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A HAMILTON PROJECT POLICY FORUM

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Introduction:

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Framing Remarks:

ERIK BRYNJOLFSSON
Schussel Family Professor of Management Science;
Director, Center for Digital Business
Massachusetts Institute of Technology Sloan
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ANDREW McAFEE
Principal Research Scientist, Center for Digital
Business
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Roundtable: The Future of Jobs:

ERIK BRYNJOLFSSON
Schussel Family Professor of Management Science;
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PARTICIPANTS (CONT'D):

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Roundtable: The Future of Business Innovation:

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P R O C E E D I N G S

MR. RUBIN: Good morning, I'm Bob Rubin and on behalf of my colleagues at the Hamilton Project I welcome you to today's discussion of the Future of Work in the Machine Age. Before I lay out some of the issues we'll be discussing let me say a few words about the Hamilton Project. We started about nine years ago; we are not an institution, but rather we're a small partnership of policy experts, former government officials, academics, and business leaders, organized as an advisory council, and our architecture is totally open. When we have policy proposals they are commissioned from leading experts around the country and then they are peer reviewed rather than coming from internal staff. Our purpose is to support policy development and support serious as a purpose about policy discussion, debate, and dialogue. We believe that that is particularly important at this time when unfortunately the public policy debate in the United States has become so affected by politics, by ideology, and by opinion that is not grounded in

facts, or an objective analysis. The Hamilton Project works in partnership with the Brookings Institution. Brookings contributes enormously to our intellectual vitality.

Since launching the Hamilton Project our view has been the objectives of economic policy should be growth, broad-based participation in that growth, and economic security. We believe these objectives can be mutually reinforcing, not antithetical as is so often argued. For example, wide spread income gains promote growth by increasing demand, by increasing the ability of workers to access education, nutrition, housing, and so many inputs and factors that contribute to productivity and by increasing public and political support for growth enhancing policies. We support market-based economics and equally we support a strong role for government to perform the functions that markets by their very nature will not perform.

And that takes us today's subject, The Future of Work in the Age of the Machine.

Technological development and globalization are keys to increasing productivity and growth, but they put pressure on job creation and on wages. Over the past few decades as technological development has increased at a rapid rate and globalization has increased median real wages have been increased sluggishly or in many cases even been stagnant, and inequality has increased substantially. The exception was the second half of the 1990s when tight labor markets increased incomes at all levels. Today we're going to talk about how to think about that tension between the growth enhancing effects of technology and globalization on the one hand, and the effects of technology and globalization on wages and on job creation for lower and middle income workers.

This forum is a continuation of a long line of programs that we've had at the Hamilton Project focusing on middle income and lower income workers. Growth is necessary but not sufficient for the purpose of aiding and enhancing the economic position of middle income and lower income workers. Growth

creates tighter markets, labor markets, as happened in the mid to late '90s, and it increases the pie but we do need a broader perspective. For example, policies that focus on education, and policies that focus on job creation and on productivity through infrastructure investment, basic research, and so much else, both promote growth and directly improve the position of the American worker.

With this frame in mind, I'll pose a number of questions today's discussions may address. Is technological development likely to continue moving forward at a rapid rate and with great economic significance, or as some argue will its pace slow and its significance decrease. Relatedly, is the dynamism of the American economy in tact or has it declined? If you don't have dynamism then the technological development won't be applied. Data show that the rate of new business formation in the United States has decreased significantly in very recent times. Is that relevant to the question of dynamism in our society? And if it is relevant is that a cyclical phenomenon or

something more fundamental changed? Similarly, productivity has clearly fallen to relatively low levels over the last two years. Again is that a cyclical phenomenon or something secular and more fundamental happening? If labor displacing technology does move at a rapid pace and with great potential for economic significance, and if dynamism continues such that technology is deployed, will new industries and new jobs develop that will replace those that have been lost, and will those new jobs be well paid? In other words what will the net effect of all of this be on job creation and on wages for middle income and lower income workers?

To go further, are there trends in the workforce that aren't yet adequately understood that may relate to these questions. For example, will the nature of jobs themselves change? With fewer employees of companies and more independent contractors, with the increase in the number of functions performed by independent contractors being a function of the enabling power of technology. For

example, what's the future of clerical help when you can get clerical help on an on line basis on demand?

And that takes us to policy; policies that could help address the pressures from technology and globalization. If those pressures continue, aside from improving the ability of workers through the many facets of education and training to succeed in this new world, are going to need enormous amount of creative focus. For example, we may need an increase in the earned income tax credit not only for those who receive it at the present time, but perhaps much further up the income scale. Measures that facilitate collective bargaining can result in a broader participation in the benefits of productivity and growth. And there are numerous other possibilities and potentials that we should consider in the policy arena.

Moving further I think there may be a more fundamental question that's going to have to be answered at some future time, and that may be a distant future time, but if we have ever more rapid

technological development and it is labor displacing at some point in the future, as I say that may be some distant point in the future, should that lead to some basic change in our lifestyles, with less work, more leisure, and a richer, more robust use of that leisure? And if the forces of technology and globalization continue to create rising inequality, even if that rising inequality is accompanied by growth, in addition to everything that needs to be done to enhance growth and tight labor markets, and to improve the position of middle and lower income workers, should there be increased redistribution to accomplish the broad objectives of our society? And if there is to be increased redistribution how does that get done without impeding growth?

The United States has tremendous strengths and I think we are well positioned to succeed over time, but we need an effective government, one that can deal with the hugely consequential policy challenges that we face such as sound intermediate and longer-term fiscal positions, robust public

investment, and reform on immigration, K-12 education, energy, and so much else. In that context technological development and globalization raise the thorny issues that I've just mentioned and I'm sure many others that will come up on the course of these discussions.

We will begin our program with framing remarks from Erik Brynjolfsson, Schussel Family Professor of Management and Science, and Director for the Center for Digital Business, MIT Sloan School of Management, and Andrew McAfee, Principal Research Scientist, Center for Digital Business at MIT. They will be introduced by Roger Altman, the Founder and Chairman of Evercore.

Our first roundtable is entitled The Future of Jobs. Participants are Erik Brynjolfsson, who I just introduced, David Autor, Professor of Economics at MIT, Aneesh Chopra, Co-Founder and Executive Vice President of Hunch Analytics and Former Chief Technology Officer at the White House, and Larry Summers, former Secretary of the Treasury, and Charles

W. Eliot University Professor at Harvard. The moderator will be Melissa Kearney, the Director of the Hamilton Project, and a Professor at the University of Maryland.

The second panel is the Future of Business Innovation. In addition to Andy McAfee whom I've already introduced, the participants will be John Haltiwanger, Dudley and Louisa Dillard Professor of Economics and Distinguished University Professor, University of Maryland, and Arati Prabhakar, Director of the Defense Advanced Research Projects Agency, known to all of us as DARPA. The moderator will be Laura Tyson, Professor of Business Administration and Economics at the Berkeley-Haas School of Business and a member of the Advisory Council of the Hamilton Project.

Let me close by extending particular thanks to Melissa Kearny, who I've already mentioned, our Director, Kristen McIntosh, our Managing Director, and Brad Hershbein, the Visiting Fellow at the Hamilton Project, for providing the intellectual construct for

this session and putting together what is truly a remarkable program. Let me also thank the members of the staff of the Hamilton Project whose thoughtful and hard work is central to everything that we do at our project.

With that let me turn the program over to Roger Altman. Roger?

MR. ALTMAN: Good morning, everyone. I'll be real brief. I think that the upcoming framing remarks and the two panels we're about to have are going to fit anyone's description of provocative. I too want to thank Melissa and Kristen and the entire Hamilton staff for once again organizing an event as rich as this and as substantive as this. As Bob said we're going to start with framing remarks from Erik and from Andy. They are both professors at MIT and the Sloan School of Management there. Erik runs the MIT initiative on the digital economy, and Andy is a principal research scientist at MIT and the Sloan School, and his field of research is the impact of digital technologies on business, the economy, and on

society. So we really could not have better framers, including because they've written a profound book -- many in this room I'm sure have read it -- The Second Machine Age. I took away three points from that book. One, that we're at an inflection point on the pace of digital technological advance, that it is accelerating, and that it will produce unexpected and transformative effects. Two, that these effects will be on the whole positive; more choice, more freedom, more wealth. And three, getting to our focus today, that these effects also will produce considerable economic disruption, in particular the premiums which labor markets have increasingly been placing on education and skills will rise and rise sharply. And by implication the wage pressures and lack of employment opportunity for those workers who don't possess those skills will worse.

Bob reviewed a series of questions that we want to debate today that stem from the book. I'm really just going to add one to his very good list. The past 20 years have already seen labor markets

place a big premium on education. Most people in this room are familiar with the ubiquitous charts that detail the returns to education. So this trend has been underway for some time and it's an absolutely central element in the outlook for American society. And that it has been underway for some time, even apart from this prospective acceleration of digital technology and its impacts is why Larry Katz and Claudia Goldin for example describe the challenge as a race between technology and education. And the obvious question is, is it imaginable that we will raise education levels in this country in proportion to these rising skills premiums and in proportion to the acceleration in the pace of digital technology and software and its impacts that Erik and Andy are now going to discuss.

So, over to you.

MR. BRYNJOLFSSON: Thank you, Roger, and good morning. It's great to be here. You know, America has never been richer. Private wealth is over $80 trillion, our national income whether you measure

it overall or per person is also at record levels, American workers have never been more productive than they are right now. And the reason for much of this bounty is because of some advances in technology. But there's also a paradox. As Bob mentioned median income has stagnated; in fact it's lower now than it was 15-20 years ago. Andy and I -- let's see if we can get the chart up here -- Andy and I call this the great decoupling. The share of the workforce that's employed has also fallen. And if you look back for much of the 20th century there was sort of a rising tide that lifted all boats and an implicit social contract that people would participate in that, but recently that's become somewhat unraveled. And again there are a number of reasons for that. The great recession didn't help, but as you can see this decoupling really started before the financial crash of a few years ago. There have been changes in tax policy and globalization. There are some measurement issues. We're not counting some of the free goods like Wikipedia or the free apps that give us driving

directions. But that's not really enough to close this gap. A lot of it has to do with some changes in the nature of technology. And if you look at the broader sweep much of the wealth creation can be traced to some amazing improvements in technology going back say 200 years ago when a powerful general purpose technology, the Watts Dimension, helped ignite the industrial revolution, and successive general purpose technologies replaced a lot of muscle work with machines. And by and large broadly these machines were complimentary to human labor. Wages grew and more people were working. But we're now in I think the early stages of what Andy and I call a second machine age where machines are also beginning to supplant minds as well as muscles and do a lot of the control functions that used to be integral and only done by humans. In fact about 10 years ago many of us thought that there were a number of categories that humans were uniquely good at and the machines would not be very good at substituting for, in areas like dexterity, language, unstructured problem

solving. But in recent years there have been some big improvements in machine intelligence in all of these areas, catching some of us off guard even. There have been improvements in robotics. Robots like Baxter here are working in more and more factories doing all sorts of manipulation, there are improvements in mobility. Baxter, according to Rod Brooks, works for about $4.00 an hour, and a bunch of simple tasks like this that people all over the world, people in Massachusetts and throughout the world are doing tasks like this. Machines have made huge advances in language which used to be a uniquely human capability. These days if you see somebody talking on their phone, you know, there's a good chance that they're actually talking to a machine, not to another human an expecting the machine to understand. Of course they're not real good yet, but we're in the middle I think of like a 10 year period where we went from machines not being able to understand at all what we were saying, to us expecting the machines to understand what we tell them and answer our questions

and carry out instructions. And by any measure that's a remarkable milestone. Machines are translating between languages. Skype will now let you speak in English and it will speak in some version of German or French or Chinese to other people. Writing simple stories -- here's a report about Apple's earnings, the most valuable company in the world. The text isn't all that exciting. What's most interesting is the byline. It's written by somebody with the name Narrative Science. That's a machine and they write thousands and thousands of these stories about sports, earnings reports, lots of other topics.

My favorite example of unstructured problem solving is what's happened in the thing like Jeopardy where you have all sorts of questions in a variety of different topics of human knowledge, whether it's sports or geography or science or current events. And David Ferrucci, the father of Watson came to my class at MIT and showed me this remarkable chart that I want to share with you. These little dots at the top, these are all the human Jeopardy champions. And you

can see that most of them are pretty good, they got 80-90-100 percent of the questions correct in any given game and they're fairly aggressive as well. When Watson first came out the frontier wasn't very impressive; it couldn't really answer questions at all well, but Watson had a capability that humans didn't, and that was the ability to learn at a ferocious rate. They fed all the information from Wikipedia and lots of other data bases in, and every few months there was another version of Watson that performed better and better. And a few months after Dave showed me this chart they went on national TV, they played Ken Jennings, the champion of Jeopardy, and Watson won as you may know, not just $75,000, but now Watson is being used in all sorts of other applications. There's a call center in South Africa that answers questions when people call in and Watson is powering that question answering system. There are legal versions of Watson, runs in the cloud now; there's a banking version. A team of students of mine worked with IBM to create a version of Watson that has read

the Dodd-Frank Rules (laughter) and helps explain them to companies. Apparently, there are billions of dollars at stake. There are versions of Watson that do medical diagnosing. You describe your symptoms in something pretty close to English and it does a remarkably good job of diagnosing what you may have however obscure it may be. And if Watson is not today the world's best medical diagnostician I suspect it will be within five years and be available on the cloud. And you may well being going for your second opinion or even your first opinion to versions of Watson or other related machines.

