GARY GENSLER: Welcome back to Fintech: Shaping the Financial World. This is our last time together. And so we're going to try to summarize up what this semester's been and some thoughts going forward as all of you go forth, and try to think about this intersection of technology and finance.

And again, we've taught it from that point of view, not necessarily just about startups, but how technology and finance come together in the world of finance. And it's been shaping it, really, for centuries. But the dominant sort of themes that we've been talking about is the new technologies that, in the last five to 15 years, have really been transforming finance around artificial intelligence and machine learning, natural language processing, having dramatic changes, but also open API and the access to data through technological connections, sometimes done by commerce, sometimes the official sector has sort of moved and pressed against it.

And then, of course, data, and all the different forms of alternative data, some off of just traditional means, like whether we pay our rent on time, some from social media. And then when we looked at insurtech, that I know really lifted the class up, this look at insurance and finance, but then also telematics, meaning all the data that a car brings on us, or wearables, if we wear a Fitbit or a watch or something, or the Internet of Things.

And then we've talked even about some technologies that haven't yet come into the technology stack, like blockchain technology, and will it? It's already been a catalyst for change, but will it sort of come in and dramatically change finance.

So as we normally do, if we can try to be part of the community and have our videos on, I still see some with it off. I know at 12 lectures in, and it's early morning. But I think if we can just try to close out together with our videos on, and if you have questions, raising the little Zoom blue hand or going into the chat room. And Romain is going to take a close look and try to have a dialogue here.

I do have some slides to put up. I'm still the same faculty member of the other 11 classes, but let me share some slides and we'll get going.

So we're going to talk a little bit about this finance technology stack and how I see

these technologies fitting in, the actors again, and then a review of the key areas, machine learning, open API, credit scoring, alternative data, and the question marks around blockchain technology. And then a quick sector review, and bringing those all together and wrapping it up

The study questions was really about what is fintech? And so I don't know if everybody just wants to have an easy, hit the ball out of the park moment. But to you all, what is fintech and how might it shape the future?

ROMAIN: This is the last class and your last opportunity to shine, guys.

GARY GENSLER: Don't you love how Romain sort of pulls it all out of you so readily, easily?

ROMAIN: This is the last class. Danielle, go ahead.

AUDIENCE: The application of technology to financial services, and how might it shape the future of money and finance in unlimited ways.

GARY GENSLER: An optimist. I like that about you, Dani. Unlimited ways. So do you think we'll have banks in the future? Let's go right to the heart of it. Will we have commercial banks in the future?

AUDIENCE: I think yes. I think it's hard to dislodge institutions with that much inertia. But they may not look the way they look. They may get slightly more agile, adapt, and have digital currency. They might pull in some of the fintech disruptors. So yes, we'll have commercial banks, but they may not look precisely like they do today.

GARY GENSLER: I, too, think that we'll have commercial banks. And I think it's more than just inertia. I think that there's certain network effects that we've seen for centuries about bringing depositors and borrowers together and forming that intersection, sort of like a neck of an hourglass, but forming that intersection where the grains of sand, money and risk, flow between depositors who have money but want to save it, and borrowers who want to borrow it, and the commercial banks bring that together.

Peer to peer lending has been around now for some 15 years, this concept that we don't need an intermediary in the middle. And then maybe borrowers and lenders can come together on a technology platform. And it's had some success, not just

here in the US, but it started in Europe. It's been here in the US. It's been in China with great numbers and some challenges as well.

But I think what we've seen is, by and large, we still have some centralized marketplaces that come together. Now that's not the only reason I think commercial banking will be around, but I think there are significant network effects pulling at the center.

How do you best assess the viability of a fintech project?

ROMAIN: Carlos, you like to take a stab at that?

AUDIENCE: Sure. So I think there's a couple elements. One is to what degree is it an improvement relative to a traditional product? How much more convenient is it for users? And how much more accessible is it? I think those are important factors.

Of course, there's a financial liability. You have to look at the actual economics of the product to see whether or not it's scalable, above all, and whether it makes sense to have it at a large degree. And then ultimately, I think we've seen, especially the last five years, whether fintech companies can actually become publicly owned companies, how they handle themselves in the stock market, et cetera. So I think there's been several phases to the evolution, and it's continuing.

GARY GENSLER: So very helpful, in part. So first Carlos said fundamentally, you have to have a value proposition. I'm using my words, but sort of translating it, if that's all right, Carlos. So what pain points are you addressing? What gap in the current system of finance? And it might be about user interface and user experience. And as mobile phones came along, as we moved from online banking and online trading to mobile banking and mobile trading that, creates opportunities.

Many of those opportunities have already happened. They're not all done, but many of those opportunities of that transition from bricks and mortar to the internet, to mobile phones, have happened. But they create opportunities of user experience and user interface. But it has to address some pain point, do something quicker, cheaper, better. It's an old saw in terms of strategy.

But then Carlos is also saying we need to have financial viability. At some point in

time, you have to be able to build a model where revenues are more than costs. A lot of these startups are looking for that sweet spot, that sort of nirvana moment when you build a platform, where platform economics and the network effects take off. But Carlos said you still have to have some financial viability at some point in time. I think there was another hand up, Romain.

AUDIENCE: Yeah, I think to kind of built on Carlos's point, another thing that might make or break a product is potential for fraud or the risk profile increase on a specific area. One thing we were kind of talking about as a group was alternative scoring, and that's something that we're just not sure if we're hot on or not just because is taking alternative data actually going to increase or reduce risks looking forward.

GARY GENSLER: So Michael, I think what you're saying is you still have to live within regulatory constraints and social constraints in terms of there's normative behavior, and this is a highly regulated field, and for good reason. We're dealing with trust, and trust is at the center of finance. We're also dealing with other people's money and livelihood and savings and investments.

And so there's investor protection, there's consumer protection, and in terms of alternative data, the basic tenets around the globe that when you extend credit or offer somebody insurance, it should be done fairly and unbiased. And so how do we ensure that the use of alternative data still stays within those social and legal norms about offering credit and insurance in an unbiased and fair way. I think that's what you were chatting about.

AUDIENCE: Yeah, kind of. I was just thinking about, also, the lack of adoption crypto. It's like, if it's just going to sort of attract scammers and fraudulent activity, the technology is going to have a hard time being adopted.

