WILLIAM B. BONVILLIAN: I'm just going to go very quickly through the World Economic Forum. I only wanted you all to glance at this and get an idea of it, because what it's in here for is to show that we're not the only ones trying to think about innovation factors, right. They are trying to figure out what these factors are as they assess different national economies. They have a whole global competitiveness rating system, which they get out every other year.

So in 2015, 2016, as you saw, Switzerland was number one, Singapore number two, and the US was number three in their rating. And then they have a whole series of elements that they consider in their global competitiveness analysis. So they look at what they call factor-driven economies, and the pillars there are institutions and infrastructure and macroeconomic environment and actually early-stage education as a pillar in health. And then efficiency-driven economies, they call them-- that's higher education, that's market efficiency for goods, that's labor market efficiency, that's financial market developments, technology readiness, and so forth. And then innovation-driven economies, business sophistication, and innovation capability.

So they have a very different mix here. I just wanted to throw in kind of a comparative way of other people looking at the problems that we're talking about, and the kind of pillars that they come about, and how they sort different kind of world economies and organize them. But a lot of these factors we've just been talking about. Kind of the core, I think, of what the takeaway is from this study, and let me get-- you also had Rycroft, Lily, as well, so why don't I get Rycroft out on the table too.

That's Bob Rycroft and Kash. They did this piece back in 1999. And I'm leading in to how do you look at some of these more indirect innovation factors? Because they remain important, and we're just going to pick three. And you know they're looking at a kind of an element of innovation organization, which I think is a core factor, but they're talking about kind of a sub-piece of it, this kind of networking theory of innovation organization.

I think it's an intriguing piece. They argue that we are now at a stage in the world economy

that complex technologies drive the economy. So with complex technologies, the lone inventor in the garage working solo-- that's a myth. That doesn't work anymore, because the technologies that lead to innovation are just too complex, they argue. So that means that the traditional focus of US technology policy on R&D at particular institutions and in open markets, that's not necessarily right anymore, they argue. So they say that a much more self-conscious networked learning environment is actually key.

And what does that mean? Well, complex technologies, we know, dominate world exports-- 82% in 1995 compared to 43% in 1970. The rise in complex products means a rise in complex organizational models that goes with it. The number of corporate alliances, corporate interrelationships, the connectedness to the actors, becomes all that much more critical when the dominant products are complex technology based. So as product complexity grows, the need for innovative networks grows. And technological progress in this phase really requires that network learning, integrating, and applying a whole wide variety of new science and technology knowledge and know-how. That now becomes key.

Gee whiz, you know, we're not organized around that. If these guys are right, we've got an innovation system that's organized on a much earlier idea of how technologies evolve. It doesn't necessarily reflect the reality of the complexity, and the fact that the complexity drives much more complex organizational system, which includes networking, they argue.

So they cite George Brown, who is a great former chairman of the House Science Committee, on the point that neglect of the processes of knowledge and their diffusion and application needs to be a core concern of the innovation system. And Brown is talking about particularly at the governmental level, the governmental kind of role here. There's new kinds of learning that need to take place and need to be organized around. If you're going to have this kind of learning network system-- so a shared network learning, which cuts across a series of institutions, institutional engineering that brings in other parts of the systems, like the regulatory side, into the network-- there's got to be a whole evaluation and what they call co-evaluation between complex organizations and the technologies that they're developing.

So learning by doing, learning by using, learning from scientific and technology advances, learning from spillovers, learning from interaction. They argue that these are whole new features of learning that need to occur that aren't necessarily accounted for our current learning systems. So they need to be changed to really accommodate the new realities of the way in which innovation is going to have to get organized.

So that's their proposition. I thought it was just kind of a fun read. It tells us a little more about the determinism piece that we were talking about earlier, complex technologies demand new organizational models. And if Nelson is right, innovation organization really amounts to a core direct innovation factor, then you know stuff like what Rycroft and Kash are proposing becomes significant in the process. Lily, it's all yours.

LILY: That was speedy.

WILLIAM B. BONVILLIAN: Yeah, I'm going to go high-speed for the rest of the class.

LILY: First I'll point out a couple of things that Bill didn't hit the World Economic Forum 2015-16 report. They do mention that, after the global economic crisis of 2008, economies are experiencing increased growth again-- and actually in the United States, are experiencing the lowest unemployment rate since 2008. However, global economies are projected to have slower rates of economic growth than they did pre-housing or global economic crisis of 2008.

And so that sort of brought me to a question-- it was a question for a couple of the rest of you as well-- which is, why is it not enough, or is it enough, for growth rates to be positive and slow and steady? So what is the magic thing that happens between a growth rate of about, what are we at, 1.8%?

WILLIAM B. BONVILLIAN: Yeah, around 2.

LILY: And about 3%, which seems to be more of an optimistic atmosphere. So what's going on in that 1%, and do we need to maybe, for the next few years, post 2008 prices? With the global economy struggling, do we need to readjust ourselves to adapt to a lower rate of economic growth?

MAX: So in the report, I remember that they had mentioned that we should be trying to push further and try to keep our growth, to try to make it faster. But when I was reading I felt like, well, maybe that extremely high growth rate was emphasized in the first place, part of it anyway. So, at least from what I see, maybe we should just try to adapt to what we have now, and just keep things more steady [INAUDIBLE] we do that it'll be less intense.