Now this is great news in many ways because it's creating all this wealth that I mentioned. And it was a puzzle to me at first when we saw the stats. Andy and I were looking at the stats on stagnating median income and we didn't really understand how that could be, but then we were reminded that look, there's no economic law that says that technology automatically, even if it grows the pie, that everybody is going to benefit evenly. Some people

could be left behind maybe, manufacturers when cars come in or whatever, or there could be potentially, at least theoretically, a majority of people who are left behind, people who do routine information processing work or basic manual skills. There's nothing in the economic theory that says that that can't happen, and some of the data at least recently do suggest that we've had various flavors of biased technical change. In the book we describe three sets of them although there are more. There is skill biased technical change. Here's a chart that David Autor and Daron Acemoglu, my colleagues at MIT, made that very nicely illustrates the fanning out of skill biased technical change, although maybe it has leveled off a little bit there towards the end. Capital and labor have been getting different shares. The share going to workers has been going to workers has been falling in the United States and other countries quite precipitously which may be some evidence that machines aren't as complimentary as they once were to human labor. Superstars are getting a bigger and bigger share, and

again there are a number of reasons, but one of the reasons is the nature of technology. Digital technologies are quite different. You can take a process and codify it and once you codify it you can digitize it, and once you digitize it you can make a copy or ten copies or a hundred million copies, and each of those copies have three very interesting characteristics. They can be made at almost zero cost, they are perfect replicas of the original, and they can be transmitted anywhere on the planet more or less instantaneously. Free, perfect, and instant are three adjectives we didn't use to describe most goods and services historically, but they are standard for digital goods and they lead to some weird and sometimes wonderful economics. They can lead to a lot of bounty, but they can also lead to winner take most markets. If you codify tax preparation you don't need hundreds of thousands of human tax preparers each serving a local market. A few good tax programs, maybe one or a few, can cover a big chunk of the market. And of course as Marc Andreessen has said

this isn't just in a few obscure corners of the economy; software is eating the world. It's coming to retailing, to finance, to manufacturing, to media, more and more parts of the industry. So these economics are coming to more and more parts of the economy.

Now ultimately this can have profound effects as Roger was saying, not just on the bounty but also on the distribution of income, but really it's how we use these technologies. It's not the technology per se that does this, it's how it interacts with our organizations, our skills, our institutions. And at the end of the day the most important thing to remember is that technology is and always has been merely a tool. Now we have more powerful tools than we ever have had before and they have the potential to create enormous wealth with much less need for work. Some people see that as a bug. I think we should see it as a feature. It should be good news. I think shame on us if we aren't using these amazing tools to create more shared prosperity.

So at the end of the day ultimately what's going to determine how we distribute this bounty is our choices, our choices in tax policy, in education, in health and welfare. Ultimately technology doesn't determine the distribution, it's our own choices.

Thanks. And let me turn it over to Any who has got a few additional comments on that.

MR. MCAFEE: Thanks, Erik. Before we get to the panels I would just like to say two things building on what my colleague and co-author, Erik, just talked to us about. The first is to thank our hosts for bringing us together this morning. It's fantastic for Brookings and the Hamilton Project to convene this conversation and to bring such a room of fantastic participants together for this and I'm deeply grateful. In particular, I'm extremely appreciative of the focus that the Hamilton Project has. To my eyes a lot of the debate about the trends in the economy, it's not that it's pointless or misplaced, but it's missing the really important story. We're arguing about the one percent and the

one percent of the one percent and that's a valid conversation. I think a much more important one is what's happening at the 50th percentile of the American workforce, what's happening at the 25th percentile of income and of earnings. These are the people as we've looked around who are really facing the job and the wage challenges. So Hamilton's focus on exactly those portions of our population and our workforce seems to me to be exactly the right focus for us to take.

The second thing I'd like to do is congratulate our hosts, particularly Bob and Roger, for bringing together a really diverse crowd of people this morning. Erik and I have a fantastic partnership, but we have a bit of a problem in that we're now finishing each other's sentences, and we see technology under every rock. And so this morning you're going to hear from people who don't quite look at the world that way and who have done really the best work in many areas, and they're going to bring a variety of viewpoints and perspectives and stories

about what's actually going on in the economy that are going to be extremely valuable for us all to listen to. I know that I'm going to learn a lot. And all of I think our colleagues agree that we're living in deeply interesting and somewhat weird times and we'd better figure out exactly what's driving these changes so we can figure out what levers to pull on. As I said, Erik and I think that technology is one of the big, probably the underappreciated levers.

And the second point I'd like to make before turn it over to the panels is that if that story is anywhere near accurate then hold on to your hats everybody, because honestly we ain't seen nothing yet when it comes to technological progress. We heard this idea of an inflection point. Erik talked about how surprised we have been by recent examples of technological progress. Even after writing our book the two of us still get surprised all the time because it keeps on appearing to us that objects in the future are closer than they appear.

I want to tell you three quick stories to

make that point. These are things that we learned not since publishing the book in January of 2014, these are things that we've learned this year so far. In our conversations so far in 2015 Erik and I had the chance to talk with an entrepreneur whose name would probably be familiar to you, who is pretty well known for making really cool, fast cars. And we were talking to him about the amount of automation in his vehicles and we said when will you have like the capability for a fully autonomous car. And he essentially said yesterday. And we said, I'm sorry. He goes, yeah, I believe our cars are about as good as the average human driver in fully automatic mode. And we said well then why haven't you turned on that mode and made that available to us? Are you worried about the regulators, are you worried about liability? He said no, that's not the main factor. When the time comes we will deal with the insurance issues and the liability and the regulation issues; the main reason we haven't enabled that fully automatic mode yet on our vehicles is because we want to wait until we are

confident that our technologies are ten times better than the average human driver, not just at parity with them. So then we asked of course when does this happen. He said look, I have stopped trying to make that prediction because I kept noticing the date kept going like this, kept marching forward in time. So the driverless car, Erik and I have ridden in one version of it; I think more robust versions are coming more quickly than even he and I probably anticipated. The second example I want to give is of a task that we've been trying to get computer to be good at almost as long as we've had computers. Honestly 40 or 50 years or progress on this with unbelievably poor results. How many of us have heard of the Asian board game, Go? Is this familiar to people here? Go is -- if you're a strategy geek Go is probably the purest expression of a strategy game. Geek is a term of praise by the way. Go is an unbelievably simple game. It's a 19 x 19 square. You and I take turns putting our white versus black stones on it. When I surround your stones I take your stones off the board. We go

back and forth. It's one of these sentence to say, lifetime to master kinds of games. Go masters spend decades playing the game, trying to understand how to play it well. So of course the computer geeks saw this and said great, a strategy game, let's try to program computers to be good at it. They have made unbelievably little progress at that for two main reasons. One is the game is just too complex for brute force simulation methods to work. You can't come close to simulating all the possible Go games before the sun burns itself out. So the brute force that we have with computers is not that useful in this context. Then the geeks would say okay, well why don't we teach the computers the right strategies for playing this game. We'll program in the strategies and we'll refine them over time, and we'll beat the best human players that way. The main problem there is that when you got ask the best human players how they knew what move to make, they go, I don't know. I've done this for 30 years, I understand the patterns, some part of my brain gets it, that move

just felt right. They cannot articulate the strategies that they're using to play the game at a high level. So our brute force methods won't work, understanding the strategies doesn't work. It feels like a little bit of a dead end.

And then just this past year a team of geeks said let's try a different approach. Let's just configure a system and show it a bunch of examples of games played at a very, very high level. We have this great library of Go games played at a very high level, let's show the computer just a bunch of examples of those games and that's it. We're not going to try to elicit the strategies or tell it the strategies or point it to the patterns that are most salient here, we're just going to show it a bunch. Then they showed it high level games in mid stream and they said, hey, what's the smart next move here. They are at the point right now where that system is able to come up with the exact same move as the human expert more than 50 percent of the time. This is after less than six months' worth on this problem. So I made a bet on

Twitter, a platform for all deep thoughts these days. I made a bet on Twitter that by the end of 2015 the world's best Go player will no longer be a human being.

So with a couple of examples like that it just becomes more and more clear to me and Erik that the future is coming at us more quickly than even the experts have been predicting. That means the economic consequences are also going to come at us I believe more quickly than a lot of us were expecting, which make the discussions of today all the more important.

Thanks very much. (Applause)

MS. KEARNEY: Well, thank you all for joining us this morning. My name is Melissa Kearney and I have the privilege of moderating our first panel discussion this morning. This panel is going to take the premise that Andy and Erik laid out for us, that there has been rapid technological advance, in particular in the information sector, and we're going to ask the question what does that imply for the future of work, for the future of workers and the

nature of employment in this country in particular. And as we try to lay out in our Hamilton Project framing paper, there are a wide range of views on this topic, and in particular on whether this is going to be good on bad on that, or how good or how bad on that for the whole of society.

And fortunately this morning we have a really expert group to discuss these issues with us. I mean truly I would say some of the leading minds in the world on these very questions. You have their full bios in your program so I won't run through them in detail, but I'll just briefly introduce our panelists this morning. To my immediate left is David Autor, Professor of Economics at MIT, and one of the nation's leading labor economists who has probably contributed more to the academic literature on recent trends in labor markets than anyone. Then we have Larry Summers, university Professor, President Emeritus at Harvard University. He's also served of course in a number of senior policy positions including Secretary of the Treasury of the United

States and Director of the National Economic Council. Aneesh Chopra served as our nation's first Chief Technology Officer appointed by President Barack Obama, and previously served as Virginia's fourth Secretary of Technology. He is currently the Co-Founder and Executive Vice Director of Hunch Analytics, a technology focuses firm. And Erik Brynjolfsson has already been introduced and he is still a Professor up at MIT Sloan School. (Laughter)

MR. BRYNJOLFSSON: As far as I know

MS. KEARNEY: Yeah, that's right. So the way we're going to do this is I'm going to pose an opening question to each of our panelists, then we'll move into a moderated free flowing discussion, and we'll leave the final ten minutes for audience Q&A. We will be collecting your questions on note cards which then will be brought up to the panel.

Okay. So, David, I'm going to open it up with a question for you. So you have written extensively about the nuanced relationship between technology and computers and workers, and particularly

noting that there are certain things that computers can do that substitute for tasks historically or traditionally performed by humans, and other things that computers do that compliment tasks performed by humans. So in light of your research and the framework that Erik and Andy have laid out for us, how do you see this all shaking out for workers?

MR. AUTOR: That's a great question. I'm honored to be a part of this discussion. I really like the book they've written and I think this is -- and I'm glad this topic is getting the sort of thoughtful discussion that it deserves. I think 15-20 years ago Erik and I started talking about this regularly when I was a graduate student and Erik was an assistant professor and at that time we felt that people weren't taking this issue seriously. If anything I would say people should not panic at this point. (Laughter) And I think there are a number of remarks I could make. I think there's reason for some skepticism or at least a little about how fast things are actually moving. And I would think there's a lot

of aggregate data that don't support the idea that the labor market is changing or the economy is changing nearly as rapidly as the kind of very dramatic stories. So for example, the premium to hire education has plateaued over the last ten years, and in fact we see evidence that highly skilled workers are sort of moving -- have less rapid career directories, are moving into less skill occupations if anything. So that's an important puzzle. Productivity is not growing very rapidly, and a lot of the employment growth that we've seen in the last 15 years has actually been in relatively low education, in person service occupations, which has a technological element to it. So what I would just say that it's easy looking at these examples to see an inflection point, but when you look at the aggregate data there's nothing that suggests that we're at inflection point. Now the aggregate data could be wrong; we can be looking in the wrong place. That's the reason for skepticism. At least for thinking things are not changing that rapidly.

The second point I want to make is that when think about how technology interacts with the labor markets we think in terms of substitution of labor with machinery. And that's a completely natural thing to do because technologies are generally made to substitute, do some tasks that we were doing. But we've been substituting machinery for labor for as long as we've been able to think of ways to do that. And that's a kind of a first order effect, that's a mechanical effect that we can automate transportation, that we can automate calculation, that we can automate information storage and retrieval. But in general what is neglected is that compliments us as well. Many activities require a mixture of things. It may require a mixture of information processing and intuition and creativity. It may require a mixture of motor power and dexterity. And if those things need to be done together, when you make one of them cheaper and more productive you increase the value of the other. So doctors have not become less valuable as medical technologies have advanced, right. They can

do more, diagnose more, and that makes them more valuable. Now ultimately there are kind of three things that sort of contribute to how an aggregate, a reduction in the cost of doing one activity affects employment more broadly. One is whether the technology directly substitutes you individually or whether it helps you do one thing -- does one thing for you so you can do something else. So if you think about diagnosing, medical testing, obviously physicians can get a lot more information in the course of a day. The second is how elastic is the demand for those services? If we are so much more productive with medicine, we could do all the medicine we did in 1950 in ten minutes a week, right, and probably people would be healthier if that was the case given the state of medicine at that time. But of course as we get better at it people consume more of it, right. We spend more and more on healthcare partly because there are many problems with our healthcare delivery system, but partly because the services can be sort of of much greater value, and so

demand for them is quite elastic. And then third, from a labor perspective, it also matters how scarce the skill set is that's complimented. So it takes a lot of education and training to become a doctor, so when doctors become more productive we don't just get an infinite number of doctors at minimum wage, right, because they have to have years of training. And so they're complimented, but their supply moves slowly and so that tends to raise incomes.