GARY GENSLER: Right. Right. So of course we want to protect against fraud in the capital markets. We also want to protect against manipulation and ensure investment protection. And we've seen, particularly in some fields like cryptocurrencies, that they're rife with fraud and manipulation and sort of quick buck artists, frankly, around the globe. And so to ensure that any long-term viability of a project, real viability comes with investor protection, consumer protection norms, as well as norms about fairness, inclusiveness, explainability, and the like.

In most nations, these are embedded in various regulations and laws. So standing up a new effort, whether it's inside of an incumbent, inside a big tech, or a startup, you've got to look at the regulatory context. But Michael's pointing out, also, you've got to go a little further and make sure that you're really serving your public and your community.

And then the last question is, I hope that we've met the goals of the class. But I do ask you today and over the next few weeks, write me. Write me at gensler@mit.edu and tell me what we could do better. This the first year we've stood this up. This class is also going to be shown publicly in MIT'S OpenCourseWare.

So those of you that might be watching this publicly, write me and tell me what we can do in this class going forward and how we can make it a better product. I'm kind of curious whether it's made some folks more bullish or more bearish on fintech, and I'm going to ask this at the end of class as well, but if there's anybody who wants to chat now, Romain? Anybody want to take the bullish side or the bearish side?

ROMAIN: Danielle has her hand up.

AUDIENCE: I think it depends on which hat I have on, if I'm an investor or entrepreneur. The class has made me more bullish. Lots of opportunities out there. If I have my citizen hat on, I think I net out at bearish, not so much on the industry, but more on its impact for me. I'm certainly thrilled at the ability to access different forms of payment and lending. But ultimately, I think the long-term costs in terms of the data these companies will have on me, and the just immense role and control over my life, I net out at bearish.

And then if I'm the government, I'm probably netting out at bearish as well because this is going to mean a gnarly set of regulations and laws to navigate that means a lot more work for me.

GARY GENSLER: Very interesting, very nuanced answer. I see some other hands up.

ROMAIN: Celi?

GARY GENSLER: Maybe you've got your mute on still.

ROMAIN: Yes, we can't hear you. OK. Then let's move on to Lamide.

AUDIENCE: Yeah. I'm more bullish. For me one of the interesting trends I see is serving the underserved, whether that's in crypto trying to serve the population that doesn't have to be VC, or whether it's in insurance. you have all these trends where people are getting more nuanced products to really target populations that are underserved. And all these different kind of new innovations around that inspire me.

GARY GENSLER: So we've got bullish as an investor from Dani. We've got bullish for economic inclusion and product inclusion just now from Lamide. But there were some bearishness from Dani on data and the industry knowing so much more about us. Was there anybody else, Romain, that wanted to add in?

ROMAIN: Maybe Celi, if her microphone works, and Luke.

GARY GENSLER: Right. And then we'll move on. We'll take Luke and Celi.

AUDIENCE: Yeah. My internet connection's poor. But I think I'd like to echo-- I missed part of Lamide's but my thing was financial inclusion. So really entering, I think, also, it's in the benefit of the government, too. I know that there are some concerns there, but I think if you're thinking about it from an economic growth perspective, there's a lot of opportunity through fintech that would end up really benefit the entire economy. So I think that there's the argument for the government to have interest and to be a more bullish approach as well, even though there are risks involved.

GARY GENSLER: So you accept a little bit what Dani was saying that for the government, the official sector, some of the challenges, to use her words, were gnarly. But though there's challenges, you think to the extent that it promotes inclusion and economic activity, that innovation is a net good, and competition, if I can insert something.

What fintech does is it provides an opportunity both for incumbents and startups and big competitors like big tech to start to bring competitive challenges. We saw this in China when Ally Pay and WeChat Pay bring economic challenges to the

banking sector and now dominate the retail payment space. But for a while, all of that inclusion creates economic opportunity.

I say for a while because at some point in time, then they too become a bit of an oligopoly. And they can charge, over time, economic rents. But that has certainly brought a lot of inclusion, a lot of growth, a lot of economic opportunity to underserved populations, in that case, in China and elsewhere in Asia. We've also seen that across the US and in Europe with competition from challenger banks and neo banks and payment companies, long ago, like PayPal started 20 years ago, or more recently, by many of the payment innovators in this space, whether they're data aggregators or direct payment solutions like Toast in the restaurant business.

But as Dani said also, the Plaids, which are the data aggregators, or even the Credit Karmas giving us free access to our credit reports, or Robin Hood giving us free access to trading online brokerage, also then are collecting significant amount of data. And whether they're commercializing that data in ways we understand, appreciate, and want, Dani is sort of raising that makes her a little uncomfortable as well. And I think we were going to close it out with Luke.

AUDIENCE: So I'm bullish in the long term in the sense that two conditions are met, the convenience and then technology acceptance in terms of blockchain. You teach blockchain and money. And if people accept blockchain as technology as core to fintech, it has a lot of potentials. If not, this is nothing more than making any status quo industry more convenient and more accessible. So little bearish.

GARY GENSLER: So you're bullish, and one of the reasons you're bullish is you feel the blockchain technology is a positive. And is that positive because you feel it's pushing at the side of central banks, pushing at the side of central payment processors and the rest of finance, which I would share that view. I think it's a catalyst. And it's part of why we've seen a lot of innovation. Even our US Federal Reserve, who was thinking about doing 24 hour a day, seven days a week payment systems, is rolling out something called Fed Now. I think that's in part because of this catalyst for change.

But do you also think that it will be a mainstream product offering, and that blockchain technology will roll into what I call the technology stack in finance?

AUDIENCE: Well, I believe in evolution, so in 10 years or whatever years that may take, this is indeed the best technology if everyone accepts it. So I don't see why not. However, it will take a tremendous amount of time and energy and effort for everyone to accept it and understand it. Either it takes a crisis or it takes governmental intervention.

GARY GENSLER: You may be right. I still haven't been convinced, but you may be right. I'm sort of a middle of the road. I'm neither a minimalist or a maximalist on blockchain technology. But it hasn't yet because of the dominant challenges of governance. How do you have multiple parties sharing a ledger? And these issues of governance are not new. They're just in this context of blockchain technology.

But the opportunity to have a new data structure, a shared data structure amongst multiple parties, I think you're probably right, will come into use somewhere. The question is how broadly because you have at the center a really-- Dani used the word gnarly, but maybe if I use that here, gnarly set of governance issues, how you have a shared data structure, a shared ledger.