AUDIENCE: So, like kind of stay on that more gradual slope, rather than the steep one that bubbles out

and then hits that? Is that what you're saying?

MAX: Yeah.

WILLIAM B. BONVILLIAN: So let me take that on for a minute. Because if technological and related innovation is the dominant causative factor of growth, and your societal well-being depends upon your ability to have that growth and to spread that well-being across this society, then if we're stuck at a one at a 1.8-2% growth rate, isn't that going to be an enduring disruptive problem in this society? Aren't we going to be a lot better off if we could push that up to 3%?

LILY: Is it emotional? Is it like the stock market, that's emotionally driven? Is that what's going on here?

WILLIAM B. BONVILLIAN: Well, if we've got a deep problem of economic income inequality at this point, an economic growth rate helps a lot in dealing with that. It's much more problematic to deal with that with a low growth rate. For example, this kind of barbell effect that we've got in this society of a growing upper-middle class, and then a thinning middle, and a growing lower-end services, lower-paid services sector which the middle is being pushed into, it gets a lot harder to fix that unless you've got a stronger growth rate, I'd argue.

I understand your point. How much stuff do we really need, right? How many things we actually have to have? Is there a whole new way of organizing this society? So you're making an interesting underlying point, I think, Max.

AUDIENCE: Then there's also the competitive [INAUDIBLE] competitive piece we're supposed to be beating other countries. We need those innovation waves if we're going to keep ownership of technologies.

MAX: Although, in this more globalized world, we're all very connected, which is why the housing crisis that really was local here affected everyone.

AUDIENCE: Yes, on the other hand, we definitely see ourselves as leaders compared to other countries. I mean, there's no doubt about it, and I think that there's a real argument to be made that if we're not the ones to do the discovery around energy, or whatever, others will.

WILLIAM B. BONVILLIAN: And the gains are substantial. A first mover advantage is substantial.

AUDIENCE: But I guess I would say that it's a good question of how much do we really need to consume?

LILY: Or perhaps it's not necessarily the 1.8% that's the problem, it's the one-two punch of the dot-com, our technological wave, or bubble, bursting, and then immediately after that having also a global economic crisis that compounded each other. But one of your points brought up another question that someone made, and that is have we identified, either within the United States or internationally, what could be our next innovative wave? And is it the same for the United States as it is for the rest of the world, or have we even identified it or do we think we know what it is yet?

MARTIN: The next wave is probably going to be biotech as well. Because what's happening with biotech is that there's this thing called Moore's law, which is a [INAUDIBLE] every year, I think, every 18 months you double your capabilities. For a lot of bioengineering the ability to sequence and also write DNA, [INAUDIBLE] sequencing, I forget how fast the [INAUDIBLE] is. You might be able to Google it, I forget what the name is.

LILY: That's what I do. The Human Genome Project was over 10 years and cost billions of dollars, and now I can sequence a couple hundred genomes for a few thousand dollars.

MARTIN: Those kind of exponential economics is what drives the next wave. But that's a lot like IT, energy would probably be like [SNAPS] somebody figures some key thing out, and it's all ahead. Due to the nature of that market, because of fusion and stuff like that, you could figure out a way to--

LILY: True, but then I think--

AUDIENCE: It's not the history of energy technology.

LILY: Yeah, I was going to say something like, for example, the light bulb. Yeah, sure, Edison figured out the light bulb, but then on top of that, there was all the infrastructure and moving over to that technology that really spilled over.

WILLIAM B. BONVILLIAN: So Lily, why don't we go to Rycroft and Kash.

LILY: It was summarized by Bill, and I just wanted to bring attention to a couple of questions about Rycroft and Kash. So one was a closed question. How do you strike a proper balance, or can you identify a proper balance between encouraging competitive R&D inside a single industry

or field, and then for encouraging this collective learning that Rycroft and Kash say is so important? And I also have a similar question is, is it possible to foster networking and shared learning while protecting profits and patents? Which I think is exactly what you were saying. So do we-- yeah.

AUDIENCE: So, while not always considered the most innovative field, the oil and gas sector has actually come up with interesting ways to do shared learning with, like, joint industry projects where they have third-party labs run projects and companies or buy into them. And that they all share the knowledge of information that has collective good to them. And I've always thought it's interesting that you don't see that in many other industries, but it seems like it has a lot of potential to be useful. Some of you sign these confidentiality agreements, and you recognize that we all benefit from understanding this better. It seems like it could be widely applicable

AUDIENCE: I think one thing to note about that is that oil and gas is pretty mature heard industry. And, say, take biotech. There's a ton of startups and new companies, like for example the new IP battle over the CRISPR/Cas-9 technology, that's huge, because there's so many different companies-- like five or six-- things spawned out of these core ideas and these IP technologies that they're licensing from essentially two different entities. And whoever gets those rights, they have to pay money to. So I think it makes sense, like to kind of share knowledge on a more mature level, but for early technologies and early companies it's hard to say, because you're still trying to protect your market share and kind of enter the market that way.

AUDIENCE: Could I [INAUDIBLE] you? How do you feel like that will be impacted by international science competitiveness?