So there are many, many examples where productivity increases lead to growing wages, growing employment, and genuinely making jobs more interesting and challenging. But that's not always the case and I should -- I don't want to take too much more time, but to say we see -- so that's on one side of the labor market. On the other we do see a lot of growth of work in non technical jobs that require sort of generic skills and those are hard to automate.

So let me make my final point. A lot of what matters is how rapidly things change, right. So if tomorrow Amazon -- as an example I've used before -

- introduced the $1,000 baso spot and it could clean your house and drive your kids to school and do lawn care and cook for you, and it came on Amazon Prime so you would have it by Monday, that would be a dramatic advance and we would all buy it, but it would be extremely disruptive because there are lots of people that that's their primary activity, driving and cleaning and childcare and cooking and lawn manicuring. However, if Amazon said we're going to have this in 2045 for $1,000 we would be well situated to adjust to that because people would recognize that that was not the place they wanted to be over the long-term for a career. So it matters how quickly we get there. And I think a lot of the debate is not whether these thing will occur, but it's whether we're sort of at the second half of the chess board where the inflection point and all the sudden things are doubling from a small number to a small number, all the sudden double again and it's a large number, or whether it's a very incremental process. And I would say that the technology community, especially the

academic computer science community is very divided about this. I think if you go to Silicon Valley entrepreneurs by nature believe everything will be accomplished immediately. And you talk to -- maybe the MIT crowd is particularly skeptical.

MS. KEARNEY: It's very optimistic out there.

MR. AUTOR: But their view is these problems are really hard. We are making progress which was true 30 years ago, but we're a very long way away. So as Andy said and put it well, we live in very interesting times.

MS. KEARNEY: Thank you. I'm sure we'll revisit a lot of those ideas when we have our discussion. So, Aneesh, I'm going to turn to you. So as our nation's Chief Technology Officer you were tasked with using technology and innovation to further our nation's goals of job creation, reduced healthcare costs, protecting the homeland; tall, tall order. But you've spoken very optimistically about the power of technology and innovation to improve our lives on a

wide scale. So I'm curious to hear how your view of what technology has done compares to that as Andy and Erik laid out, and in particular how have you seen technology impact a variety of sectors, including education and healthcare among others?

MR. CHOPRA: Well, thank you very much for the question. I have three general observations, all very bullish on this next decade.

The first starts with my first trip to Google which was probably in '06. I was Virginia's Secretary of Technology and we were trying to open up government data to search engines to make it more accessible to the American people. Most people were getting information about government through search engines, not coming to the URL of XYZ.gov. And I saw this globe when I walked in which had ostensibly a light emitted for every search that was conducted on Google, and as the globe was spinning you'd get to North Korea and it was like dark. And it was sort of the stark observation when you -- and by the way large swaths of Africa and many parts of the world had just

darkness. If you think about the American economy what sectors are on the functional equivalent of that level of darkness as it relates to the impact that the internet has had on the sector. Healthcare, energy and education have not necessarily been plugged into the internet, especially around data sets that have been constrained by regulatory policy. You know, medical records aren't flourishing on the internet, and your energy usage data isn't flourishing on the internet. And so when you look at all this amazing capability and productivity gains in manufacturing and others, you look to like, you know, more than a quarter of the GDP and you're thinking these groups of sectors have been completely missing from this revolution. And obviously if incentives start to change and data opens up at the same time, you might just see an explosion of innovation. We're seeing that now in healthcare. We've made great strides opening up data, digitizing and now eventually connecting medical records systems. And more venture capital is flowing into this sector than you would

have ever imagined, not necessarily because they're trying to make the traditional system function incrementally better, but now the incentives are changing toward a different type of healthcare delivery system which makes it a wide open terrain for entrepreneurs. And that's very exciting because it's creating new types of jobs that had never been existed before in the healthcare sector, not all of which require a Ph.D. in physics. In other words you can be a relatively low level employee who is utilizing these technologies to help on home health needs and so forth. So category number one is we are now opening up these big sectors to the internet age and I think that's going to bode well to ensure productivity gains hit them.

Second, again when I was Virginia's Technology Secretary, the North Carolina-Virginia used to be like the world's hot spot for furniture manufacturing. That was it. And we've gone through a series of policy debates about those jobs aren't coming back and so how do we build the safety net down

there and maybe broad band is the answer. And we sort of did everything we could to try improve that North Carolina-Virginia border. But something interesting happened around this concept of automation, manufacturing is all of the sudden cheaper because you no longer have to have the same labor intensity, so we can insource manufacturing jobs back to the U.S. at a faster rate in response to China. So Ikea opens up a manufacturing plant for furniture. Where? Right in the heart of that North Carolina-Virginia border, the same place that had been written off for its capacity to build furniture and with being told in the neighborhood you have to do different things because your life as a furniture person is over. What, all the sudden because -- robots as coworkers, automation, you can actually compete on a more effective footing. And we're seeing that insourcing trend now all across the country. Manufacturing jobs are coming back. They're not the same labor intensity as they were when they were previously here, but that's still a net positive.

And then I would say the third observation if I had any is this democratization of entrepreneurship is pretty much the most exciting thing that I've seen because in that same North Carolina-Virginia border there are people who used to have parents and grandparents working in textiles as well. Now they're building designs for clothing that can be 3D printed or can be -- their intellectual property can be transmitted over the internet to textile production all over the world, and they're creating economic value in that same market because folks that previously didn't think of themselves as Silicon Valley entrepreneurs can now plug in because of the democratization of capital, of information. So I'm really fired up about the impact this is going to have over the next decade, acknowledging that obviously in certain sectors we're going to see challenge.

So too bullish, I don't know, but I'm very excited.

MS. KEARNEY: Great; thank you. Okay,

Larry, we'll turn to you. You've been thinking about and commenting on these issues for a long time, and you wrote a 2013 NBER piece that raised a lot of the issues that we're talking about this morning. And recently you led a Commission sponsored by the Center for American Progress on inclusive prosperity, the goal of the Commission being to address rising levels of income inequality and stagnant wages at the middle and bottom of the distribution.

So in your thoughts and views on all of this what do you see as the long run implications for the macro economy?

MR. SUMMERS: Thanks, Melissa, and thanks for the chance to be here. I'll leave the question of what we should until later and so let me focus on diagnosis and make a confession of ignorance and observation and express a worry.

Confess an ignorance is this, and I think it should apply to everybody who speaks confidently in this area. On the one hand we have enormous anecdotal evidence and sort of visual evidence of the kind that

Erik marshals, that point to technology having huge and pervasive effects. Whether it is complimenting workers and making them much more productive in happy way, one possibility, whether it is substituting for them and leaving them unemployed is another possibility; that can be debated. But in either of those scenarios you would expect it to be producing a renaissance of higher productivity. And so we on the one hand are convinced of the pervasiveness and far greater pervasiveness of technology in the last few years, and on the other hand the productivity statistics for the last half dozen years are dismal. And any fully satisfactory synthetic view has to reconcile those two observations, and I have not heard them satisfactorily reconciled which leads me to think that we don't have this all figured out. But it is a big problem to believe. And by the way, if you believe that technology happens with a big lag and it's only going to happen in the future, that's fine, but then you can't believe it's already caused a large amount of inequality and disruption of employment

today. So that is a major puzzle which I think hangs over this subject which I just want to put out there for discussion.

Second observation, I think it is a mistake to think of the economy as homogeneous producing something called output as we approach these issues. And there's an aspect that doesn't get enough attention which is sectors through progress working themselves into irrelevance. Let me give an example, the illumination sector providing light. It actually has had about a tenfold increase in productivity every decade for a century. And we now think of it as a trivial sector in the economy. No doubt we could continue to produce tenfold increases in productivity, but actually most of us want it to be dark at night. And so in fact there are more little league night games than there used to be, parking lots are lit more brightly than they used to be, but basically what's happened is that illumination has become quasi free, and whereas candle making was a major industry in the 1900s illumination is a trivial industry today. And

we need to recognize that a sector that has rapid technological progress, but the world can absorb only so much of it, becomes ultimately unimportant in the economy. Is that kind of thing relevant in thinking about the world? Here's a fact that continues to astonish me and I concede that there are a million measurement problems around it, but it is a fact what I'm going to say. In the way they compute the consumer price indices by definition they were all set to be 100 for every good in 1983. Consider two goods today, a television set and a year at a university. And instead of using a year at a university I could use a day in a hospital. (Laughter) The consumer price index for the latter two categories is in the neighborhood of 600. The consumer price index for the former category is 6. So there has been 100-fold change in the relative price of TV sets and the provision of basic education and healthcare services. If anybody is wondering why governments can't afford to do the things they used to do, I just gave you a big hint. If anybody is wondering where most people

are going to be working in the future, I just gave you a big hint. If anybody is completely confident that we're going to have rapid productivity growth in the future they should be given pause because no matter how fast productivity we have in agriculture or illumination it doesn't really matter for the aggregate economy. And increasingly that's becoming true of a larger and larger fraction of what it is that we produce.

Third, when I was an undergraduate at MIT in the 1960s there as a whole round of concern about this, will automation displace all the employment. And what I was taught as an undergraduate was that basically the people who thought it would were a bunch of idiot luddites and that obviously there would eventually be enough demand and it would all sort of work itself out, and if people got more productive they'd be richer and they'd spend and maybe we needed some transition assistance, but that it was all basically going to be okay. That was what I was taught. That's what Bob Solow thought; he was a hero

and the other people were all a bunch of a goofballs was kind of what I learned. (Laughter) I actually believed that for many years and actually repeated it often. It has occurred to me that when I was being taught that about six percent of the men in the United States between the age of 25 and 54 were not working. And that today 16 percent of the men in the United States between the age of 25 and 54 are not working, and it won't be very different even when the economy is at full employment by any definition. And so something very serious has happened with respect to the general availability of quality jobs in our society and we can debate whether it's due to technology or whether it is not due to technology. We can debate whether it's the cause of dependence or whether it is caused by policies that promote dependence. But I think it is very hard to believe that a society in which the fraction of people in -- choose whatever your most prime demographic group is that should be working, whatever that group is, a society in which the fraction of them who are not

working is doubling in a generation and seems to be on an upward trend is going to be a society that is going to function well, or at least function well without major social innovations.

And I would want to leave you with that concern as there whether you think it's due to technology or whether you think it's due to globalization, or whether you think it's due to the mal-distribution of political power, something very serious is happening in our society.

MS. KEARNEY: Great, thank you. So I definitely want to make sure we return explicitly to the questions that were raised about policy and where we need to push. But before I do I want to pick up on the first observation Larry made and, Erik, this is a great point for you to jump in on, which is given all of these technological advances really celebrated, why is it that GDP per capita isn't rising more rapidly? Why is it that median wages are essentially flat and in particular what does that imply about the impact technology is having on our living standards? We are

not seeing it in the numbers. Are we not measuring it appropriately?

MR. BRYNJOLFSSON: That's a great question. I think it's good for Larry to bring up, and it is part of what spurred Andy and I to sort of start working in this stream in the beginning. People like Bob Gordon and Tyler Cowen and others talked about a great stagnation, and at the same time we were seeing these amazing things. Andy touched on a few of them and there are lots more; we could spend days talking about the wonders of technology we've seen. So it is a bit of a paradox there. There are a couple of parts of it though that are worth kind of decomposing. The part about median income, I don't see that being such a paradox. I think that as I suggested earlier, there's no economic law that says everybody is going to evenly benefit. It could be some small group is left behind, it could be unfortunately a big group. And so you can have biased technical change that grows the pie, but some people are made worse off and I think that's a fair description, at least in my mind.

I don't know, other people would disagree about a big part of the story of what's going on is that people with certain types of skills are in much less demand than they were in the past in part because of technology and many of them are in the median income. And David has been one of the people who documented this, but lots of people have touched on it.

The question of overall GDP per capita is more puzzling. Although as I showed you the chart, you don't see as much of a problem in that great decoupling chart there as you do with the median. I mean I think the big part of the angst, you know, whether it's the Tea Party or Occupy Wall Street, and other people feel is that median line not the top line. But even there it maybe hasn't been quite as robust as maybe some of us would have expected in part --

MR. SUMMERS: No, but it should have been. If technology has been super and more strong and more potent and more everything than it should have been before, the question isn't whether it slowed down, the

question is why didn't these new gale forces of technology lead to a big acceleration. That's what is sort of expected.

MR. BRYNJOLFSSON: So let me address that. So I've spent a lot of time visiting companies that are installing these technologies and some of them are actually quite complicated. So you can install say an ERP system or a customer relationship management system. We documented it takes five to seven years for them to roll out and during that process there's a huge amount of organizational disruption. And you can do this on a case by case basis, lots of case studies of disasters including at MIT and elsewhere trying to roll these things out. Quite disruptive as they're being rolled out. No productivity gain or even a decrease while they're being rolled out, and we have aggregate data from hundreds of these firms that we've -- you know, I've written some papers on this that show that there is a long lag. If you roll that up to an entire supply chain or entire economy, you can imagine that these organizational disruptions, these

organizational compliments which are often about ten times larger than the technology investments themselves, and they take much longer to roll out, can be part of these -- both enormous disruption but also until the complimentary pieces are in place you don't get the full productivity benefits. People like Paul David have documented that when you go back go electricity it took 30 years for significant productivity gains. So I think that may be part of the story, that we're in the midst of a big reorganization of the economy. Yes, that is disruptive, yes people see that these people have to be laid off and these other people have to be hired, and these other people have to be re-skilled. And as you're doing that you don't instantly get the full productivity gain, but you do get a lot of disruptions. So that can I think partly answer Larry's question about how you can have disruption without getting the full pay off.