And then, of course, in cryptocurrencies is another set of challenges. Is a private sector currency needed? Well, if fiat currencies are well managed, if monetary policy and fiscal policies are well managed, probably not. But then again, the history of nations, the history of finance and money of 200 countries, there tends to be one to three at any given time that aren't managing their fiat currencies well. So there you have it.

AUDIENCE: One last notice. Only when governments' interest aligns with the blockchain, because fiat currency's centralized and blockchain is decentralized, would we have a wide acceptance of blockchain, correct?

GARY GENSLER: That's a good point, that the sovereign currency is probably here unless there's some collaboration between the central authorities and the use of that technology is your point.

So we're going to dive in a little bit. And just sort of summarizing, I talk about the technology stack. And the cloud, mobile, the internet were important parts that were added to the finance technology stack, really, from the 1990s all the way till now. And if you look at big finance, all using the internet, of course, from the late

'90s, and into the naughts, all pretty much rolling out mobile applications, particularly in the last 10 years, often because of the pressures from startups.

Not so much all have rolled in the cloud. And many big finance companies are still having their centralized data structures. But more and more are using the cloud. What's important about the cloud, though, is that it gives startups a real chance to sort of rent versus bill. So you don't have to build your own data structure, put it in Microsoft Azure, put it in an Amazon AWS, put it in [INAUDIBLE] equivalents and so forth.

So those were all earlier technologies fully in the finance technology stack. But we've talked a lot about in this class machine learning, natural language processing, the critical pieces, really, in the last call it seven to 10 years, that computational power and the ability to analyze data and extract correlations. And what machine learning at its core does best, it's remarkable at extracting correlations, pattern recognition, if you wish. And that pattern recognition on data has started to really be important in this field. And we'll talk a little bit more about it.

But it's also access to data and digital interfaces through open application program interfaces, or API. And you could have machine learning and natural language processing without open API, but open API is a really important piece of this, particularly as startups try to get into this space. And as we talked about, some of that's because the official sector says, thou shall do this. Some of it is technologically facilitated by companies that provided that access. And then many of the incumbents wanted to provide it as well.

And then, of course, there's a whole bunch of things that have been in the technology stack for decades or centuries. We took those as givens. And I think at some point, when this course is taught in the 2030s, machine learning will just be taken as a given. Open API will be a given, and there'll be new technologies beyond that.

Now we talked about one that's really in insurance. And I kid the class a little bit because I know the interest has been more in payments and in challenger banks and neo banks. But why I find insurance so interesting is it's starting to layer a new technology into the technology stack. We don't see this as much in the challenger

banks and in credit. But sensor data, telematics in the automobiles, wearables and the like.

All that remarkable amount of data to assess and underwrite insurance risk, whether it's on an automobile, whether it's on a home, will that come into the technology stack of banks and credit card companies? We haven't yet seen it. But other than sort of social norms and regulatory reasons, why wouldn't we see that wealth of data from your automobile, from your wearables, from Internet of Things sensors wouldn't start to influence, and one might say infiltrate, into how credit decisions are made, again, within the regulatory construct and so forth. So one of the reasons why I find insurance so fascinating, because there's sort of another technology that they're starting to use to collect data. Really important.

And then lastly, we've talked a lot about blockchain technology. I teach it as well. I find it a fascinating area. But just as that back and forth with Luke, I put question marks. Will it come into that full technology stack? It's most definitely been a catalyst for change. It's pushing at the edges of finance. It's starting to make each institution, whether it's JP Morgan thinking about a new way to do payments with something called JP Morgan Coin, or a whole collection of incumbent banks around a project called Finality or utility settlement coin.

We have, of course, seen how Facebook caught a great deal of attention in 2019 and 2020 with their Facebook Libra project, a consortium to roll out a new global currency, both multi-basket and single currency. So incumbents in big tech are taking very close look at this. And then you have the Central Bank of China, People's Bank of China doing something called a digital currency electronic payments program. It's not using blockchain technology. But for sure it's inspired by cryptocurrencies. It's for sure put a higher emphasis for all central banks around the globe to consider what's called central bank digital currencies.

So I put some question marks because we know it's already been a catalyst for change, but will it actually be incorporated in the technology stack? Romain, any questions?

ROMAIN: Let's wait just another second. Yes, Hassan.

AUDIENCE: Yeah. I just have a question. Now at the beginning of the slide, you said internet,

mobile, and the cloud. What do you mean exactly? I mean, did it move from internet to cloud, or is is just like a new technology? What do you mean?

GARY GENSLER: I'm sure-- because your voice is fading out-- are you asking whether I think these are new technologies? I think they were new when they rolled out the internet fundamentally in the mid- to late '90s for most of finance had to take notice. But I assure you, having lived it, in the early '90s, the internet was not in the technology stack, meaning most of big finance and startups of the time didn't use it.

But many of the startups by the late '90s had to. Amazon started in 1995, and they embedded the internet in it. Of course, it was what made Amazon so successful. PayPal started in 1997 or 1998, for instance. Now you can't survive if you don't use the internet. So that's what I'm saying there.

And mobile phones similarly. By and large, finance, at first, was providing things online, or shall I say, on the internet, but not necessarily on a mobile app. And the first mobile apps were fundamentally just the same that you could do online, and then you had to give a better user interface, more adaptable, in essence, something for the small screen that our fingers can do easily and readily on this rather than on a laptop.

So I'm saying that today, whether you're big tech, big finance, or a startup, you have to do these things. You have to do them well or you can't compete fundamentally. But maybe I didn't understand the question, Hassan.

AUDIENCE: I mean, when you move to cloud, is it like supporting the mobile application, or does it have a different use?

GARY GENSLER: I think it does a number of things. Great question. The cloud, I think, facilitates greater competition both as a support function and also a cost function. A lot of finance is about trust. Embedded in finance is trust, and we give data to financial firms. We want that data to be protected.

Now earlier Dani raised the underbelly about how they use the data. But we want to protect it. So by using the cloud, any financial competitor can better insure for cyber security. One of the dominant things about the cloud is it can lower cost. It can provide a standardized form of data security or cyber security. And I think it

somewhat levels the field of competition.