AUDIENCE: Yeah, I feel like international kind of--

AUDIENCE: Again, so I probably should've framed that a little bit better, I think the context of CRISPR technologies, it's primarily domestic right? It's really Berkeley and MIT who are really fighting for the patent. So in that instance, what do you think, in terms of this particular technology, is the role in international competition or is this a conflict that can be resolved domestically-- in another more innovative way that does not involve patenting? I don't know if that's too much--

AUDIENCE: So I think the fight also kind of extends to Europe, just because there has been some patents filed there. I don't know too much about the legal stuff necessarily, but I think especially since CRISPR is kind of like the new frontier for biotech and medical technologies to really get into the genome editing and could be really applicable to a whole bunch of different subfields and

applications that actually about lot labs are working on here and elsewhere. So I think it's also kind of international, just because companies abroad-- I'm sure Germany and other big biotech companies there are probably interested in probably working them, like right now.

WILLIAM B. BONVILLIAN: Right, and just to add a point to this IP point that you all have been raising. So in our panoply of direct and indirect innovation factors, this whole world of intellectual property rights is indirect, but we can all see how potentially significant it could be. In other words, it's not going to fundamentally affect your ability to undertake the innovation itself, but it sure may affect your ability to realize gains off of it.

MATT: Can I ask a quick question about the-- you mentioned the advantage of a first mover, and so Nelson was saying that the first firm doesn't necessarily get most of the economic gains. To me intuitively, especially where it's something like energy, where you're maybe the first person, and you're setting up a bunch nuclear plant, you get stuck with outdated infrastructure, and you can't change that. So could you elaborate a little bit on that?

WILLIAM B. BONVILLIAN: Matt, I agree with you. I think the distinction here, and I probably should have been more explicit, but the first-mover advantage in launching an innovation wave, in other words a national or regional advantage for the benefitting economy, I think is very real. I think the point you made, that the first-mover advantage for a particular firm may be much more questionable. Others may see what they're doing and be able to make improvements and bring those out more rapidly than the initial firm that's kind of locked into its initial approach. And we see in many cases, with new inventions that bring on innovation advances, we can certainly see firms that have a first-mover advantage. We can also see second movers that are able to capture that. So I think it's a more complex question at that company level, but I think it's clearer at the regional economy, national economy kind of level.

So I would argue that the US, by building strong innovation capacity and its ability to lead most of the innovation waves of the second half of the 20th century, that was a huge advantage. That was a huge gain. So no sooner did the US miss the quality manufacturing wave to Japan in the '70s and '80s, but it came right back with the IT innovation wave in the '90s, which Japan missed. So when you put your economy at the edge of the frontier, leadership of the frontier, capturing those innovation waves becomes pretty important. But I digress, Lily.

LILY: We have 45 minutes total left, which would mean 15 for each of us.

WILLIAM B. BONVILLIAN: Why don't you give us a closing thought on Rycroft and Kash.

LILY: OK. Yeah, I thought they needed to be more explicit with what they were actually saying, as someone who doesn't come from an economics background, the terminology was hard for me to get past.

WILLIAM B. BONVILLIAN: All this learning by doing was a little too squishy.

LILY: Yeah, exactly.

WILLIAM B. BONVILLIAN: Right you need a more exact portrait.

LILY: I need my terms defined.

WILLIAM B. BONVILLIAN: Got it. OK, well, I think that's a valid critique. All right. So I'm going to race through the next couple, which, Martin, I think you've got.

MARTIN: Yeah.

WILLIAM B. BONVILLIAN: This is Egils Milbergs and I'm not going spend a lot of time on it. But again, it's one of these indirect factors that turns out to have some significance here. His point is the old economy was a world of tangible assets. What counted were your plant, your equipment, your land, your physical resources, your product inventory, your infrastructure, support system, physical stuff. In the 21st century of a new economy, intellectual and intangible assets, those are key. So we have a wonderful 19th century accounting system. It's really wonderful. Can really value the old economy. It really can't value the new economy.

And we've been discussing this whole problem with the ability to get capital on the advances. If you've got an accounting system that can't value true value in the new economy, then of course you're going to have a serious problem getting capital funding available. So here's an indirect thing, you know, the accounting system, that turns out to have a fairly significant effect.

So the inability to measure intangibles undermines the willingness of firms to invest in innovation because they can't really score it and get gains from it, and it limits the investment flow into innovation as a result. So, and he argues, paints a picture, of how this intangible

process came about, arguing that by the late 90s, looking at the US economy overall, it was about $1.1 trillion invest in intangible assets in the manufacturing sector. In that same sector, there was a trillion dollars in combined in R&D business processes and software. Much more intangible.

And intangible capital, he argues, became 82% of US firms' market value, just an overwhelming portion of their market value. So we need new metrics for how firms invest in these qualitative innovation factors, so that we can drive investment in an efficient way and to the right places and we just don't have them.

We only measure a couple of things. We measure total company R&D investment-- that gets reported on quarterly reports, and we get company patent filings-- that gets revealed as well. But then all this other stuff, and maybe these aren't the right factors. Maybe some of them are completely wrong. But there's a whole set of other potential measures we don't even ask for, or even think about how they could be best organized. So that's Egils core idea here. That's why you need to get some of these indirect innovation factors right, along with the direct ones.

Another example. This was Udayan Gupta's early book on venture capital, kind of an early history of venture capital. It came out in 2000. Venture capital, by 1999, had grown from $3 billion at the beginning of the decade to $30 billion. Now venture capital in 2015 was $60 billion. So venture capital was built on the idea that introducing new technologies delivers much higher investor returns.