I would also just take a moment to touch on some of the things that David brought up because I

think those are also very interesting. I mean partly about that leveling off of skill biased technical change, or these college premium, I should say is actually very consistent with what we see changes in the technology that are now as I showed addressing different parts of the labor market. And more broadly I think he raises the right questions about compliments and substitutes and what's happening. And if you look, often times technologies initially are broadly complimentary as many pieces of the system require humans or others to fill in. I mean if you look at horses, the number of horses increased all through the industrial revolution. Up until about 1901 that was peak horse. And because, you know, whether saddles or carriages or other things, you know, made horses much more valuable. But then the numbers plummeted once the remaining component that horses added was no longer not automatable -- if that's not too many double negatives. And you could see similar things. Potentially, you know, are humans different than horses? Of course we're different in

many, many ways. We have a much broader skill set, we can, you know, think a lot better mostly, and --

SPEAKER: And horses don't own capital.

MR. BRYNJOLFSSON: And also once labor starts disappearing you can have humans own capital or at least some of them. Humans can vote, humans can have guns, and do other things that if they're not happy with the income distribution. So there are a lot of other things that are potentially different, but as an economic factor I don't think that there's any necessary inevitability as Larry was saying that what people thought in maybe the '60s, that don't worry, it automatically takes care of itself. And that's one of the reasons I think we should have this discussion is to figure out what are the policies to address it. And even in the first industrial revolution there was a lot of policy changes that helped us navigate that in a way that we did create shared prosperity or inclusive prosperity.

MS. KEARNEY: Larry, do you want to jump in?

MR. SUMMERS: Just on the productivity and

disruption thing. I think it is a difficult argument. So let's take retailing. So you can imagine you're going to have all kinds of spiffy technology so you're no longer going to have to have people behind cash registers and all that. The problem is you wouldn't kind of expect that the people behind the cash registers would get fired before the people working the systems got the new systems working. And so the challenge about right is that people see that there's a lot of disemployment that's already come from the technology, but they don't see any productivity increase. And I understand why it might take years for it all to have an effect. What I have a harder time understanding is how there can be substantial disemployment ahead of the effect of the productivity. That is if you thought that it just was impossible to put in these systems and so forth, then you might think that in the short run it would be a big employment boon because you'd have to keep your old system going, you have to keep your legacy system going, and you would have to have the main guys

running around figuring out how to put the new computer system in. So I understand low productivity, but I think it is hard to square -- and it's not like I have the answer to this puzzle, but if you think about it hard I don't think it's easy to square low productivity and substantial disemployment. And I don't think the lags to reorganization story quite does it because you shouldn't be getting the disemployment ahead of the productivity.

MR. BRYNJOLFSSON: Well, it is a complicated story, and I don't think I've totally nailed it yet, but I think another part of the puzzle is that there are a lot of rents in the economy as well. And if you get the types of people who do the reorganization being very different than the type of people whose demand is falling you can have some big changes in where the rents are happening way ahead of the changes in the overall output.

MS. KEARNEY: So let's deal with the fact that there is disemployment and decrease in labor force participation rates.

MR. BRYNJOLFSSON: Right. The bottom line is there is -- that part I think we agree that the data are -- it is happening.

MS. KEARNEY: Right, we agree on that. And we all agree we don't want to go the way of the horse. So what do we do about this? (Laughter) I want to talk about policy and I'm going to pose this to the panelists as a two part question so bear with me.

So, first, it seems to me that in large part the way this is going to play out for the American worker is going to depend on how labor supply responds, in particular in terms of skills. In other words is there a way to imagine that a sufficient number of people in our population will acquire the skills or the talents that are needed to economically prosper in the second machine age, and what would it take. Is our education system broadly defined up to the task of delivering those skills and talents. The second part of my question is what about those workers who simply can't acquire those skills or don't possess those talents, or even the ones who do but there are

simply not enough high paying jobs for everyone. So I will admit that I am in part worried about a scenario where a small share of the population commands increasingly high wages and a larger hare is relegated to low paying service jobs, presumably providing services to the high wage folks. Like it doesn't make me feel much better that robots are not going to be able to give a good manicure or clean houses any time soon. So, you know, is that a reasonable thing to worry about, and if so don't we need to really rethink our social contract and dramatically expand our system of wage subsidies and income supports?

MR. CHOPRA: I might want to take a stab at this, starting with the premise that if we applied the same capabilities that we've said may have a positive or negative effect, but to unleash them in this particular question of how efficiently are the skills being communicated by employers, the training programs communicating what you'll get if you join, and what the job seeker has or might wish to get, to me we're like in the dark ages of the quality of that

experience. You log onto Amazon.com and there are feedback loops that they've been analyzing to know what's the probability I'm there to shop for a video or for lawn equipment or whatever, and if you ask the same question of the workforce the sad answer to that is drastically no.

We just did a study on the unemployed veterans' skills gap, and what we tried to do is -- we read every job posting in the economy and said what are the underlying skills associated with the job postings. And we then looked at as best we could through open government data the underlying skills of unemployed veterans. And we took the spotlight on the Commonwealth of Virginia and you had hundreds of technology companies post jobs from employers who made a commitment to hire veterans. And they're going out of their way to want to hire veterans, but they communicate the job in such a manner that feels like it's not really available or attainable to some set of the population. So by doing this sort of skills assessment what we figured out was every single entry

level technology job, every single one in April of 2014 from an employer who made a veteran hiring commitment could have been filled by a tech trainable vet who was at that moment in time unemployed in the Commonwealth of Virginia. Yet neither the employer knew to look for that tech trainable vet whose background may not have made the initial screen when they did the screening, nor did the vet know that they could get that tech job because it was not in their like suggested career path. There was no recommendations engine to say this is a very simple and attainable opportunity to get you to the next stage. So if there's that level of inefficiency in information sharing about just basic matching of talent to opportunity -- I mean every one of these *New York Times* stories, how many young people have the skills to get into a Harvard or an MIT -- in minority communities don't even apply because they didn't even think they could get in or know that financial aid is available. So we're making bad decisions in our economy.

So if we unleashed recommendations engines, the same that the gentleman that talked about the Go game or whatever, if the same capability could advise -- if every person in the economy had a little helper that said given who you are and where you want to be here is the shortest path to awesomeness based on the limited additional skill you need to attain to land the best job that is available to you. Is that anywhere near in our system today? How exciting would it be if there was an unleashed marketplace of tools to do just that? Would we solve this -- before you get into the income subsidy question, just make the system work better. I think that's an initial place to start.

MS. KEARNEY: And where is the vet going to get those skills? From the employer, from local community college, from Udacity?

MR. CHOPRA: So this is the other fascinating question. We did a little panel at the Center for American Progress highlighting this AT&T Partnership with Udacity for nanodegrees. These are

six months chunks of learning. Here's the irony of it, they're great for cyber security and other sort of entry -- the interesting areas of growth. So I asked the question, are any of you regulated as learning programs that quality for government subsidy, whether they be Title IV funding or qualified for the GI Bill benefit, or qualify for Workforce Investment Board vouchers. And the sad reality is these innovations are disconnected from any actual government support because there aren't thoughtful regulatory on ramps for these new entrants to be reimbursed in that manner. So these are the areas where I think there is opportunity.

MS. KEARNEY: You want to jump in?

MR. AUTOR: Sure. I agree with the direction you're going in terms of skilling. And I think there's a policy focus on sort of college for all and that has been healthy at some level, but it's very incomplete. Our education system is geared towards get people out of high school and into college. If they don't go to college we sort of well,

it didn't work out. And that's not productive when less than half of young adults are going to complete a four year degree, and that's not going to be 75 percent within 10 years or within 30 years in all likelihood, although there has been an increase in both high school graduations and college completions over the last 10 years. I think we need to think about the skill sets that allow people to do evolving jobs in healthcare, health para professionals in technical positions, many of which require real skill sets, but they don't require four liberal arts training. And so I think we push too many people towards expensive four year degrees which either are not as efficient as they could be or not as appealing as they could be. There are opportunities in kind of in the same area. Holzer has written a lot on kind of the sort of new middle-skill occupations. They aren't things that you can just get with a high school degree. A high school degree is foundational; it's a credential, but it's a credential for further vocational training. I think there's a lot of

productive room for investment there. Hopefully technology will allow us to be better at that. Unclear. As with so many things there is great potential and great uncertainty about how fast and how well it will work.

My biggest concern in all of this is the sort of inequality with which people have responded to these market signals. So you might have thought in a time when college is becoming more valuable and more and more people are going to college that sort of the gradient between household income and college going would get shallower because everybody would take a -- and that has not occurred. The gradient in college going has become much steeper in family income and in college completion much steeper still. And so I think that that works against economic mobility, it means that kids from low SES backgrounds are much less likely to be going to school and to be gainfully employed. And so when Larry talks about the declining employment rate among U.S. workers, we're primarily talking about young males, many of them minorities,

many of them from poor families. And so it's a pretty concentrated problem which makes it worse, not better. If you sort of look from the median on up U.S. society looks mobile, it looks healthy, it looks like it's making the right investments. If you look from below the median that message and the tools to correct that problem are somehow not coming together.

MR. SUMMERS: Let me say a few things, and I'm actually more confident about these than I am about the technology stuff given the productivity question. First, with great respect I would engage in the experiments. I think the policies that Aneesh is talking about are largely whistling past the graveyard. The core problem is that there aren't enough jobs and if you help some people you can help them get the jobs, but then someone else won't get the jobs. And unless you're doing things that are affecting the demand for jobs, you're helping people win a race to get a finite number of jobs and there are only so many of them. This was very powerfully demonstrated by a study done by Esther Duflo in France

where they looked at a variety of these kinds of job matching innovations and they basically found that in low unemployment areas of France they worked, and in the high unemployment areas of France they only helped some people at the expense of other people with no net impact. Folks, wage inflation in the United States is two percent; it has not gone up in five years. There are not three percent of the economy where there is any evidence hyper wage inflation of the kind that would go with worker shortages. The idea that you can just have better training and then there are all these jobs, all these places where there are these huge shortages and we just need to train people is an evasion of the problem. I'm all for trying to do it, but it is fundamentally an evasion.

Second, what we need is more demand. And that goes to short run cyclical policy, it goes more generally to the way we operate macro economic policy, and the enormous importance of having tighter markets so that firm have an incentive to reach for workers rather than workers having an incentive to reach for

firms. It's quite remarkable to look over the years at the Harvard Economics Department when there are 30 professors and 40 graduate students, it's remarkable how badly the graduate students get treated. When there are 30 professors and 20 graduate students and every professor wants a graduate student, it's remarkable how well the graduate students get treated. (Laughter) People who have been to school and environments where there is 60 percent men or 60 percent women are not unfamiliar with this phenomenon. Having the labor market run tight is fundamentally important for fairness, it is fundamentally important for generating investment in workers.

Third thing I would say is that I -- and this is in the same direction as what David was saying, and I agree with him and he knows much more about it than I, I think we can't think of education as just an undifferentiated blob of human capital where more is good. The idea used to be kind of the way I sort of would have thought about this 30 years ago was that part of what would be good about having

more education is that people would be able to work in an office rather than being plumbers. And that was part of what was good, that would upgrade people and give them new opportunity, and plumbers' children could work in offices rather than being plumbers. It is kind of the essence of the technological changes that are being described, that they are much more heavily bearing on people who work in offices than they are on plumbers. And so the whole idea of working with a craft and a specialized skill rather than this generic general manager with liberal arts competence is I think central to thinking in a rational way about wages.

If I can say one other thing, I think that the broad empowerment of labor in a world where an increasing part of the economy is generating income that has a kind of rent aspect to it, and the question of who is going to share in it becomes very large. One of the lesser puzzles, but very large puzzle of our economy today is that on the one hand we have record low real interest rates that are expected to be

record low for 30 years if you look at the index bond market, and on the other hand we have record high profits. And you would tend to think record high profits would mean record high returns to capital, would mean really high real interest rates, and what actually have is really low real interest rates. And probably the right way to think about that is that there is a lot of rents in what we're calling profits that don't really represent a return to investment, but represent a rent. And the question of who is going to get those rents which goes to the minimum wage, goes to the power of unions, goes to the presence of profit sharing, goes to the length of patents and a variety of other government policies that confer rents, and then when those rents are received goes to the question of how progressive the tax and transfer system is. That has got to be a very, very large part of the picture. An I am concerned that if we allow the idea to take hold that all we need to do is there are all these jobs with skills and if we just can train people a bit then they

will be able to get into them and the whole problem will go away. I think that is fundamentally an evasion of a profound social challenge.

MS. KEARNEY: So let me ask you though, you've raised the issue of the minimum wage and unions and the bargaining power of workers, but it strikes me that we're faced with a conundrum in the sense that these technological changes we've been talking about make the imperative of giving workers more sort of bargaining power and a higher minimum wage, make that more compelling and important, but at the same time those same technologies make it easier for employers to replace workers who become too expensive with machines. So how do we thread that needle?