But it's a supporting role. You're right. It's not something, necessarily, that's there for the users, for you and me to see. But we couldn't use Credit Karma, we couldn't use Robin Hood, we couldn't use many of the insurance apps if those venture capitalists and entrepreneurs behind it had decided to build their own data centers. They wouldn't have been able to stand up with the same scalability and same time frames at the same costs. So it's facilitated a tremendous amount of competition.

AUDIENCE: Thank you.

GARY GENSLER: So sometimes in infrastructure technology, I might consider the cloud an infrastructure technology rather than a user facing technology. But as an infrastructure technology, it's darn important.

And so in that context, I've also sort of said, well, there's the customer interface and chat bots and open API or what we've been talking about in this class. But it all builds on that which came right before it, mobile phones, the internet, as we just said.

And we've dominantly focused on customer interface and risk management. Risk management, what we've focused on in this class, machine learning dominantly, sensors and telematics in the insurance field, peer to peer lending is in the risk management side. But all of this built, and could not have been built without the asset-backed securitization.

And like the cloud earlier, Hassan, if I can use that, the cloud is an infrastructure technology, the technology of risk management, that you could take a pool of mortgages, a pool of credit card receivables, a pool of auto loans, and take those and sell them into the securities markets, has facilitated a number of startups to say, look, I don't need to use balance sheet. I can maybe sell these pool of receivables and loans into the marketplace. I could be more like a broker, more on the front end, and give great customer interface, and then sell into the market. So some risk management tools that were inventions and new technologies of the 1970s to the 1990s allows, then, this build here.

And so one of the central themes of this class that I want you to take away is not

necessarily how machine learning works, not necessarily how open API works, but how new technologies come along in the past, and they will in the future-- every five to 15 years there's going to be some new technology. We seven billion humans haven't stopped coming up with innovations that are relevant to the financial world-- and as they do, think about how it opens a crack, how it creates an opportunity.

And if you're at a big incumbent, if you're a Bank of America or Mitsui Bank, think about how it's going to create an opportunity not only for you, but your competitors. And if you don't act upon that new technology, somebody will. There'll be a new Transferwise or Revolut or a Robin Hood or Ally Pay that comes along to use that technology. And I think they will be dominantly in these two areas, customer interface and in risk management. But just like the cloud there could be also things that are pure infrastructure. And the cloud created opportunity and moved finance along.

So that's kind of the central sort of conceptual framework that I bring to this. And I think that finance has a fertile ground. And the important opportunities in finance, digitization of money. Money is now electronic. Money itself is but a social construct. But we used to think about it in physical ways. Before a few decades ago, it was all really physical paper money or gold or silver. But frankly. We're in the 2020s. We're living through this coronavirus crisis. We will have accentuated that.

There's a wide public acceptance of new tech. And each time there's a new tech, a new way to interface, though finance is a world of trust, we tend to have a lot of trust in new technology. Now often it's the new generation. It's going to be the Gen Zs and the Millennials before it's going to be folks of my generation.

But there's still a wide acceptance of new tech. Look at all of us in the coronavirus crisis using Zoom and online. It's not as good as being in the classroom. I have to tell you this is definitely not as good as being in the classroom, but we're learning how to use this new tech. And the interface and the processing systems of the legacy incumbents leaves opportunities for competition. And of course, we've talked about data.

I'm pausing, Romain, in case there are questions.

ROMAIN: Let's give it a few more seconds. We have a question from Luke.

AUDIENCE: Quick question. What do you think about encrypting the tech to money via blockchain so that we can kind of see where the public money is spent, i.e. Korea is actually trying to think about doing that. You mentioned China is thinking about doing that. This is more possible in more of the East Asian countries versus very, very high individual rights countries such as the US where they might be allergic to it.

GARY GENSLER: So you've embedded a whole bunch of parts in there. But let me just say blockchain technology has a positive attribute that it's a shared public ledger. On some level, you can make data on that ledger public. You can also encrypt it and make it not necessarily public. So it depends on the architecture. But a blockchain technology with a shared ledger is what often is called tamper resistant. Tamper resistant, some people say immutable, which isn't quite technically correct.

And so a government, or even a private sector firm, could use it to say that's a record of truth. That's a record that is tamper resistant. I haven't seen any government doing that yet. But it certainly can be done. It's been done more in the private sector. You'd still have to trust in the protocol. You'd have to trust in whatever nodes or network maintain that ledger. But it's a possibility going forward.

So who are the actors in fintech? Who are the broad actors? Well, we've talked about them. Big finance, I like to quote the Central Bank governor of Brazil, who gave me this little saying where he said, big finance is like fortresses. They have moats and towers and sovereign affiliations. And I mean, it breaks down a little bit, too. But it has some apt parts of it, being the towers are big finance are dominant in payments. They have their balance sheets. They, too, collect data, and they're vast corporate structures, often, of 1,000 to 5,000 legal entities around the globe.

But there's challenges to big finance, particularly in payments, and some of them are now even incumbents themselves like Pay Pal and Square and Stripe and the like. Startups of just 10 and 20 years ago, now they feel a little bit like incumbents as well. But I think big finance, as we talked earlier with Dani, I think big finance, we will still have banks in 10 and 30 years because there is network economics around balance sheets.

Any study of diversification would tell you if you have a balance sheet that has

thousands of loans on it rather than a single loan, you can lower the risk just through the diversification of the underwriting and the risk allocation. Also, big finance has data. But there's challenges to big finance for sure from big tech, and the Bank of International Settlement talks about big tech in terms of data networks and activities.

Now the data is a little different than big finance because it includes data outside of the financial world. So they get a picture on all of our activity in a different way. Google has Google Chrome, it has Google Maps, it has Gmail. It has so many ways to assess data. Phone companies like Apple have a lot of sensor data as well. That sensor data is currently being used in insurance. But will it start to be used in credit and payment systems and the like?

And then the startups. And I don't count the startups out, but I think to think about fintech just about startups is too narrow, and it's why I think of fintech around these three sets of actors. But startups, disruptive innovators, if you throw up 100 finance startups or fintech startups, two to five of them are just going to break through. I mean, there's some odds to this that some will break through. And they have flexibility, and they're a bit of asymmetric risk takers. They don't have business models to support and protect.