Remember that chart that one of you cleverly asked me how many years it covered, was that-- that was Martin? This is, he's saying the same thing. In other words, if you can capture the gains of radical investment, they can be really big. And that's what the venture capital sector is organized around. And he notes this interesting history.

So we're in one of the capitals of venture capital, we're in the place that originated it. The East Coast model originally was much more focused on what we would call, today, financial engineering-- you know, tax benefits, short term returns, that conceptual framework kind of dominated the early Boston venture capital model. The West Coast developed a very different model around science and technology-driven growth in places like Sand Hill Road and Silicon Valley, it's still its capita.

So now those distinctions have pretty much disappeared. Both sides are in the same game. And you include within the term of venture capital, some people include a much broader

phraseology, including angel investors, corporate venture firms, foundation venture firms, sometimes university endowment funds, that go to a venture kind of purpose. So it's a bigger landscape than it was at the early stages. But the East Coast model, which did things like late-stage buyouts, turnarounds, roll-UPS, consolidations, in addition to early-stage venture. That's now prevalent, frankly, in both the East Coast and West Coast models. So the two sides have kind of merged.

The originator of the venture capital idea was General Georges Doriot, who was World War II general, helped in the organization of industry in Europe during World War II and following it, so a remarkable figure. He taught at the Harvard Business School, but he's the one who kind of saw this potential gain from innovation-based growth.

And the West Coast model really was kind of a maverick model. It was very high-risk investment based on quite unproven technologies, and that turned out to be the right model. The problem is we're not frankly doing enough of that in enough areas, and we'll get to that at another point in class.

So that's the venture capital story, and let me just close, and then we'll have some dialogue that Martin will lead. This is Charles Schultze, who was quite a famous economist. He was budget director for Lyndon Johnson and for Jimmy Carter, who is head of the Council of Economic advisors. Very highly thought of economist from Minnesota. Deep historical role in governmental policymaking.

He's taking a look at the debate-- which will actually get into our next class-- about what's going on with Japan's economy of the 70s and 80s, where they're bringing on this new innovation wave of quality manufacturing and the US is trying to figure out how to respond. And he's talking about the political debate, much as we were talking about the political debate that's going on now, he was talking about the current political debate of that time when he writes this in 1983.

And there was a big debate over US competitiveness. There was a deep concern that the US was, guess what, de-industrializing. Sound familiar? That essential US heavy industry was in decline. And the 80s concern was that the US may have been at the cutting edge of technology advanced, but it was not implementing those technology advances. Whereas, by comparison, the US perception of the time was that they had a very activist governmental kind of role, an interventionist governmental kind of role, that's identifying technological winners

and moving those right into implementation.

So in a way, Martin, it's like the point you were raising earlier. Don't just do sculptures, do buildings. Japan was deep into the building phase. The US was still at the sculpture phase. And its principal arm for doing this was MITI-- which is now called METI-- but still very prevalent. But considerably less interventionist now than it was back in the 70s and 80s.

What proposals are the parties coming up with on how to deal with this? Well, here's what the Democrats were up to. They decided there should be an industrial development bank. It would, just like in Japan, pick winners and, heaven forbid, it would protect losers. So no one would have to lose, jobs would be protected, and so forth. And yet they would also select winning new areas to get investment. And it would work to rehab failing major industries, upgrade them, protect their workforces, but also attempt on working on a new labor agreement between management and labor to get labor cost cuts that would help fund the restoration of these sectors. That was the Democrats idea. The Republican idea was to-- you guessed it-- support reductions in marginal tax rates.

Schultze is very concerned about this idea. His concern is that the US government is not able to select a winning industrial structure. This is just not a good job for government to be doing. It will not be good at this. The regional politics, the state politics, are just so powerful that it's going to unglue the government's ability to pick a winning technology sector and ride with it. It's going to have to be dispersed, everybody's going to have to have gains, jobs are going to have to be located all over the place. Just not something that's going to be supported well, that the political system really cannot efficiently choose between individual firms, and particularly regions, for getting support at this stage of the industrial process.

So find and support R&D, but when it comes closer much further down the pipeline and you're actually picking industrial winners, that's a really tricky political process he warns us about. So a lot of this class, as you all were driving us towards today, is going to be what is the governmental role. So Schultze stands as a warning about the political imperfections of government, the political difficulties of government in undertaking an interventionist role.

So I think that's probably a pretty good since we all skipped the rest of Schultze, but that's really his core idea, is to tell us a cautionary tale about what the governmental role is going to be. That the sheer massive weight of politics is not going to necessarily drive optimal technology decision-making. Now. Martin, let me turn it over to you, and let's go through these

three. So first Egils, and then maybe do a couple of questions on that and say some points, and then let's do Gupta on the venture capital structure.

MARTIN: Just do like a general overview?

WILLIAM B. BONVILLIAN: Yeah, let's just have an overview, and we'll start with Milbergs, and then go into a couple of questions.

MARTIN: The objective is to increase incentive for private sector, especially long-term, innovation strategies and investments, but that can be pretty difficult to do. Market values are driven by economic conditions, demand, potential market size, and profits. Various [INAUDIBLE] competitors reason [INAUDIBLE] alternative substitutes. But intangible assets most likely will determine the long-term success of a company. It has to do a lot with their corporate strategy.