MR. BRYNJOLFSSON: Well, I think that is a real challenge. One of the ways that I think a lot of us have talked about is not just the minimum wage, but things like the earned income tax credit which is a way of encouraging people to work and sharing some of the benefits from the economy to people who are working and maybe not making very high wages.

MS. KEARNEY: That's through the tax code not the employer-employee relationship.

MR. BRYNJOLFSSON: Yes. And one of the differences is that while it increases the incentive for people to be working and helps with income distribution, it's a broadly shared cost that lots of people bear as opposed to specifically the employer who comes up with a way of employing that person. And I think that you could make a good argument that those employers, those entrepreneurs who figure out how to put some of those people to work should not be the only ones that bear the burden of having to raise the incomes of the people who are right now having their skill demands fall. So an earned income tax credit is a way of sharing that more broadly.

And the net effect is not only encouraging more people to work, but also there's a spill over that it could actually encourage more people to look for creating those kinds of jobs.

MR. SUMMERS: Let's just have some numbers here just to put this in perspective. Roughly

speaking, if we had the same income distribution in the United States that we did in 1979 the top one percent would have $1 trillion less today, and the bottom 80 percent would have $1 trillion more. And that works out to about $700,000 a family for the top one percent, works out to about $11,000 a year for a family in the bottom 80 percent. That's a trillion dollars. I don't know what the number is. My guess is that the total cost of the earned income tax credit is $50 billion. Nobody has got on the policy agenda doubling the earned income tax credit and the big aggressive agendas for the earned income tax credit are probably to increase it by a third or a half. So we're talking about -- so I'm for it, I'm all for it, but we are talking about two and a half percent of the redistribution that has taken place. And so you have to be looking for things -- and there's no one thing that is going to do it. My reading of the evidence, I think it's a fairly general reading of the evidence, is that while there may be some elasticity the elasticity around the current level of the minimum

wage is very low. Perhaps a good way to make that point is to observe that the real minimum wage in the United States today is about 20 percent below where it was when Ronald Reagan was president, and even Ronald Reagan when he was president wasn't really complaining that the then existing minimum wage was doing a lot of damage to employment, and productivity has gone up since that time. It's tempting to think that everything is tradable, but if you ask not across international borders, between the United States and other countries, if you just take the Boston SMSA and you say how much of the Boston SMSA's GDP is tradable, it's less than half. And so there's a lot of scope for raising wages in areas where there isn't going to be some broad kind of competition.

MS. KEARNEY: Good. So we have some questions from the audience and I'm going to ask one that relates directly to the last point. So the question is what is the role of trade on technology and vice versa? How does this relate to the relative skills of people in different countries?

MR. AUTOR: Actually this is what I wanted to bring up. A lot of the disruption that people attribute to technological change of the last 15-20 years actually has a great deal to do with changes in international trade, especially accession of China to the WTO in 2001. To everybody's surprise, but to an enormous surge in imports in the U.S. and a very sharp decline in manufacturing employment has had very large spillovers to surrounding communities in work that I've done with David Dorn and Gordon Hanson, Daron Acemoglu, and Brendon Price really documents this. I think we've all been surprised by how big a factor that is and fortunately that we're most closer to equilibrium now. Policy aside the next 20 years are not going to look anything like the present, but I think this kind of disruptive power is underappreciated and has been quite significant. So that doesn't have a -- I am actually in favor of the President receiving fast track authority for negotiating trade agreements and so on, but I do think that often we find an effect and we look for a cause,

and sometimes we get it wrong. We want to attribute it to the most obvious thing rather than something more subtle. We though the internet economy was an amazing thing from about 1995 to 1999. I don't see how it all the sudden became a disastrous thing around 2000. I just don't think that's plausible.

The other thing I would say is I do think that trade does circumscribe, or the possibility of trade, some of the things we do, we could not in my opinion restore unions to where they were 40 years ago without having very substantial and competitive effects because we don't have the kind of rents, the kind of market power. And you can point to countries like Germany that have much stronger unionization, but then German companies are outsourcing a lot of their employment to Eastern Europe. So I think that that is a real constraint. On the other hand I also want to point out that we bring a very sort of western centric perspective. This globalization and the technology jointly have brought more human beings out of poverty in the last 20 years than anytime in world history,

and that's not just because we have a larger population. I mean as a percentage, right. If we look at what's happening in China, we look at what's happening India, and a lot of the things that we view as threatening are creating much broader prosperity. At the same time they create greater concern. When I think about machines substituting labor I worry much more about Indian textile workers than I do about the general employment patterns in the U.S. So if I am thinking about this kind of technological dystopia, I think about a world where, you know, poor people in Kenya have solar cells but there is no job for which their skills are really scarce. But I think that we should be thinking about technology and globalization as working hand in hand at this point. And the view in the 1980s early '90s that trade was sort of irrelevant to what was happening in the U.S. I think is quite out of date and still has not fully permeated the consciousness of how people thought about the developments of the last 20 years.

MR. SUMMERS: I want to agree in part and

disagree in part. I think first it's right to say that trade and technology in a sense are strongly associated with each other. We wouldn't have much more trade but for the much greater ease of communicating and transporting across trading, but the for the technology that represented the container ship, and a great deal else. So what we call trade and the great increases in trade are very much tied up with technology. That's the first thing I'd say.

Second, I would agree but be inclined respectfully to disagree with David on one aspect. I agree with David, and certainly my thinking would have evolved over the last 20 years, on the question of how much has changing trade patterns impacted the U.S. labor market. I think there is pretty clear evidence that there have been significant impacts. I think some people exaggerate them, but I think there have been significant impacts. I think it is a quite different statement to assert that all of that is due to trade agreements, and I think one has to look carefully for example at the counterfactual. David

asserted that since China's accession in the WTO what is the counterfactual. I have some familiarity with the level of U.S. tariffs on China prior to China's accession into the WTO and they were not high. And so the main reason why China is exporting more to the United States is that China is producing six times as much as it was in 1999 and producing in much more technologically sophisticated ways. Now it's true that if they had not been in the WTO conceivably we could have passed a whole new set of protectionist measures, but I think if you ask the question if the United States has maintained its trade policies vis a vis China as they stood before China was admitted into the WTO, what fraction of the increase in Chinese exports to the United States would we have observed. I think the answer is the vast majority of that increase in exports. And I think that's very important because I think there's a tendency to suppose that if trade developments impact the wage distribution importantly in the United States then presumptively trade agreements are a bad idea. And I

think that in order to analyze any given trade agreement one has to ask the question how much are barriers being changed in the United States and how much are barriers being changed in the affected country. And my reading of the evidence is that in many of the cases because rightly or wrongly the United States market is already substantially open, if you look at the proposed trade agreements the reduction in barriers and the consequent increase in exports to other countries looms quite large relative to any impact in the United States. And so I just think that's an important qualification on the globalization story.

MS. KEARNEY: I'm going to ask a different one that takes things in a bit of a different direction. So someone asks from the end of the 19th century technology let the work week decline. Why can't that process continue with the benefit of technology being a shorter work week with no loss of income? And I'm going to add a bit of a maybe existential question or spin to this, which maybe is

too existential for an economic policy group, but still all of this technology really changes our view of the good life and how we think about our time. And Aneesh's story about the expert craft furniture makers who now put together ready to assemble products for Ikea, I mean maybe this is too nostalgic for an economist, but something seems lost in that to me. I mean, Erik, I'm going to open this to you. This must be something you've thought a lot about.

MR. BRYNJOLFSSON: This is a great question and those haven't already read Keyens' great article, Economic Possibilities for Our Grandchildren, he talked about and made predictions about what would happen to our generation. He was more or less spot on in terms of GDP per capita. He extrapolated those exponential functions exactly right and he got that right. And he inferred that -- he looked around people who were that wealthy in his area, that people wouldn't want to work a lot. They'd maybe go fox hunting occasionally or whatever, but there wasn't much else to do with that much wealth. And of course

that part he got very wrong. People are not working he thought 10-15 hours a week. Mostly those who are working are working a lot more than that. And there are a number of reasons for that. I mean part of it is we have a lot more we can spend our money on than we did back then. There are lots of new goods that people I think enjoy. Part of it also -- and this gets into sociology -- I think a lot of people sort of they enjoy working. There's a meaning that it gives to life for a lot of people. Bob Putnam described what happened when work leaves a community and it's really sad to see how all sorts of other social indicators just plummet because of the way we are wrapped up in having a job and having a worth.

And going forward could we have shorter work weeks, would that be part of it. I think certainly we could and there is somewhat of a trend in that direction. Not as rapid as Keynes imagined, but we probably have to start thinking about new ways to get -- how we get meaning in life and I don't think that's an insurmountable problem. We'd also have to continue

to have enough productivity growth to make that work, but I also don't think that's insurmountable.

MR. SUMMERS: I'm uncertain what I think about this. If you look at introductory economics textbook from the 1960sf or 1970s in about chapter five there's always a discussion of something called the backward bending labor supply curve. And the idea is that as your wages go up at first you work more and more because it's attractive to work, and then after a while you have enough income. And then when you have enough income you take a bunch of it in leisure and so the labor supply curves looks like this. If you look at an introductory economics textbook today that idea is largely not there. And the reason is that it used to kind of be true, that high wage people worked less hours than low wage people. Your image of the 1930s was that the CEO sort of went out to play golf at 4 o'clock and the workers worked 60 hours a week. And if you look today, for the first time basically in economic history, people who have higher wages on average very consistently are choosing to work more or

are finding themselves working more hours than people who have low wages, and it's in part a matter -- it's not all because the people who have low wages are not able to get more work, there is choices that people are working more hours. And that's why this idea of a more leisurely nirvana is less in fashion.

That said I must say I have to be impressed that Americans work about 50 percent more hours, maybe 45 percent more hours in a year than Northern Europeans. And I'm not sure that I would want to call that a great virtue (laughter) of American society, but I think we have to think very carefully about what the alternative to work is and how meaning and community are found in the absence of work. Classical economics has this simple view which is working is bad, leisure is good. Those who spent time in communities with 28 percent unemployment I don't think find that a riveting formulation of human motivation and desire. And so I think it's something that needs to be thought about a great deal. And I guess the thought I have without knowing where to go with it is

it sure seems like in our society, whether it is taking care of the young or taking care of the old, or repairing a lot that needs to be repaired, there is a huge amount of very valuable work that needs to be done. It's much less clear, to use a modern phrase, that there's a viable business model for getting it done. And I guess the reason why I think there is going to need to be a lot of reflection on the role of government going forward is that if I'm right that there's vitally important work to be done for which there is no standard capital business model that we'll get it done, that suggests important roles for public policy.

MS. KEARNEY: Great.

MR. AUTOR: I'd like to make a friendly extension of where Larry just ended which is there's actually some activist work in government to make it, with a business return on investment, the social good. So addressing climate change feels like a big priority for all of us to do something about, and the fastest growing job in America is -- energy job, what's the

fastest growing energy job in America? Solar panel installation. Solar panel installation. Now you made an earlier comment about trade and technology. Partially this is because the cost of importing solar panels is low. Now here's an interesting conundrum, if you benchmarked Germany against the U.S. on the cost to install solar panels, in a world where you've got globally competitive prices for importing these technologies, these fancy panels, what explains the delta? It's a little over a $1 billion if you kind of ran it out. What explains it is something called the soft costs of solar installation. The lack of automation in something as simple as permitting the ability for a home or a business to put solar panels on the roofs. So if we took this powerful concept of information technology and innovation, and if we had ubiquitous same day permitting processes and much more efficient financial markets for credit in order to finance these things, and we had much more readily available match making services so that folks who want the solar panels at a lower price can get them more

rapidly with the local installers, if all of those technologies could be put to work that way we would reduce this billion dollar hidden tax on the American solar panel economy which is already the fastest growing energy job in America. So you'd create more jobs on the backs of what is essentially a low cost trade import, you would address issues important to the world like climate change, you would -- and what's getting in the way? The lack of the adoption of these capabilities in of all places the Mayor's office or the government. Can you do same day solar permitting in New York City? You cannot, but you can in certain parts of California where they're making an emphasis here.

So my only comment about -- there's too much work to do to have the leisure question, but if you're going to do it and you're worried that there is -- as Larry said, there's work to be done but there is no return, we can make it profitable. There should be many, many, many companies that are organizing labor to put solar panels in. If we could de-cost the

process by applying these technologies that would grow the market, create jobs. And not all of those installation jobs require a Ph.D. in physics, right. You can do them with different levels of skill in the economy.

So I think there's a role of government to create market opportunity in places where we need it.

MS. KEARNEY: Well, we will be having another Hamilton Project on March 11 focused on removing frictions in the labor market with the goal of increasing jobs. So hopefully you'll all join us again for that.

But in the meantime please join me in thanking our panelists. (Applause)

(Recess)

MS. TYSON: Welcome back, everyone. I have the honor of moderating the second panel in this amazing conversation.

I want to start by really congratulating the Hamilton Project for pulling a wonderful event

together, and also, in case you have not read "The Future of Work in the Age of the Machine," which I think you put together in record time -- if you want a summary of the issues that we're trying to discuss here with a very distinguished set of speakers, read this. It's really a great overview, and it links to everything you need to know. And besides that, they brought everybody here you need to know right here. So I recommend this.