And often big finance is protecting a business model. Credit cards in the US are dominated by seven big companies. And those seven big companies that dominate in the US, they want to protect some of their profit and revenue models. And so that gives an opportunity for companies like Toast to get into the restaurant business. It's a little harder for a big actor to go into those individual sectors and the like.

They also have a bit of asymmetric risk as it relates to regulation, and this is what Dani was saying earlier. It's neither good nor bad. It's just an observation that startups often have a little bit of an attitude as try it out. If it breaks some rules somewhere, clean it up. Work in good faith with the regulators and the like. And because they're smaller, often regulators around the globe have decided to give a little forbearance. There's something called regulatory sandboxes to promote innovation. If they were larger, there would be more systemic and customer-facing problems.

And then fourthly, there's the official sector. And so while finance, tech, and startups are competing and sort of trying to provide better products and better opportunities and user interfaces, the official sector cares about economic growth, but they also care about financial stability. And sometimes they're a little bit in conflict. Also, guarding against illicit activity, promoting inclusion, and the tenets of investor and consumer protection.

So what were the big technologies we talked about? And Romain, I'm going to pause to see if there are any questions. Still there?

ROMAIN: Yes. I don't see any so far.

GARY GENSLER: I just wanted to make sure my internet connection didn't go. So right now in finance, where we've seen machine learning, this extraordinary ability to extract patterns, extract correlations out of data. We've seen it primarily in the middle here around fraud detection and prevention, regulatory, that a lot of the credit card companies and big banks are using it to extract correlations to better do fraud protection and better do what's called any money laundering and compliance. So that big bucket is compliance.

I'd say the second most developed area is around natural language processing or call centers, chat bots, robo advising. We all have studied together robo advising and investments like around firms like Betterment and Wealthfront, I think it's called, and others. But robo advising, both in the credit space, investing space as well. And Bank of America has their voice assistant called Erica. The Siris and Alexas of finance are going to be built out in the 2020s.

But I think the most interesting area, which is not, frankly, used that much yet-- it's being used, but not a lot-- is around the underwriting decisions, underwriting and insurance, underwriting in credit. Basically, how do you allocate and extend and price credit or risk? This is at the core of finance because the core of finance, that sort of neck of the hourglass, is standing between savers and borrowers, or standing between those who have a risk and those who are willing to bear a risk.

And as you're at that neck of the hourglass, if you can use machine learning to better allocate price and extend credit or insurance, then you're going to use that technology. And extracting patterns is an important part to do that. Now you need to

do it within the law you need to do it within these questions of fairness and explainability. But I think we're going to see this grow dramatically by the mid 2020s. It's already there. I'm not saying it's not there. I'm just saying we will see machine learning used much more, especially around alternative data.

We've seen it a bit in asset management and trading, but frankly, it's not dominating the trading floors yet. It's not dominating the hedge funds yet. And a lot of folks in the hedge fund community and high frequency trading community say that their algorithms, their linear sort of type of regressions and classic statistics, are doing well enough. But I think we'll see this dramatically shift.

And I think at times, the real question is, will machine learning be better than a classic set of regression analyses, a classic set of statistics that you can do? The answer is if it's not, you'll stick with the classic statistics. It's not as if you have to throw away the classic data analysis. This is just a stronger tool in certain circumstances to add on top of it.

Romain, questions?

ROMAIN: Let's give it a few seconds. One, two, three. No questions, Gary.

GARY GENSLER: There is this debate sometimes, is artificial intelligence machine learning a tool or a Service? Is it itself an industry or not? I find myself thinking more and more, it's frankly a tool dominantly. But it is also a service at times. It is a tool that is already being used and will be used more and more inside of big finance, big tech, and disruptors.

But that's not to say it's not also a service at times. It can be something like I'm showing here as a compliance software. So you can stand up a company that does one of these things going back. You can stand up a company that does fraud detection better than the banks do right now or stands up something around credit or insurance, as a number of startups have done in the insurance field that can take data in, access data. And maybe you're a data aggregator from the payment space like Plaid , or a data aggregator in insurance that's taking in all that telematics data from automobiles.

And taking that data, you can use AI as a service. And some of these, like anti-fraud

softwares like Featurespace and others, or Tractable, which is doing insurance claims processing, are doing AI as a service. I think you'll see, though, that the dominant way we're going to be thinking about AI, really already now, but within a few years, it's a tool that if you don't have it in your toolkit, if you don't use machine learning to do better data analytics, you're going to fall behind somewhere, whether it's in your compliance side or whether it's in your underwriting side.

And others who use machine learning will have a more nuanced, more flexible, and ultimately higher revenue potential, lower cost potential underwriting of insurance or credit. But I'd think about it as both ways.

Natural language processing, a form of artificial intelligence, but important slipstream. It's really about taking human words and computer language and doing the interface. Content generation, content summarization, and the like. And so what are we already using it for in finance? A lot of ways. Customer service, those chat bots and the Ericas at Bank of America and the robo advisors and the like. That's a big piece.

But that's going to continue to be facilitated and go further, where one day we'll get on the phone and we won't quite know, are we talking to a human or a chat bot on the other line? Chat bots right now can't deal with sarcasm too well. So you can kind of suss it out, still, a little bit with a little bit of sarcasm. But I don't know, in a number of years, what it will be.

Basic process automation, and an area that asset managers are using more and more, still just a little bit, using more and more, sentiment analysis, analyzing vast amount of spoken words, written words, and seeing if they can assess a sentiment that might be important investing in the markets.

We spent a fair amount of time on open API and open banking. And the critical thing here is really access to data and an ability to build software on top of platforms. So in this case, think of big finance as the platforms, just like you might think of Facebook as a platform. Can you build some software on top of it? Maybe it's software to do one small aspect of finance better than the big platform is doing right now, just like you can build one small application on top of Facebook and say, we can do something better.

Now Facebook and other technology platforms sought to facilitate this through open API, saying developers can build on top of our platforms. Big finance was of mixed minds. Some of big finance wanted to promote it. Some didn't. The official sector stepped in, particularly in Europe, with the payment systems directive and other directives in the United Kingdom around open API. But then around the globe, Brazil and other countries, as we talked about, said no, we've got to promote some competition here and share data, in essence.