Most likely, the company that we see that are successful today that are going to be successful 100 years from now won't be doing the same thing. An easy example would be if you look at what Monsanto, originally they were a chemical company, and now they're focusing on agriculture. So I know a few of these long-term innovation strategies, on these things that are hard to measure.

And so a couple of questions that were left up were, what innovation trends and sectors represent the most promising growth areas for VCs in the few years? What can incentivize the shift to long-term intrinsic value creation compared to short-term objectives? If anybody has any interesting insights or experiences that just kind of [INAUDIBLE] Feel free to share them.

Rasheed: I think about, particularly the old accounting system, which is kind of measuring money flows, financial engineering which is kind of important, I think that might have been easy-- I guess it was easy and so it's easy to probably think of it as easy because you were doing it for so long. But I think particularly in valuing its intangibles as something that we see is going to be create all this growth.

And then, I don't know if there's any management studies or kind of behavioral things that we can take a look at how are we doing at these intangibles, because these intangibles seem like something like, you know it when you see it. You might not be able to put bounds on it, or put a number on it. I feel like it's because we haven't tried.

And so I don't know if there have been any efforts sustained, or even accepted, or even argued over, to start valuing these intangible things as we can complain all we want about how

we can't measure the intangibles [INAUDIBLE]

WILLIAM B. BONVILLIAN: So, Rasheed, a very interesting point. And there's been a significant amount of work in Britain, actually, to try and figure out measurement systems for these intangibles, these kind of know-how based assets. And then following from that work in the EU on trying to measure these. Interestingly, we really haven't done much in the US on this, as crucial as it is.

AUDIENCE: Because I think it's really important to have some sort of standardized way to measure this, because otherwise it all comes down to trust between companies and investors, and companies will always have an incentive to overstate what their intangible assets are. And because they're intangible it's harder to prove whether they're being honest or not, so there needs some sort of standardization process.

AUDIENCE: On the other end, like from an investing standpoint, isn't the fact that valuing intangibles and things like IP, the main reason why there could be like hidden value or of mispricing based on, because not everyone has a good idea of how to price these things, that's how they can find sort of an edge based off other companies that might not have the same insight.

I feel like that might be one of the reasons why there hasn't been a push to kind of, I don't know, standardize, how to quantify those-- not only because it's difficult to. Especially, like, I think he brought up like customer satisfaction. I feel like that's really hard to figure out a way to come up with a metric to say, oh, this customer satisfaction is higher than this one. I feel like it'd be difficult but interesting to come up with a system.

AUDIENCE: I was also curious whether he's talking about a system that's applicable to companies in different industries, or just companies within the same industry. Are you looking at Dropbox and Box, or are you looking at like Dropbox and Facebook? Can you actually compare across-- not even the same industry, but across like applications, even.

MARTIN: Another interesting question to add onto that is, why are we treating intellectual property for different industries the same? I think the lifetime of a pattern is around 20 years, and so why is it that something that is really easy or relatively easy to do that [INAUDIBLE] as a patent for IT, like for Facebook, where it's very quick to capture value relatively to other industries versus like energy, where they might take you years and years of research to do it.

And then even to execute, 20 years is a short time frame because it might take you 10 years to negotiate where you're going to put it, right, if you're doing a reactor system. So by the time

you kind of get started, there's incentives there to now really focused on those industries. So even biotech, where I think it's around a billion to $2 billion to create a drug. Why aren't there longer intellectual property cycles for those industries, in order to incentivize more growth in those areas?

MATT: So I mean, the 20 year thing is a general framework, but there is for pharmaceuticals, there are patent laws that will extend the lifetime of your patent to compensate for some of the R&D. But they do exist.

WILLIAM B. BONVILLIAN: When we do a class on the life science, health science kind of case study, we'll get deeply into this whole question about patent term, and could you start to vary patent term, to encourage small-market drugs, third-world disease drugs which wouldn't ordinarily come about to the system. Where you're right, our team, we've got to capture a [? billion-eight ?] just upfront in order to bring a drug to market.

MARTIN: Did anybody have any interesting thoughts or disputes or any ideas they wanted to express? [INAUDIBLE] Can you put on the Doriot slide?

WILLIAM B. BONVILLIAN: Sure.

MARTIN: So originally, venture capital started, the story is that William Shockley came up with the transistor. He won a Nobel Prize for it, but then he got really cocky. And he had all these brilliant people, he acquired the best talent in the nation, PhDs from MIT, Stanford at the time, and they all came to work for him. But he was such a bad boss that all these great minds felt under stress working for him. They were called the Traitorous Eight, and they chose to leave him and start their own company.

What they did is they wrote a letter to this guy called Arthur Rock, who was a Wall Street financier, and they asked him if they could get some funding to create their own company. And they had a strong IP and strong knowledge of the industry. And he got the funding. So that was the beginnings of venture capital.

It really didn't speed up until the 90s and the IT revolution, because originally venture capital was very much a long-form capital. What happened is that you would invest money, and you expected it-- they were going to get a core capability, they were able to reap profits for long periods of time. But that changed when the IT religion hit, in that it could be a fast way of

making a return. And so a venture capital fund became a lot like hedge fund, and it took a lot more risk.

So pretty much the way a VC firm runs is they'll last round 10 years. The way they work is that they focus on outliers, and winning with outliers, so pretty much what they'll do is, they'd give each of us about-- well, I'll just keep the same figures-- so they'll give us each like a seed round of about $100,000 to a million, but they only expect one of us to really become like a Facebook.