SPEAKER: If you want my best stuff, you'd be reading entire books on this stuff -- (Laughter).

MS. TYSON: Oh, I assumed that was the price of admission (Laughter), that you actually had to read the second Machine Age. In any event, this panel is really going to focus on business innovation. And it's going to focus on it in two ways. One is, you know, what technologies are we really talking about?

So much of the conversation is about software coding, a little bit of robots thrown in there occasionally (Laughter). But which technologies really are transforming? Are they enhancing

productivity? Have we reached some technological plateau, which some people argue we have. But then, even if the technology is rapidly changing, are our organizations changing rapidly enough? Is our innovative capability to absorb all of this on the decline?

And the finally, what are some of the business models that might work to actually help us absorb all of this, and make the most of it for all of us? So, that's what we're going to do. And I will start with someone I think a number of you know very well, John Haltiwanger.

He has done a lot of really important work documenting the fact that the pace of innovation in organizations in the United States may be declining; that entrepreneurship maybe stagnating; that labor market fluidity may be less than it has been, and believe, you need fluid labor markets to make the most of this.

I thought I would start a question to John by making an observation that Erik and Andrew make,

which is that in the face of rapid technological change -- so let's assume that is happening for a minute. The benefit will not go to labor, and it won't go to capital, as we traditionally know it. It will go to entrepreneurial people and entrepreneurial organizations who can create new products, new services and new business models.

But I think John's worried about whether we -- our capacity to do any or all of these things is declining (Laughter). So, John, is it declining? Why? And what are the implications, then, if you've got a stagnant sort of structure trying to absorb this rapid technological change?

MR. HALTIWANGER: So, thank you. It's great to be here.

I think all of us, when we get the chance to listen to Erik and Andrew, we're struck by the sort of gee whiz aspect of all of the rapid technological changes. But then, we also heard in the first panel, I think, nicely, some of the skepticism. It doesn't seem to be showing up in key numbers like productivity

statistics. And I think actually, the evidence on the declining entrepreneurship and the declining dynamism in the United States economy may actually be part of why we're not seeing it in those numbers, and also raises questions, again, about whether the U.S. is well poised to deal with this.

So, if we were having this discussion -- in fact, a number of people in this room were having this discussion back in the 1990s -- so we have lots of folks here who were playing an important -- pulsive roles back in the 1990s, and the U.S. was just surging in the 1990s, in terms of both productivity growth and jobs growth and the earnings growth was doing okay. This was just sort of before the great departure.

And I have quotes from some of the notable policy people in the room, including folks on this panel (Laughter), that indicate when they were giving speeches and saying, well, why is the U.S. so -- doing so well in the 1990s. And oftentimes, the two words that were used by these distinguished policymakers were the dynamism and the flexibility of the U.S.

economy.

And so, what have we sort of seen historically? Well, so one thing we know about innovation, at least from what we've sort of seen in the data -- I'm someone who looks a lot at the micro data businesses -- is innovation and productivity growths is a very noisy and complex process. It's not just here's some new idea come along and we'll sort of talk about it. It takes many, many years to figure out how to use it.

And that noisiness, that complexity at least historically, for the United States, has been that when we had booming times and booming sectors, we'd see a very high pace of entrepreneurship and lot of volatility. And also, what's kind of striking about the nature of that volatility is, you know, it began back in the 1990s. It's only a small fraction of businesses that make it.

And so, again, what a striking feature the United States economy is. We have the surge in good times, surge of entrepreneurship and dynamism, and a

very small fraction make it. And then, the other feature of the U.S. economy -- I'm talking about the dynamism part, is the flexibility part. Well, what this means is that there's lots of restructuring that's going on in the United States economy as a result of all this kind of volatility, and the U.S. has been quite flexible and fluid in terms of being able to move workers to other kinds of productive uses.

And the fluidity has actually helped us. You've got to remember, it's not just businesses that are experimenting. Workers themselves experiment. A key way that workers build their careers is job hopping. So, we know that particularly young workers, the way they find the right match in the labor market, it's not just at the high end, all over the place. It's where earnings go up and where again, they find good, you could say lifetime careers is through lots of job hopping.

So, it should, at least cause us concern that we see now in the data, several indicators, I'll

say of dynamism and fluidity down, especially since 2000. Now, some of these have been going on before that, but especially in 2000, where things have accelerated. So, what have we seen? We've seen a decline in entrepreneurship, actually, that predates 2000, but in key sectors like -- the tech sector was actually rising through 2000, and then it's fallen.

And some of you might say, oh, was that the dot.com bubble? No, it's not just that. If you actually look at the data, entrepreneurship was rising through the 1990s in the high tech sector, then it has this sort of little mountain peak where everybody was apparently starting a dot.com business. And then it came down. And again, if you look at entrepreneurship in 2005, it's lower than it was in 1991. All right? And so --

MR. MCAFEE: John, can I jump in?

MR. HALTIWANGER: Yeah.

MS. TYSON: Yeah.

MR. MCAFEE: Is it on the upswing since 2005?

MR. HALTIWANGER: No, it continued to decline.

MR. MCAFEE: It seems -- how can that be true? (Laughter)

MR. HALTIWANGER: Okay.

MR. MCAFEE: We hear about crazy Internet billionaires every --

(Simultaneous discussion)

MR. HALTIWANGER: Okay, but --

MR. MCAFEE: I'm honestly puzzled. (Laughter)

MR. HALTIWANGER: Yes. So when I talk about an entrepreneur, I'm talking about a new business that hires at least one workers.

MR. MCAFEE: Fine.

MS. TYSON: Okay.

MR. HALTIWANGER: All right? So, what I have been doing and others have been doing is tracking the number of businesses that hire at least one workers. And again, what we've seen, I'll say, is that these entrepreneurs as so defined have been

critical for job creation and productivity growth and innovation, with a large pace of entrepreneurs coming in and a small fraction really taking off and disproportionately creating lots jobs and high in terms of innovation and productivity.

So again, we've seen a decline in the post 2000 period that's continued. Because then the Great Recession was insult to injury.

MS. TYSON: Okay.

MR. HALTIWANGER: So, young businesses that were already on their way down pre recession, and they just got hammered, and they've been slow to recover. So, we're obviously concerned about what this might mean for productivity, earnings and wage cost. So, do we fully understand this decline to this point? And the answer I'm happy during the questions and so on, in the panel, to talk about what are ideas.

But let me just talk briefly about what we know about both the causes and consequences. Obviously, the consequences are going to depend upon the causes. So, one thing that we see -- one thing

that we've done and I worked on an idea with presented with Steve Davis that was presented at the Jackson Hole conference last August, is we looked carefully at the impact of this decline and labor market fluidity for something that was on -- a topic of the first panel, which was unemployment rates.

And what we found is that it looks like thank you closely connected. So, these declining unemployment rates that we talked a lot about in the first panel, has been especially for young and less educated workers, and especially young, less educated males. And what we found is, it turns out there's lots of variation across states in where we've seen this decline in dynamism and fluidity.

And what we found is the states with the biggest declines in dynamism and fluidity are exactly the states that have had the biggest declines in the employment rates for young, less educated males. And we pushed it even further. I'm not going to go talk about detailed econometrics here, but we tried to use instrumental variable procedures to try to generate

causal effects. And in fact, our results were consistent with that.

So, that already says that it looks like there's at least some adverse consequences. The second thing we've done is we've tried to look at what the productivity implications of all of this are. So, one possibility of this decline and dynamism and entrepreneurship, is you might say, well, maybe the business model in the United States has changed. Maybe we don't need to do so much experimentation as we used to.

Maybe we've even gotten better, so we don't -- you know, because a lot of that was waste. Right? You have this massive set of entrepreneurs come in. Many of them fail. A very costly reallocation. Maybe we even got better. Maybe even information technology has made that -- we need less of that.

So, one way to look at that is, what we've seen in the micro data is that we've seen that there's lots of dispersion in productivity across firms. That's actually very much what's driving the dynamism,

and that's consistent with the economic theory. So again, you get this wave of entrants in. Lots of them are experimenting. Some of them do very well. They take off. Some of them are not doing so well. They shrink and contract.

So, what we want to do is just go look at the dispersion and productivity across businesses; particularly young businesses and particularly young businesses in high tech. So, one possibility is maybe that dispersion has decline; the business model exhibit, so we just don't need to see so much of that.

Actually, what we see in the data is exactly the opposite. If actually, dispersion and productivity of businesses has gone up rather than down. So, there's actually a need for more reallocation rather than less reallocation. So, something is causing -- at the end of the day, it's not that the shock's hitting businesses, and you could say, it's not that the technological changes have slowed down.

So, this is kind of consistent with the

stories that we're hearing, but the responsiveness of businesses to this change has slowed down. And again, that has -- by construction, that has adverse consequences for productivity. So, at least in a mechanical sense, part of the way we were getting productivity gains, and we always get productivity gains is we were moving resources away from less productive to more productive businesses. We're just not doing that as much as we used to.

MS. TYSON: Okay. So, a question -- and I don't expect an answer now, but a question to put out there to try relate to the previous discussion, is to what extent -- what might you think that these amazing changes in technology that are labor displacing or potentially labor displacing actually are discouraging the formation of an entrepreneurial venture with one person?

What's the point? I mean a lot of the entrepreneurial ventures with one person are very labor intensive local things. And if you can do those things online, you don't need the local entrepreneur

and the one person that that person hires. And by the way, I would link that to the fact that a lot of those one person shops, they're more like Mom and Pop shops. A lot of them are founded by women.

There's a whole issue here of labor force participation rates of women stagnating around 2,000. Right around 2,000.

MR. HALTIWANGER: Yes, exactly.

MS. TYSON: Okay? So, voom. What's happening there? So technology -- and as a cause of this is something to think about. But let's go from there to technology and to Arati. We have here the president -- the head of the -- of DARPA, a very well known source of technological innovation in the United States.

And economists tend to -- when they're looking at this technological change, tend to raise two issues. One is, it's not showing up in the probe activity numbers. We heard that very eloquently in the first panel. The other is just you know what? These technologies are not all that important. We're

not doing major innovations in health. We're not doing major innovations in transportation and energy. Nothing similar to electrification or telephonic communication. What's the big deal? Right?

So, I don't think we have a better person than Arati to sort of talk about these pessimistic views of technology coming from the economics community, and your sense of where the big technological changes are coming from. And is it all IT and software?

MS. PRABHAKAR: That's very much what I would love to talk about. Thank you, Laura. Let me just first say how much I appreciate the chance to participate in this dialogue. The work that you and Erik have done, Andy, and then the Hamilton Project -- I think we're talking about unraveling this complicated set of linkages between technology and work, and it's so core to what is important for our country, for our values and for our future. So, I really think this is terrific.

I want to take the conversation in a very

different direction and talk about technology itself. You know, the word technology has almost become synonymous -- many people use it synonymously with information technology. If you read the *New York Times*, their technology section is only about information technology. Everything else is relegated to the science section.

But in fact, technology is much, much broader than that. And what I thought I'd do is take a few minutes and just share with you some perspectives about the bubbling pot of things that are happening in some very, very different areas. First of all, let me just say that there is a lot more to be said about the technology factors driving the many dimensions of information technology. We can come back to that, but let me just set that aside.

Let me give you some very different examples. One is something that is bubbling today in the maker movement. Part of that is new tools, like 3D printing, which everyone has talked a lot about. But part of it, too, is finding different ways to make

those kinds of tools available to lots of people.

One example is a tech shop here in Alexandria, Virginia that we at DARPA helped get started a little while ago. We co-funded it working with the Veteran's Administration in part, to be able to provide a gym membership like access to the tech shop here for veterans. So, for about what it costs to belong to a gym, they or anyone else, actually, can have access to advanced 3D printers, but also, sewing machines and welding tools and every kind of production equipment. A wonderful machine shop.

And I went by to visit there right before Christmas. I wanted to just get a sense of the vibe there. And one of my most engaging conversations was with a young fellow who is in high school. He found out about tech shop somehow. He drives an hour and a half each way many times a week, as often as he can break away, to come to the tech shop and to build things.

And so I said, well, what do you with these things? And he said, well, I put them up on Pinterest

and all my friends and my family buy them. So, I got his business card and I raced him. And it was right before Christmas, and I thought, well you know, maybe I'll buy something that he built. And it turns out I don't know anyone who wants accessories for guns to play paintball, which was pretty much what he was building (Laughter).

But you know, that's what's happening today, is people are experimenting. This is a kid who's finding a way to build a business. I don't know what tomorrow holds. It might be something that broadens and taps the skills and the energies and the creativity of new sets of communities. That would be awesome. I don't really know yet if that's going to happen, but that's one thing that's bubbling.

A major area of research that we're very excited about at DARPA, because we think it holds the seeds for technological surprise -- that's our business -- is that's happening today in research as biology is intersecting with the information sciences and technology, but also, the physical science and

technology world.

And let me give you two examples of what's happening. And I'll tell you what's happening today, but I'll also try to take you out into what I think could be a very wild future. Let me start with synthetic biology. This is, of course, the ability to engineer micro organisms to create chemistries and materials that the world has never seen before. Doing it in dishes, and then trying to scale it up and then doing it in factories.