The shared data is permission by us. That means we say, yes, you can have my data. It's sitting there at Bank of America, but you can have it. The alternatives-- and this is kind of an interesting technological competition-- the alternatives was, I could permission an application like Credit Karma to go get my data at Bank of America. And if Bank of America did not provide an open API to Credit Karma, or an open API, possibly, to Plaid, which is a data aggregator, that Plaid then created data to Credit Karma.

If Bank of America said now, then maybe Credit Karma would go and do something called screen scraping, literally taking pictures of screens using technology to get that data, or reverse engineering of a robotic process automation. So there was a little bit of a competition that open API is also a safer, more secure way to do it, a more standardized way to do it.

So what we've seen is banks kind of-- a little bit disappointing to their business model-- banks kind of coming into this. As I said, many banks thought it was a good idea to be more like Facebook and let startups build apps on top of them. Some banks said no. The official sector got involved. But also, technological competition got involved, this screen scraping and reverse process automation.

Romain, I'm going to pause.

ROMAIN: Let's see if the class has any questions.

GARY GENSLER: And I assure you that more opportunities hacve been created around open API and open banking than we could ever talk about in a semester. And it's usually sort of thought of as a little bit infrastructure, a little bit back office. But there's rarely a central bank governor around the globe that isn't talking about this, thinking about

AUDIENCE:	We don't have any hands up, so we can continue, Gary.
GARY GENSLER:	I mentioned robotic process automation. Some of robotic process automation is just the startups using it to compete and get the data in a closed or more resilient system that doesn't want to give them data. In some countries, you can't get it easily through the market structures or the official sanctioned open API. But it's also being used by incumbents just to accounts and onboarding. It's basically taking something that humans were doing and automating it. And it's called robotic process automation. But just think of any process. It can be reading documents and onboarding a client.

this, how to promote competition within their banking sectors and in their countries.

So how does a big wealth management company, how does an online broker or a mobile broker or online us now, and that you can literally just scan the documents. It reads it, and voila, we're in, that we don't have to go to some bricks and mortar place and get physical documents any longer. So it's an important piece of competition in lowering costs, also, and enhancing user interfaces.

Let me talk a little bit about credit scores and alternative data. The Fair Isaac Company, founded about 50 to 60 years ago by a couple of Stanford graduates named Fair and Isaac, so thus FICO. It's used in 32 countries. There are many countries that don't use it, but it is a dominant way to think about credit scoring in the latter part of the 20th century and even the early 21st century.

And here's the ratios, that 30% of this and 35% of that. It's very static. It's been updated about eight times. There's a rollout of a new FICO score this summer of 2020 as well. But alternative data might give us a better picture on somebody and whether they're going to default on a loan, or whether they're the right insurance risk.

And so the first sort of rudimentary level of alternative data that goes beyond FICO score is your employment or income, or whether you even paid your rent on time. FICO score traditionally hasn't used even whether you're paying your utilities or rent checks on time.

Or, as Ally Pay and WeChat Pay can do, look at a small business and look at your

whole cash flow picture, your revenues and your costs. Or here in the US, Intuit, which Intuit is a company that has TurboTax and has more recently bought some fintech startups as well, that Intuit can see the whole cash flow picture around you. And so why is Intuit starting to think about credit? Because they can get a really good picture around you.

But there's also everything we do online, our consumption and purchase transactional data. Think Visa and Mastercard and what they know about us, or what our bank knows about our consumption and purchase data, using that to say if we buy one product versus another, are we a better credit risk or a lesser credit risk?

In an earlier era, one of the things that people would look at, and this is just a narrow slice, is whether you replaced your automobile tires on a regular basis with new tires, or whether you bought retreads, literally putting rubber on the old tires. And it was found that new tire purchasers on a regular basis were better credits than if you bought retreads.

Well, expand that out. What purchase history would tell you that somebody is a little less or a little bit more capable to hold a loan going forward? But app usage, browsing history, emails, et cetera, your geolocation. And in China, we see this being used in a social credit scoring system where the government, in coordination with many online services, including Ally Pay and WeChat Pay, but even extended to social networking sites like dating apps. Literally the dating apps are feeding in some information into the social credit scoring system in China that then can be used about extension of credit or not.

And then thirdly, particularly out of the insurance field and insurtech. But my question is, how will this be used all the way into credit extension as well? Is the information being collected through drones and Internet of Things and sensors throughout society? And we're moving into a world now where we'll go from tens of billions of sensors around the globe, and that's the rough measurement now, to hundreds of billions of sensors around the globe.

And whether it's in our refrigerators at home, whether it's in our automobiles, whether it's wearables, whether, frankly, one day it's in the paint we paint our

houses, literally. That type of sensor technology, then how does it feed back into, first, in insurance, our homeowners insurance, our automobile insurance, our health insurance from a wearable, but how that data analytics then moves into our credit scoring as well.

Now all of this has to be done somehow within social norms and laws about fairness and explainability and guarding against biases. And those are real and important issues, but I think that's where we're headed with a lot of this alternative data. Questions? This is sthe stuff Dani gets a little nervous about, I think.

ROMAIN: Danielle?

GARY GENSLER: I knew I would spark something.

AUDIENCE: Well, since you asked. So there is a international framework of laws around the right to privacy from the human rights space that are applicable to some of the emerging ways in which we're seeing data be collected. And I'm just curious your thoughts on whether you see that ever really getting traction, particularly in the US, in terms of impacting regulations around how data is collected, how it's used. I realize it's quite an open-ended question.

GARY GENSLER: I think that this is going to be an ongoing public policy debate and cultural debate. And it's not something that will settle down in just two or three years. I think this is a multi-decade how we feel about this, that as sensors, particularly, will go from 20, 30 billion or so sensors already00 maybe it's maybe it's even further than that now to hundreds of billions of sensors-- as they become truly ubiquitous, and cameras in the homes and the like, that data is going to be collected, analyzed, stored, assessed, and used in some way to underwrite insurance and extend credit. I think that's the large cultural trend and technological and financial trend we're on.

So then how do we deal with that? How do we feel about that, coupled with all the data that's being collected as we are online in our geolocations with our cell phones? So we've seen some jurisdictions like Europe pass a General Data Protection Regulation, GDPR. We've seen in the US it's more state-based, California. But even years ago, Illinois put something in place around photographs of our face that are unique to us and so forth. So a handful of states, and so forth.

