of it, if you think about the building blocks, they're really the foundation of these next generation networks. There is the actual network infrastructure, so we had, in the past we had 3G and then 4G and now looking out into the future we'll have 5G base stations and really the pieces that are going to enable the connections. There's going to requirements for a lot more fiber over the next several years. You'll see a lot more of what's called small cells as the industry tries to densify its networks, because if you have a proliferation of devices, both from people and in factories, in fields, all sorts of places are going to require bigger highways if you want to think about it that way. And so there's the network and then all the different – these things, Internet of Things; each one of those is going to have intellectual property. It could be software and/or semi-conductor content, and so we look at companies that we think will be able to capitalize on the proliferation, really the tremendous growth of these things. And then another bucket we would highlight is really the services. And I think what has been very, very interesting in the 4G era is that we've seen new business models evolve. We touched on ride sharing a little bit. But what's happening is that given the enormous compute power that we as individuals or businesses have, we're able to communicate, interact and transact in a very efficient way. And that is allowing new business models and new use cases to evolve. And so what we think about in the 5G era is that there are going to be many, many new types of business models. And so as all of this grows, develops and really gets embedded inside companies and changes processes, we think that there are and will continue to be a number of significant and interesting investment opportunities that will have significant growth potential over the next several years.

Anu: Right, absolutely. Well, Dan and Y.T., I want to thank you both for joining me today on this episode about 5G. This has been very interesting and fascinating and we're looking forward to seeing how this space evolves in the coming months and years. So thank you very much.

Dan: Great, thanks, Anu.

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