So, what is happening today is, we're able to build new specialty chemicals, new medicines. A very interesting beginning, but in fact, it's only a beginning. We can see in these capabilities -- we can see a progression of new materials, chemistries, but also, functional systems and self repairing systems. We can imagine a future where you might be able, in your built environment, you might live in a building in which the walls are able to sense the environment around them, adjust temperature and humidity and lighting conditions.

These walls might support microbial communities that can disinfect the air, that can purify the air. They might be materials that can self repair, so that you know, when your teenager sort of puts a gauge in the wall, it can fix itself (Laughter). And when the time comes and when you want to, the wall could biodegrade and not create, you know, this sort of perpetual waste that we live with together.

So you know, that all sounds a little crazy, but imagine a century ago, if someone had told you about magical new PVC material that was going to be super lightweight and incredibly easy to work with, but would be able to be so corrosion resistant that it would change the way you do plumbing. That would have seemed a little crazy, and I think today, some of these things that seem crazy might become actually -- I think technically, they look like they might become possible. And then of course, how we turn those into businesses and products is another question.

Let me finish with any example from neuro

technologies, another area where biology and technology are coming together in some very exciting ways. And we're just at the very beginning of this adventure of understanding the brain and how to harness its amazing capabilities. Today, much of our work in this area is about the restoration of function. But in that work, you can start imagining what might be possible out into the future.

One of our areas of focus here has been revolutionizing prosthetics, moving beyond the simple hook that's been the standard of care for many years for upper limb prosthetics. To pursue that vision, our program manager developed a very sophisticated robotic hand with many degrees of freedom, and that was one branch of it. But because he's a neuro scientist, he also did the research that helped us understand how neural signaling from the motor cortex actually controls that arm.

That work culminated in some early human trials, and most notably, a woman named Jan who lives in Pittsburgh, who is a quadriplegic, volunteered to

have these two small implants surgically placed on the surface of her brain, on the motor cortex, and from that neural signals are directly picked up, and in real time, as she thinks, she's able to move this arm. And she can shake hands. She can give you a fist bump. She can offer you a stack of cookies with this robotic arm, just my thinking about it.

So, first and foremost, of course, the healthcare implications in that dimension, but many other dimensions of restoring function as we understand the brain. That's going to be amazing in itself. But as we do this work, of course, we also understand that we have opened a door that could free the brain from the limitation of the body.

And as we start thinking about what else is going to be possible beyond restoration of function, everywhere actually open, I think, some amazing possibilities. Some of them are going to be great, and some are going to be terrifying. And I think the societal issues there are going to -- actually, they're going to make the work issues we're dealing

with today look simple. So you know, technology has many quandaries that it raises. But I hope some of those ideas give you a sense of the very wide range of things that are happening today that could lead to alternative futures.

MS. TYSON: So, you mentioned the work issues an another set -- and then, you mentioned that there are other issues that we're not even thinking about. There are also issues that you obviously think a lot about, too, and those would be in the realm of national security. And you didn't mention that as an area, but I think that's one we might want to talk about.

MS. PRABHAKAR: It's behind everything we're doing.

MS. TYSON: Right. So, one of the things that comes to mind in thinking about technology and moving to business models is a concern that I have, and I think many Americans have, about how we finance basic science and applied science, and whether we are doing enough, because we're pulling back on the

support for basic science.

This gets to Andrew in the following way. The most research and development in the United States, most spending is done by the private sector, not by the public sector. And actually, most of the private sector is done by very large companies. Eighty-five percent of the R&D spent in the United States of the private sector is done by the U.S. multi-national companies that are big.

Now, let's get to Andrew, because Andrew is concerned that the existing companies cannot cope with the new technologies, and that we have to develop whole new organizational structures and business models to take advantage of. But remember, right now, we have this situation where we've got the government doing the basic science and being very resistant to doing more and wanting to do less and wanting to know what the business model is right away.

And then, we have these very large companies who you're worried about they won't be able to make it. So, talk a little bit about what kind of

companies, and how would they support their ongoing investment in R&D, unless you become huge overnight, like Google or Apple, and then you're running your own venture capital firm, your own R&D facility, your own everything.

MR. MCAFEE: And can I just highlight, first of all, how interesting this panel is? I say this with no pride, because I haven't started talking yet (Laughter). But look what we're hearing about. We're hearing about this time of deep technological ferment, which is such unbelievably good news, coupled with institutional sclerosis.

MS. TYSON: Mm-hmm.

MR. MCAFEE: It's bad news in a lot of ways. John, as you pointed out, we don't fully understand this phenomenon at all. I really don't understand why, at a time when the tools of entrepreneurship are really good, more widely available than ever and getting better all the time -- the maker space you described is a really good example of that.

It's on the decline in this country? This

is a deep, deep puzzle, and we'd better spend some time figuring it out. A lot of it is completely opaque to me. Some of it is clear. Some of it is self inflicted damage. Some of our ways of approaching this situation and our reactions to it are making the sclerosis worse.

I live in Cambridge, Massachusetts. Pray for the people of Cambridge right now (Laughter), by the way. I live in Cambridge, Massachusetts, and the city council in Cambridge made a very sincere effort to specifically ban Uber from operating in the city of Cambridge. They wanted the taxis to continue. They wanted nothing but the taxis to be able to pick up anybody in the city of Cambridge.

I think my head came close to exploding when I heard about this. I have trouble imagining a worse response to this situation that we're in, because Uber is a very controversial company. I think their management has done them no favors, in some ways. But I want to go on record as saying I love Uber and its business model, not just as a person who likes to get

from point A to point B, but the more I understand about the opportunities they are providing to put labor back in the economy and to provide a decent living for people, the bigger fan I become of the company.

Laura, you probably saw the study that Alan Kruger just worked on and published, where he says that the average Uber driver -- the comparison is a little bit difficult to make -- pretty clear they get paid at least as much per hour as a cabbie does.

MS. TYSON: For the hour issue.

(Simultaneous discussion)

MR. MCAFEE: Per hour, they get paid at least as much. They have great flexibility about how many hours they want to work, in contrast to almost all other part-time workers, they appear not to suffer a penalty on a per hour basis from working fewer hours.

You make $15 if you drive three hours. You make $15 bucks an hour if you drive 30 hours a week. These are all really good things to have, especially

to the point that Larry was making earlier, if we want to bring jobs in demand back, here is a platform that's bringing jobs in demand back. The harshly negative reactions to it honestly don't make any sense to me, and I get the idea that some people kind of want to legislate secure jobs in the middle class back into existence. I think that's a fundamentally misguided approach.

Now, the question you brought up was, are today's great big successful companies going to be able to navigate this transition that a lot of us feel is beginning. And the pattern of history is not an encouraging one when we look back at these big technology trends; steam to electricity being the most recent big one that we went through.

The pattern is fairly clear that the companies that are on top at the beginning are usually not the companies that are on top at the end. And there appear to be two main reasons for that -- one is financial. When you've got a factory totally set up for steam, it's really hard to get out your sharp

pencil and justify the retrofitting for this weird, new thing called electricity. That's part of it.

The deeper problem is a mindset problem, and that if you're used to thinking about a factory as this building with a big thing in the basement and belts and pulleys that drive your machines, when some weirdo shows up with an electric motor, you say that thing is less powerful, costs more per horsepower, whatever -- why would I do that? You don't see the opportunity to get rid of those belts and pulleys and eventually, to replace them with overhead cranes and assembly lines and things like that.

The mindset challenge is a really severe challenge. As I look around at a lot of very successful, well managed companies today, I see that mindset challenge coming up over and over. The one example I'll give -- one of my messages to large established enterprises is, your management needs to become a lot geekier.

And by that, I mean, a lot more driven by the numbers, a lot more rigorous, a lot more evidence

based in things like human resources, where the dominant mode right now is you interview me, and you look deep into my eyes and judge my character and my fit for the job and make a recommendation based on that. We've got ample evidence. That's a terrible way to make human capital decisions.

Being a lot more analytical and a lot more geeky is the right way to do it. Today's managers didn't grow up with that tool kit. They didn't get to where they are by virtue of their geekiness and their familiarity with quantitative stuff. So, that particular transition, I think is going to be difficult. There are a lot of ones that feel similarly challenging to me.

So, I think a huge open question is whether today's successful enterprises are going to navigate into this technologically very different future. I think some of them certainly will. I think a lot of them are really going to struggle.

MS. TYSON: Okay. Can I sort of connect your question, Andrew, which was this confusion -- and

I agree with it -- about sort of the technology not only changing rapidly, but creating all kinds of enabling technologies like -- and I think the makers was a wonderful example. And yet, this decline in entrepreneurship.

Might that be -- John, how have you looked at the issue just of the overall demand level in the economy? Let's go to Larry's point. So, Larry's point is a very important point. The overall macro economic climate is, in fact, possibly the biggest determinant. I mean, productivity doesn't change that fast, and it's -- but the macro conditions in terms of the excess demand or excess supply in the labor market can actually change.

And then, I think about 2000 and then 2007, a lot of mom and pop entrepreneurs, particularly in 2007, there was no bank capital for these people; absolutely none. You could not keep your establishment open from one day to the next, because your demand fell of the cliff and your ability to finance fell off the cliff at exactly the same time.

So, I wonder how John -- in terms of thinking -- maybe it hasn't -- the technology may be enabling, but if you don't have the demand for your product and you don't have the financing to set up your little enterprise which may someday be Google, you can't do it.

MR. HALTIWANGER: So, I think that that's right -- all those factors are right. But I think that's mostly a post 2007 story. Right? And so, I think that's really important. I mean, the great recession clobbered the whole U.S. economy, and especially clobbered young businesses, for exactly the reasons that you're talking about.

But this was going on before that. I would say that we've seen the site of decline in dynamism and fluidity and the decline in employment rates and the decline in productivity predates this.

(Simultaneous discussion)

MS. TYSON: Was it 2000 --

MR. MCAFEE: Can you list the usual suspects for why that is?

MS. TYSON: Yes, yes.

MR. HALTIWANGER: Okay. So, this is going to be very much the two handed economist kind of thing (Laughter).

MS. TYSON: The laundry list (Laughter).

MR. HALTIWANGER: On the other hand, what might be going on? So, one or more also are more benign interpretations, but may actually have adverse implications for the United States. We talked about this in the first panel. I think David Autor, in particular talked about this.

So, we have seen this big shift away from young, small businesses towards more large mature businesses, particularly the multinationals. So, their share is going up. And one can make the case that actually what IT has been especially good --

MS. TYSON: Yeah.

MR. HALTIWANGER: -- is it's enabled the multinationals -- and Erik talked about this, as well, to be able to communicate with all their activities around the world instantaneously. And so as a result,

the question is, the big guys are saying, well, maybe the U.S. isn't the best place to do all these things. There's other places. Maybe that's actually even good for the world economy. But the U.S. is going through some disruption kind of factor.

The second thing that does seem to be going on, that again may be associated with a change in the business model -- this is not so much an explanation, is again, it's good to remember that most entrepreneurs fail and only a small fraction really grew rapidly.

MS. TYSON: Mm-hmm.

MR. HALTIWANGER: And so again, what was really striking in the data were these high growth young firms that played such a vital role, say in the '80s and the '90s. We've seen, I don't want to say a disappearance of high growth young firms, but a tremendous decline in high growth young firms. And so --

MR. MCAFEE: So, Google and Facebook are distracting us from the real story. They're

exceptions.

MR. HALTIWANGER: Well, one question is whether the business model now is -- maybe it used to be you wanted to be Google, and now the business model is I want to be bought up by Google (Laughter).

MS. TYSON: Yeah, yeah.

MR. HALTIWANGER: Now you could make a case, maybe that's not such a bad thing. That's a change in the business model.

MR. MCAFEE: Right.

MS. TYSON: Mm-hmm.

MR. HALTIWANGER: But then again, if this is all good news, is this is all entirely benign, then why are the productivity statistics so bad. So then, now let me go on the other hand. Where are we looking?

Well, the obvious concerns is the U.S. -- you know, has it changed its business climates, its regulations, its labor market regulations in some fashion so that we've seen this gradual decline, and we we're working on it, and I think we find some

evidence of this. Now, I think in trying to think about that question, it's useful to think about all of the cross country studies that have been done on this.

MS. TYSON: Mm-hmm.

MR. HALTIWANGER: So on the one hand, we have now, I'll say increasing evidence that countries that are successful are precisely those countries which have this successful productivity enhancing reallocation; so that countries that are not doing well are countries in which they have lots of dispersion in productivity and they're just able to get resources to the most productive businesses.

And we know countries differ quite a bit in terms of their business climate and labor market regulations and all the rest. We've got financial markets and so on. So, we're pretty convinced that this matters a lot, in terms of whether our country is successful or not. We struggled a lot more actually finding, even in cross country evidence -- finding exactly what are the causes associated with why this country seems to have a bad environment relative to

the other.

So, one view that's increasingly been taken kind of in the macro development community is to think about this like a death by a thousand cuts. Lots of little things. So, don't look for one big thing. And in fact, there's no evidence -- there's a big smoking gun that says, ah ha ha, the U.S. suddenly (Laughter) did something around 2000, and so we're seeing this decline.

So, I think we are beginning to look at some smaller things. So, what are two smaller things that look like they actually might matter, and at least a suggestive -- we need to push harder on this. And this is not a complete explanation. So, one of them actually builds upon David Autor's work.