I think we're going to keep trying to figure out what's the right balance. And even this crisis we're living through right, now the coronavirus crisis, about contact tracing. If we can save lives, and we can legitimately really save lives and have better health care outcomes by tracing our contacts out, not just who we've seen in the last two days, but the last 14 days, and who they've seen, and how some countries like South Korea, and even Vietnam and elsewhere, have used contact tracing to some success. There's a lot of research to be done to see how that's truly playing out.

Will we shift this debate a little bit? Will we all say, look, I'll give up a little bit of my civil liberties, a little bit of my privacy, for the good of the community and the good of health care and so forth. So I think this is going to play out for quite some time, Dani.

And I also think technology can provide solutions, and some of it can be around blockchain technology, where Luke and we were talking earlier about encryption you can have data on an immutable record, really, a tamper resistant record on the blockchain technology that is fully public. But you can also use various encryption methods called zero knowledge proofs and others to sort of lock it down and make it harder to see. And there's great work on this being done at MIT by faculty members like Sandy Pentland and Silvio Micali and the like. So I think technology can help this debate as well. It might be that we share things in certain circumstances and we sort of protected in other circumstances.

So I'm sorry you're going to end up being a little nervous for a while. I think technology can help us. But I do think we're going to be sharing a lot more data.

We talked about blockchain technology. The big question, to me, is adoption rests on addressing what's its viability? What's its comparative viability and value proposition? Do we really need a private currency, or is the fiat currency working just fine. There's been private currencies for centuries, and bitcoin has shown that it can live for now about a dozen years as a speculative digital store of value.

But can other cryptocurrencies take hold in small ecosystems, whether it's on gaming sites, in an industry that's nearly $175 billion, $200 billion industry around the globe, can it take hold in online gambling in a legal way, not in some of the

sketchier, fraud-oriented ways. Can private currencies in gambling be like casino chips, but again, in a, hopefully, legal way. Could it have some broader applications?

And blockchain technology has a shared database structure, a shared ledger. Can it promote standardization? Can it promote some co-opetition where some infrastructure is shared, and then companies compete on top of it, like in trade finance and elsewhere. I think school's still out.

We don't know yet, beyond sort of this thing that we've already seen that it's been a heck of a catalyst for change. It is pushing up against big finance and central banks to think about payment systems, I think, in a more inclusive, more 24 hour a day, seven day a week way. I think it's making payment system providers, central banks, and big tech think about new ways to do cross-border remittances.

And I think Facebook has both sort of put some nervousness in central bankers, but hopefully also promote them to do their payment solutions in a better way for the public. So it's been a catalyst for change. But I think school's still out about how much mainstream adoption we'll see.

And the payment system, we're going to quickly do some of the sectors. These were some of the pain points we talked about. Who were the players that we've seen? Well, big financer players in every one of these sectors. I won't repeat this slide, but never count big finance out. Most of these companies are spending multiple billions of dollars of a year on their technology budgets.

Most of these companies that you see on the screen, the Bank of Americs, is the Cap Ones, the Vanguards, have not hundreds, but maybe thousands of people in their data analytics machine learning side. And nearly all of them are using robo advisors or chat bots by now. So big finance is incorporating as much of this technology in, but they have legacy business models. They have legacy tech stacks. They have legacy approaches. And so that provides opportunities for big tech and startups.

So in the payment space, we talked about it. Ally Pay and M-Pesa in Kenya and Africa, really got in there. And then Amazon and Google and so forth. And in South Korea, Kakao Pay have really rolled in. And in certain countries, like in Africa, in Asia,

big tech fundamentally dominates the payment space.

Startups got in, often, around data aggregation, like Plaid and others, and open API, but also got in around sectors like Toast in the restaurant business. Or some just did the job a little better than big finance and had enough time. Some got in, also, around cross-border remittances like Transferwise and the like. countries like Brazil and seen Pax Sikora and PayTM in India. So it's not isolated to developed countries. It's not isolated to Asia. It's around the globe, the payment space has been very dynamic area.

Credit markets. Credit markets we've talked about. The market design has a lot of features, and thus a lot of gaps and a lot of pain points, whether it's around data, funding, marketing channels. I think a lot of what we've seen in the credit area has been about enhanced user experience and user interface, but then using alternative data. And on the funding side, trying to find an issuer bank partner or securitizing.

By and large, the startups haven't said, it's our balance sheet. That's sort of like a comparative advantage, for now, of the big financial firms. And you could be in any part of the value chains, all the way from the brokerage in origination all the way down to collecting and foreclosing. You'd have to pick sort of where you're going to be.

Competition has been fierce in big tech. Not only does Amazon have Amazon Pay, they have Amazon Lending. Apple has an Apple credit card now, partnering up with Goldman Sachs and Mastercard. Keiko Bank on top of Keiko Pay. And often, the theory of the case was build a payment infrastructure, get in the payment side, and then put credit on top of it. But then there's been a bunch of startups that have said, we're not going to build the payment space. That's already pretty darned competitive. We're just going to come into the credit side.

And I've just sort of thrown up the logos of 20 or 25 credit startups that tend to be unicorns. I don't know if they're still worth over $1 billion in the middle of the corona crisis. But there's a lot of different models here. Some are just going straight at the banking model like Revolut other neo banks. Some have come at it from the credit card space. Some have done it from low cost credit reports like Credit Karma.

So there's a lot of different angles to how to break into the credit space, all of it fundamentally going back to some slice of market design, that if you're looking at one of these businesses, if you're thinking about being employed by one of these businesses, think what's their business model? Is their business model fundamentally about a better user experience? Is it about somehow doing alternative data in a way that's different or better than others? Is it about one slice of the rolls? And they're the best, and they're trying to be the best at the front end brokerage.

We've seen in the mortgage space, for 20 years now, this take off, but particularly post the 2008 crisis, the Quicken Loan and Penny Mac and others now dominate the front end of mortgages. Now partly they're able to do that because our government here in the US is so involved with conforming loan market and Fannie Mae and Freddie Mac, and what's called the government-sponsored enterprises. And we have a really large, developed $10 trillion market, nearly, on mortgage securitizations.

So you can be Quicken Loan and be at the front end and say, just like I might rent data storage in the cloud, I'm kind of, in essence, renting balance sheet by securitizing the mortgages. A little tougher in some other fields, but you've seen a real takeoff in the US of the personal loan marketplace. I think you can sort of envision that's going to keep competing with the credit card space as well.