And they know that every single year there's probably only like 10 companies that you should invest in that are going to be the big winners. And they focus on these multiple high-factor returns. If you make less than 15x to your original investment as a VC, you're considered a bad VC. And there's still only like a couple of VCs that are known as the really, really good ones, and what they focus doing nowadays is not just getting you money. They actually focus on helping you build out a team.

And in that paper they actually talked about, we look a lot at the technology but also the person, because pretty much we're going to help you grow this company like it's a jet. It's going to be changing rapidly. You're going to have [INAUDIBLE] the person during each phase of it.

And so this is a form of capital that has become very popular. If you look into the, I think we have some of the numbers there for how much was raised every year in terms of funds.

WILLIAM B. BONVILLIAN: I got it.

MARTIN: A billion in 1990, $30 billion in 1999, and 2015, $60 billion. So there is kind of a VC capital bubble, and it's really illogical because there's only ten companies you should really invest in that are going to make huge returns. At the same time, though, because it's a really great business, or it seems that way, a lot of people are putting in money. So there's bubble-ish behavior.

And so, couple questions from that era. What innovation trends and sectors represent the most promising growth areas for VCs in the next few years? Any questions about VC capital?

LILY: Yeah I do, actually. It's Lily. So you said that in the first round, or like the younger VC capital, a few years ago, the expectation was for longer return. Now we've been spoiled with the tech

revolution and people want returns on a two-year, two- to five-year? Is that reasonable?

MARTIN: More or less. Like, if you're a really great company you're going to exit to an IPO in about seven years, ten years. So that's what we're looking for.

LILY: Can VC have funds that mix, long-term and short-term? Is that what they're going to have to do, because I see short term and this huge influx. Look, we have excess capital now. If you say that there are only x number of companies that really hit it big in the short-term, we have excess capital as compared to previous years. So do you think that VCs are going to have to start paying more attention to long-term returns, and is that a more sustainable business model for them?

MARTIN: So what's happened is, it's not so much like VCs in terms of making return, because the way a VC fund works is that they'll acquire money from, say, MIT's funds. And then you increase that capital. So a lot of times they can't say, oh, well, we're going to focus on this and it's much better, it's going to be net profitable, but not in terms of money. It'll be good for society.

That doesn't really happen. What ends up happening, recently there's been a fund that's like that, that was invested where the investors are Jack Ma from Alibaba, Bill Gates, I forget the name of it-- Breakthrough Energy-- and they focus on longer time cycles of around 20 years. And also they focus on having, it's pretty much like the dream team of billionaires on it.

AUDIENCE: And they announced it a year ago and they've now formed the pool of money, but I have yet to hear about any actual investments.

MARTIN: The reason I bring that one up is because it's not so much that they're trying to make huge returns on capital. What they're doing is a mix of philanthropy and venture capital.

AUDIENCE: [INAUDIBLE] patient capital.

MARTIN: Yeah.

MATT: So, related to that, I'm sure you know that there are VC firms that will only do a Series A financing, Series B financing, or Mezzanine financing. And there are firms that would do a mix of that, at different stages in companies. But then you run into the upper limit, where you have groups like the [INAUDIBLE] I'm working on where venture capitalists don't want to wait more than 15 years or so to [INAUDIBLE] a return.

AUDIENCE: So I've heard of the number of funds, especially in Silicon Valley, that aren't just like solely VC now, but are also like long/short equity funds, like more of a hedge fund style combined with VC, so it's sort of like-- VCs more longer-term horizon like two to five years or whatever. They're willing to wait out for but also in the short term, playing around with getting some returns that way. So I think that might be a response to how to address that problem with what to do with a longer-term horizon.

Rasheed: Is it also just really early to tell? Because I guess the idea is you see firms and [INAUDIBLE] So I guess we're probably not slowing down according to this one venture capital group but like, is it kind of hard to see out, you know, these firms are now starting to pop up who are willing to invest out past 15 towards 20 years, and is it a little bit early for us to say maybe these firms might have more success or less success than the traditional model? Because it really is just really new and they haven't made a single investment.

AUDIENCE: Well, and the percent of VC money that this represents is small.

WILLIAM B. BONVILLIAN: Yeah just to put a few numbers on the table. So, venture capital funding in 2015 was $60 billion. Venture capital funding before the great recession was about $60 billion as well. So we're sort of back to that number. But when you, think about, I mean after all, if growth is driven by technological and related innovation, and you've get $19 trillion economy, say, nationwide. $60 billion in nothing. That's not a lot of money to be banking on what our future growth is going to be.

So the issue I think Martin shrewdly raised, was we're not on an innovation wave at the moment. We're on the kind of scale-up part of the IT wave. It's not the 1990s anymore. VCs really work amazingly when they're right on the cusp of an innovation wave. And playing for that very rapid scale-up in growth so Art Rocks' investments in intel-- which, you're absolutely right Martin, did drive the creation of the West Coast model-- that was just at the cusp of the IT wave. And the VC firms really rode it, and we're not on one of those ways at the moment.

So the VC model has gotten much more complicated, because the number of firms that are actually going to carry the kind of rewards that occur typically in the fast scale-up part of the innovation wave is just slower. Things are slower. We're waiting for the waves, right, like surfers. And I think the old model, the maverick model, will come right back if we get onto one of these waves, but as we've discussed these are typically 40-year-long propositions. And you can be in a long trough before a wave takes off, so that's the fundamental question for this

industry.