We talked about capital markets, and particularly this move to zero commissions. And late in 2019, we saw sort of the final part of 20-, one might even say 50-year history of commissions coming down and down, starting with the early 1970s, when laws were changed to allow for competition and commissions.

But it really took a startup named Robin Hood to get to about 10 million users, a free commission app. Robin Hood just started a few years ago, sort of competing with earlier fintech startups, earlier fintech startups like Ameritrade and E-trade and the like. And last fall of 2019, zero commission. But I like this slide, which is this iceberg. There's a lot of other ways to earn revenues, revenues around selling the order flow, as Robinhood does, or earning fees on managing and custodial side of the balance sheets for investors.

So I think there's a competition going on to what might look like zero commissions

or zero fees, and then there'll be other revenue models below it.

We also have seen robo advising. And Betterment and Wealthfront and others have really gotten significantly into robo advising. 2020, already 50 million, 60 million accounts that have robo advising in there. And so the capital markets. This is the fintech startups.

Remember, Vanguard and Fidelity are not just sleeping, or T. Rowe Price. They are moving into robo advising as well. And Robin Hood pushing to zero fees also moved Ameritrade and Vanguard and Fidelity et al into a more competitive space. And they're building on top of another technology called exchange traded funds, which was an earlier era of fintech as well, these low cost asset management funds.

We talked about the asset management side itself, Acorn, Betterment and Wealthfront and the like. These are just some of the unicorns. In the capital market space as well, we have a bunch of crypto exchanges. But it's not just crypto exchanges. A few of these companies are outside of that.

And then insurance. I know it didn't light up the class, but I kind of think insurance brings so much of this together. And I think it's worthwhile to study insurm tech even if you're keen interest is over in credit tech or payment tech, if I might say, because what's happening in insurtech is the opportunities are real. The user interfaces, the user experiences are a little bit, frankly, more staid and a little bit more clunkier. They feel from an earlier time when you take out an insurance policy.

The underwriting has a lot of the same issues. But also the data, you can pull from a lot more data, as we've talked about. And the current sector, just like payment sector has pain points, the insurance sector has a lot of challenges from the fee structures, between 8% and 15% of the revenues go back to the agents and broker fees, to the claims administration, a lot of significant operating and expenses.

And we hear this debate around health care policy. We hear it about, just how do we sort of take the costs out of the system in insurance, so for every dollar that you pay in premium, a higher percentage of that dollar goes back in claims. Now we'll always have some cost of claims management and agents and brokers and the like. But how do we sort of compress claims management? How do we compress the selling so that a higher percentage of premiums ultimately goes to claims?

And so we've seen a lot of competition in property and casualty, health, benefit administration. More around property and casualty because this is around automobile insurance and household insurance. Most of the insurance startups are focusing on the retail sector. But that's also true in credit products. Think about where most of the payment and credit startups, they're focusing on you and me and small businesses. They're not trying to take away the payment and credit allocation to Ford Motor Company. They're trying to help us, help the broad public, with a better user interface and a better product offering.

And in this area, these auto insurers like Root Insurance can actually give us insurance based upon the telematics and how we're driving in that car. Now that might square Dani a little bit, that they know exactly where you're driving and how you're driving and whether you put your foot on your brake too often or not in their data analytics model. I'm not trying to judge how often Dani puts your foot on the brake. But in their data analytics model, they might think so.

Or in India, Policy Bazaar that really is kind of like the Expedia of insurance in India, where you can compare and contrast insurance. There's a lot of exciting things. Here I am going again, trying to get you excited about insurtech. But I would study insurtech to say, OK, what can I learn from it, to move back to the rest of fintech, what I might call credit tech or investech or payment tech, if you wish, because I think a lot that's going on here will influence back. Or you might say it's already happened. Some of what's happening, insurance tech, is a little later, but has already happened elsewhere.

We closed out this semester because we've lived it, the coronavirus crisis. And I think the coronavirus crisis, beyond all these huge challenges we have from a health care and economic point of view, just putting it back in the context of financial technology. I think startups are going to have to focus, and are already focusing on what we call runway, their burn rates, their cash, their revenue, their adoption and so forth.

Initial public offerings are on hold in 2020, probably well into 2021. Venture capital investment's already slowed and will continue to slow, and valuations, thus, just inevitably need to decline in this environment.

And consolidation is likely to increase. There's clearly going to be winners and losers. I'm not saying anything terribly important there. But the sectors matter. Some sectors related to compliance, that might be pretty good. But if you're a sector related to travel or entertainment or restaurants, probably pretty bad. So beyond the sectors, it's really back to runway.

Now there are opportunities serving the various fiscal stimulus and loan programs in Europe, the US, Asia, elsewhere. I think the challenges are going to mount in the next six to 18 months around delinquencies. We haven't seen this hit hard yet in the household sector. But it's inevitable, as this crisis moves forward, that the household sector is going to have to repair their balance sheets. And frankly, too, many people will have to declare bankruptcy or be in default or delinquency.

The small business sector that a lot of fintech startups supported will have to either repair their balance sheets or go into delinquency and default. So a lot of challenges around the startup deal. But I say this from my time at Goldman Sachs. Challenging times also present opportunities for all of us, for you as individuals, and for these companies.

I want to close on something that Ben Franklin said long ago about money, and it's about paying it forward. "I do not pretend to give such a deed. I only lend it. When you meet with another honest man in similar distress, you must pay me by lending this sum to him or her, enjoining her to discharge the debt by a like operation when she shall be able and shall meet with another opportunity."

This is Benjamin Franklin on money. I would say it was fintech of the 1770s to 1790s. "I hope it may us go through many hands before it meets with a nave"-- nave is an old English word to say fool-- "meet with a nave that will stop its progress. This is a trick of mine of doing a deal of good with a little money."

So take this little homage, this little sang of Benjamin Franklin, late 18th century. I call it fintech. And I ask you just to do a little good, not just because we're in these coronavirus times. But I've so enjoyed being with the 80 or so of you these last 12 sessions. Do me the favor, six months from now, 12 months from now, write me. Tell me where you are. Tell me you're just safe and well. If you're graduating, tell me that you got a job. If you didn't get a job, ask career advice. If you're working in the

fintech space, tell me what you're doing in the fintech space. I'd love to learn. I've learned so much being your faculty member.