On the other hand, maybe there's another way of looking at it. Maybe the other way of looking at it is, could you spur waves more rapidly, and is the short-term return model of venture capital a real barrier in our ability to stand up longer, stronger, more enduring innovation waves sooner? So there's a couple of ways of looking at this that I think are intriguing. And we're going to we're going to take a dive into venture capital later in the class, kind of looking in little more detail, too, as you suggested, Matt, about the engine.

MARTIN: Yeah. I was going to bring up, there is one venture capitalist that focuses on the longer time horizons, about 40 years. His name is Peter Thiel. Actually the whole idea that we are kind of like a technological recession is from him. He talks a lot about how we're not really increasing our capabilities, and he's famous for having this one quote that goes something along the lines of, we were promised flying cars, but we got 144 characters.

WILLIAM B. BONVILLIAN: It's one of my favorite quotes, Martin. I was going to use it too.

AUDIENCE: [INAUDIBLE]

MARTIN: The thing is, if you looked into the '50s and '70s, or if you look at the comic books, if you look at Iron Man and all different characters, they show this feature where energy, flying into the air, enough water, we're not focusing on resources and resource wars anymore. And what kind of ended up happening is we have the IT wave but now we are even more pessimistic, right?

And so his point of view is more that we have better things, in some sense. But in terms of having these long-form kind of technologies that have a huge impact on our society, we haven't had that. It's just really good times for this one technology. And that's his main proposition. But he does focus on these technologies that are a longer timeframe.

And that might actually be a huge opportunity, because if, you know, $59 billion of the capital are focusing on these ten year sexy chat companies, like Snapchat, Facebook, Pinterest, that really won't have a big impact, and you're one of the investors who goes, OK, I'll wait 10 more years, but I have kind of trillion-dollar companies, that are coming off [INAUDIBLE] That's a huge opportunity.

The big thing, too, is we were talking about entrepreneurs and how the first inventor usually

doesn't capture that value. This is actually an opportunity for maybe the first inventor to capture a lot of value, and then people focus on that becoming the first wave of venture again. But the drawback of that, too, is that, say, somebody in this room discovered some great technology, but you still have like a semester worth of school, or something like that. You want to stay at MIT for an extra year. Somebody could see the technology and go to Silicon Valley, raise $1 million, $3 million, and they get the scale.

The Silicon Valley model isn't first to invent, it's first to scale. Facebook was the 15th social network invented, pretty much. You've got some notoriety. So that's another big thing is that maybe that divide between the first wave and the second wave of invention is going to get either smaller or bigger. Just because you have these kind of Wall Street hyper-rapid effects.

WILLIAM B. BONVILLIAN: Right. So you're driving us, I think, to an important point, Martin, about the venture capital sector as it's organized now. It's really organized for this, that's what it wants. It doesn't know what to do with this, and it's desperately trying to make this look like this. That's kind of where we are.

There's a problem with his model. It's not there. And so just as we critique the Merrill Lynch piece for the gap here, and longer-term patient capital, it turns out that the VC model isn't really helping us where we really need a lot of help, which is more in this kind of territory. Chloe?

CHLOE: I wonder if some of that comes from, in this piece especially, there seemed to be a lot of obsession of, like, building the right team, and all the right stuff will come if you have the right billionaires all in the room together, just a small number of people. And it's probably easier to ask for a lot in a short period of time from people, because their career lifespan is much shorter than the lifespan of a technology. It would be easier to look a person in the face and be like, develop this for me right now, because, you know, your career is 20 years long. Not your career, but that billionaire [INAUDIBLE] so maybe that's why their current model is more suited for the fast growth, when actually they're in slow growth mode.

WILLIAM B. BONVILLIAN: Yeah, so I mean, Martha was pushing us and Martin you mentioned it as well, this whole Gates has organized this new group that wants to deal with exactly this problem. They want to start dealing with some of this stuff, not just trying to focus on this in order to get an energy innovation wave going. So that may be big enough to be a different model. I don't know. It's not $60 billion and it's a long way away from it, but he is shaking down people with a lot of

money.

AUDIENCE: So, Bill and Martin, isn't the VC model working just fine for the VC firms? I mean, Lily mentioned, hey, there's more capital out there. I'm not sure that's true. I think it's-- aren't they doing just fine?

WILLIAM B. BONVILLIAN: Yeah. It's fine. As long as all we want is software and biotech, it's great.

AUDIENCE: I just wanted to check on that.

WILLIAM B. BONVILLIAN: Right. It's great! It's fabulous! And some services sectors. Media and entertainment are good too. But if the society wants some other stuff, right, then we've got a serious problem on our hands.

AUDIENCE: And Bill Gates has taken it upon himself to find--

WILLIAM B. BONVILLIAN: The energy solution for the world. Right. Because energy is a huge loser in the current venture capital market.

MARTIN: I mean another thing to consider too, is that these institutes-- they're more like institutions now. Like, there's only really five that matter, like Sequoia Capital, Andreessen Horowitz is one of the top ones, what's it called, there's--

AUDIENCE: John Doerr's group.

MARTIN: John Doerr's [INAUDIBLE] something like that? So yeah they're kind of like the MITs and Harvards. Also if you're getting investment, you want it from one of the top ones, because you have to get multiple rounds of funding. So if you get your first round and and investor doesn't matter, isn't that important, it's going to make it so much more difficult [INAUDIBLE] that will matter in the future. But another thing too is that Silicon Valley, which is the cool thing is like they come up with all these ideas on how to structure teams and make innovation.

They focus a lot on disruptive business models, so what might be interesting is if somebody who focuses on like a harder industry and the energy sector, right now we could say that they're a lot like the early telegraph lines, that they're everywhere, right? But it's only focused still on building the mobile phone for energy. Or it's something that's very modular. You have these disruptive angles with technology.

And so the top like fusion startups right now they're focusing on something that's the size of a truck or a reactor that's mobile and stuff like that. But you probably know a lot better than I did.

MAX: Yeah, that's Lockheed Martin.

MARTIN: Lockheed Martin's is indoor. I'm talking about Helion. That's the one that YCombinator or someone invested in.

WILLIAM B. BONVILLIAN: Even YCombinator is only two years down. All right, so I'm going to push us to-- why don't you give us a few comments on Schultze and we'll close out the session.

MARTIN: OK I wanted to link Schultze to this idea, too, because should the government be a VC bunch, maybe focusing on let's pick the winners and the losers when inherently, that's not their nature. In general you're looking for the wellfare of society, and there is a market failure. Another big aspect, too, is they've done better-- well, Schultze's main point is that economies have done better when the government gives a supportive role, and he does talk a lot about Japan.

I think another factor to consider for Japan and also South Korea, because I don't think he brought up in his paper, but his ideas kind of align with that, is that their population periods were in a certain way. Usually you hit into these industrial high-growth areas where you have a lot of young people and very few older people. And that's why they kind of die off very quickly. So that might be a hidden factor that he didn't consider at this point.

But so, yeah. Is it this idea of, do we create this for the environment, or do we focus on industries? I think it also might have been Jorgenson in the last week's class, where he talked about this idea of specific cities that focus on certain industries. That was very interesting, especially contrasting with this point of view, where we make it easier to innovate on certain areas and certain cities and you develop the capability for the city because cities tend to last longer. Well, cities tend to have longer-lasting effects where people stay there.

LILY: It's funny. I kept thinking completely different things while I was reading the Schultze piece. I kept thinking, or wondering, would he be writing-- I didn't look up any of his later papers or pieces-- but I kept thinking would he be writing the same thing if he wrote it today or five years ago? Because he keeps-- and I kept thinking, oh my gosh. Schultze is the reason we have the president we have today. He keeps on telling everyone we're not de-industrializing, don't worry, we're not de-industrializing. But we really were, weren't we?

And so, granted, all of my economic knowledge comes from Freakonomics, but I would say that wasn't this a pretty popular view? We're not de-industrializing, or even if we are, don't worry, because the jobs are going to be replaced by the technology that we're developing, and so don't worry, don't worry. And we really let a lot of the industry here get away from us and to other countries. And so I just think he would change his tune if he were writing it today.

WILLIAM B. BONVILLIAN: You know, you raise a very interesting point, Lily. Schultze's writing in 1983. Solow doesn't get the Nobel Prize until 1987, so growth economics doesn't-- Beth and I were talking a little bit about this before class-- but growth economics doesn't really lock in until really we start to see what's happening in the 1990s. That's when you can't ignore growth theory, you see it right in front of you.

So Schultze is out of classical economics. He keeps pointing us to Japan's success story being the national savings rate. Solow says it's useful, but that's not the driver, it's this technological related innovation. So in a way you can see Schultze, just as you suggest, as a dialogue within different stages of economics thinking right. And Schultze, in many ways, is certainly in the neoclassical and in a way earlier classical economics thinking about growth, before new growth theory develops from people like Solow and Romer.

So that's part of what he's saying here. But I do think that his point about the difficulty of the political system to operate in a sophisticated technology realm, I think that's very real. So every time we-- you know, I'm guilty of this periodically-- every time we want to expand the governmental role and push it further down the pipeline, Schultze always stands as a warning for me about the complexity of how the political process is going to wrestle with this. And the reward system in the political system is not the same reward system that technology standup necessarily needs.

AUDIENCE: Going off your point, I think it is interesting that he mentions, like, if this were a problem, these would be some solutions, like unemployment compensation, relocation assistance, training, but at the time it was a problem. So we can recognize solutions to potential problems, but we don't seem to recognize the problem when it's rising so that we come up with other solutions.

WILLIAM B. BONVILLIAN: So Martin, a closing thought for us on Schultze?

MARTIN: I mean, I thought it was pretty straightforward. These kind of growth webs are very tricky for

the government to focus on, and also to do it well. But having some kind of function in the innovation space is also important to have. So it's really like being supportive of the economic environment, but if you get too close you'll burn yourself, in terms of the complexity.

WILLIAM B. BONVILLIAN: Good summary. All right. I want to thank our three discussion leaders for getting us off to such a good start. Good work, team. You set a model for us at a high threshold. I think now our classes, the participation is pretty well settled. I think we've got a great size. I can just tell from the discussion today it's going to be terrific. You guys are going to be great. And I think we're going to have a lot of fun. So I had a good time last week, but I'm really reassured about where this is going. So thank you all for participating. So I'll see you on the 28th, and I will put out a longer-term list of discussion leaders in the interim.