So, David had done work like this, and we took it and applied it particularly to our more recent data and also, applied it -- you know, I'll sort of say to this more comprehensive data that's some of his early work. And one part of David's very nice -- you've got a lot of nice research contributions -- is

he found that there has been an erosion of employment at will doctrine in the United States through precedents in the U.S. court system that made its way sort of gradually through the nature of how judicial precedents are set in some states before other states.

And it's precisely that variation that allows you to identify these effects. And in his work, and then we followed up, that actually looks like it's associated with this decline in dynamism. So, that's at least working in the right direction. That's not saying this is the whole story. It's just at least saying, oh yeah, you actually can see. Here's one of the thousand cuts that we're looking at.

The second one we've just started to look at is inspired by very recent work by Kruger and Kliner, and that's this work -- the occupational licensing requirements have risen dramatically in the United States over the last couple of decades. And those are the kind of regulations where you could easily imagine, well, wait a second. That's exactly the kind of thing that again, could sort of stifle the kind of

regulation.

We even heard a little bit about this in the first panel -- it wasn't on occupational licensing, but it was on the permit process. So a question is, has the U.S. become more sclerotic? This is our worst nightmare, of course, to become more sclerotic, because of accumulation of problems in the way things are working.

But I'm not going to argue that I think we know this for sure now, but I am going to come back and say, one, we've seen this decline in dynamism, and two, the -- when we look at the productivity statistics at the micro level, we actually ought to be seeing an increase in dynamism, not a decrease. That almost can't be good news.

MS. TYSON: (Laughter) No. One follow up here. Do you have -- you suggested that you're looking cross country. Historically speaking, for a very long time, the view was that by far, the U.S. was the most entrepreneurial and most innovative and most fluid. So, who is surpassing us now? Or maybe we're

just last, but our gap to -- so our gap of excellence has declined, but we're still number one?

MR. HALTIWANGER: I think it's more of the latter, by the way.

MS. TYSON: You do. Okay.

MR. HALTIWANGER: I don't think that the rest of the world has necessarily become that much more dynamic and entrepreneurial. And Erik tried to push this nicely before. You've got to remember, things are not that dire in the United States, at least on the aggregate productivity statistics.

MS. TYSON: Right.

MR. HALTIWANGER: They've slowed down, but we're not in a crisis. We are in a crisis, I'd say, in terms of employment rates. So, the point that came up --

MS. TYSON: Employment rates.

MR. HALTIWANGER: -- that Larry (Inaudible). And I think that is connected to this. So again, my concern about this decline in dynamism and flexibility is, I'll say it both at the top and the bottom. At

the top, it's are we poised to take advantage of all of these technological changes, or is that going to happen elsewhere, and are we going to fall behind, or at least not be as successful, for example, as we were in the 1990s when the economy was rocking?

But I'm probably even more concerned about what's going on at the bottom end, because the lack of fluidity and dynamism means that -- we know there's disruption that goes on in all of this, and it doesn't seem like we're accommodating that nearly so well. And the workers who get caught up in this -- what used to be happening is because we were such a dynamic and flexible economy, other opportunities were arising. They're not, and so I think they're just not participating in the labor market.

MS. TYSON: So, I guess what I would like to say is that another of the many pieces of David Autor's work, which is actually -- it suggests that the issue is not the -- there's the issue of demand, and the fact that we were running at a very low level of demand, so we had an employment problem across the

skill spectrum.

It's increasingly an employment problem thought existed before, which is the employment problem of high school dropouts. But in fact, that issue -- and you run a sort of high demand, high intensity economy, shows up not in employment numbers, it shows up in poor job numbers. It's about the quality of the job, not the percentage of people who are employed.

And you know, if you think about it, if you think about -- someone said on the last panel, we have to worry about the fact that the technology itself may be leading to the disruption of jobs that are quality jobs. And then, you have care giving, education, janitorial services, all of the things which actually, in a number of the periods David was looking at, you saw employment growth there. It was actually pretty strong.

It was one of the reasons that unemployment rates in the U.S. fell so far is because low waged jobs, low quality jobs, many of the part-time

increased, and people took them. So that's a demand phenomenon. But then, related to the technology thing, the technology has taken out the middle. It may be in David's more recent work, taking out some of the top. In order to run a high employment economy, if the technology is taking out those kinds of jobs, more and more people are going to have to be employed in low end jobs, which brings me back to Arati to talk a little bit about some --

When you think about these technological breakthroughs, they are very, very exciting. But think about them in terms of, I would say distributional issues. Maybe it's a little bit unfair, but every time I hear about these prosthetics, I say, how do we as a society decide who gets this stuff. This is not inexpensive stuff. Does everybody get it?

And if so, how do we generate the revenue stream for whoever -- for the societal promise that everybody gets to live in their brain outside of their body, or everybody gets an arm when their original arm

no longer can hit, you know, can be a baseball player level hitter?

MS. PRABHAKAR: Those are huge issues. But before we boil that entire ocean (Laughter), because I think that one, we do have a little bit of time, you know, before it hits us. We need to be thinking those things through.

But I want to come back to what some of these new areas, I think, will do that I hope -- my hope is -- I don't think we know, but my hope is that they will create a plethora of different kinds of opportunities, because in the information technology world, if the only answer to the challenge is well, everyone needs to go back to school and learn how to code, that’s going to be really good for some people, but it’s not going to get, you know, everyone in a 300 million person society.

So, think about you know, tying it back to maybe some of the things we talked about a minute ago. If you think about synthetic biology -- I was talking to a small company -- a startup that wants to tackle

synthetic biology pathways to new specialty chemicals and to enhancing the production of specialty chemicals that people currently already build through more conventional means.

That's a company that's 30 people today. But as they think about scaling up, they are going to look more like a traditional chemicals or manufacturing company. They are going to have -- yes, absolutely, right now, it's very PhD heavy. It'll continue to be a place where lots of smart people with lots of education can get employed.

But when they scale up, they will also need technicians and people at all different skill levels with different kinds of skills; coding, but other skills, as well. And I think that that -- you know, I think we're going to really need that kind of diversity of different technological opportunities that lead to this whole range of different kinds of skills.

I don't know how this is going to play out. And you know, one of the interesting things, coming

back to your point about where R&D investment happens, very much as you said, twice as much of our nation's R&D investment today is made in the private sector versus 1/3 in government, but that ratio was flipped when we were all small children.

So, it's a trend that I think actually is overall healthy. Right? Because it's good if we have a more innovation driven economy and more private sector investment in R&D. But that investment, of course, companies make not thinking about the jobs. They make it in order to pursue their business plans and their profits.

The government part of that investment, I make my share of that for national security objectives. The National Science Foundation and National Institutes of Health are seeding basic research, but with no particular focus or drive or ability to shape how that turns into jobs.

And so, you know, in a market economy, there are no formal drivers to shape the way this comes out. And I think that's the richness of our approach, but

it also makes it very hard to predict where any of this is going to go.

MS. TYSON: Yes, you're done.

MR. HALTIWANGER: Okay. I actually think one of the statistics that is misleading -- I mean, you can say maybe all of these statistics are misleading -- that's why we're struggling here -- is the statistics on R&D and large businesses.

MS. TYSON: Okay.

MR. HALTIWANGER: So that's actually what the numbers show, but I think that's -- I'll say it's enormously misleading. I'll say especially if you go look in the more high tech sectors, you still don't find that the young guys are reporting much R&D. And that's because the questionnaires are gauged and sort of specified, so if you have an R&D lab, then you're going to be able to report all of these statistics.

But think of all of the kind of tech companies we're about here today. They're tiny, and they don't have R&D labs. They are the lab. They're doing everything. So, I think actually, if those

companies aren't spending basically a hundred percent of their time -- indeed, that was sort of the vision, of course -- that these are businesses. They have no revenue, but they're spending an enormous amount of resources -- it's all R&D. And we're not picking that up.

So, I think actually, we're -- this decline -- this is going back in. This decline in entrepreneurship particularly in the high tech sector is as troubling, because I think we're seeing less innovation and less R&D, and we're just not measuring it in the statistics.

MS. PRABHAKAR: Well, measurement issues aside -- and in fact, I think we are capturing a lot of that. But measurement issues aside, when private companies invest in R&D, it is almost exclusively product development for known markets, and a small fraction of that is going to be the kind of next generation more exploratory work, so --

(Simultaneous discussion)

MR. HALTIWANGER: Well, I would also say

that the --

MS. PRABHAKAR: -- that's always small.

MR. HALTIWANGER: And this is not to be too critical of the NSF survey on this, it's not that well geared to pick up applied innovation. It's more geared to pick up core basic research.

MS. PRABHAKAR: Yes.

MR. HALTIWANGER: And that's sort of the second part of where I think the mismeasurement is.

MS. PRABHAKAR: But at the top level, I think we can agree that this growing corporate share is much more product development driven.

MR. HALTIWANGER: Sure, I agree with that.

MS. TYSON: Yes, that's true.

MS. PRABHAKAR: And it still remains government's function to fund the basis research, the university core.

MS. TYSON: Right. And I think that's part of the -- part of in there -- there are many messages that if we go to the policy side of this discussion, both in the first panel and this, we're all thinking

about a world in which the pace of technological change has picked up; things we can't imagine are going to be very transformative.

We need a policy debate that reflects reality. The policy debate is not about this reality, including even the fact that so much of this has been driven at the beginning from support for basic science and universities. And one thing that the large companies do do -- and then we train people who have PhDs. And if there's not a lot of research support for them to do basic research on, they go and do applied research for the companies. That's where the jobs are going to be for them.

So, we actually need to have a policy debate which focuses on if we think these are going to improve our lives dramatically, how we finance this appropriately. And I do worry a lot about that. So, we have some questions here. One is a question I think we probably should address.

This is, regarding the decline in dynamism and fluidity, is the problem that businesses are more

focused on increasing shareholder wealth and investing in risky ventures? Now, this is not directly related to entrepreneurship, but I wonder -- Andrew, you're sort of thinking about what kind of business model's out there.

Is shareholder value particularly driven by activist investors a good environment for promoting the kind of technological change that you think we should have? Is it discouraging entrepreneurship? I mean, what do you think?

MR. MCAFEE: I gave a version of the talk that Erik gave to kick off today, and showed some of these slides. And you can start to see this great decoupling happen. It starts to become visible to my eyes in the early 1980s. I was giving this presentation to the Open Societies Foundation, George Soros' organization, and he said you're misattributing the root cause here.

He said it's the rise of what he calls market fundamentalism, which he associates with the Reagan Thatcher revolution with the idea that the job

of a company was to return money to its shareholders, and not to think more broadly about stakeholders. So, he was saying, look, it's that turbo charged, fairly selfish version of capitalism that's really causing a lot of what you're seeing here, instead of any surge in technology.

I think that's a really intriguing idea, but my career as someone who kind of tries to understand what's going on in the business world is on the order of 25 years old. Throughout that entire career, I have been reading about the excessive short-termism of American business, and its over reliance on this quarter and the bottom line and keeping Wall Street happy.

The names have changed. That critique has really not changed as I've been reading it for two plus decades. So, I don't know -- honestly, Laura, I don't know how much weight to attach to that. I don't see that as a major factor here. And the most -- among the tech companies that I know, the most ruthless, growth hungry, vicious competitors are also

the ones who are investing the most in really basic and fundamental technologies.

MS. TYSON: Do you have any --

MR. HALTIWANGER: So, this is a hard set of questions, like all the ones were about today. But again, I think there's evidence that historically, the major innovations have come not so much from the incumbents, but from the newer businesses. So that's sort of kind of one concern.

And then, the second concern here is whether the -- what the incumbents are trying to. Obviously, they have an installed base of products out there, and so they are -- this is a concern that's shown up in both the economics literature and certainly, in the popular press is, are they just trying to protect their -- and grow their market share.

So, back again, I said maybe the goal now is not to be the next Google, but to be bought by Google. And the question is, what's Google's goal in that? Is it actually to take advantage of the new technology or actually to shut down competition? Those are the

kinds of concerns that fit into the kind of question that you're about.

I don't know that we've got overwhelming evidence that that's what's going on, but it's not inconsistent with the evidence that we've seen this decline in entrepreneurship and we've seen this increased share at the top end of businesses.

(Simultaneous discussion)

MS. TYSON: I want to turn that --

MS. PRABHAKAR: Yeah, I spent half of my professional life here in Washington, but the other half in the private sector, 15 years of which 10 was in venture capital and the other portion in a couple of different companies. And I think you're right, Andrew, that perhaps, that's the core market drivers of shareholder value or earning returns for LPs, if you're a venture capitalist, nothing has changed.

On the other hand, I think those are actually huge drivers. I mean, they are fundamental core drivers of every business decision that I ever participated in. And I just think the fact that that

-- this unchanging market driven decision making process, I think how it's grappling with this new set of changes in technology -- maybe it's that nexus, and that's what's different.

MR. HALTIWANGER: Right.

MR. MCAFEE: But all of these --

(Simultaneous discussion)

MS. PRABHAKAR: But I do think -- the premise of Laura's question I think is actually -- I think it's really a core issue, because we do rely --

(Simultaneous discussion)

MS. PRABHAKAR: -- on the market to solve -- right. However asked. We do rely on the market to solve a whole host of problems, and I think we are in a regime where some of these problems are not going to get solved that way.

MS. TYSON: Exactly.

MR. MCAFEE: But every venture capitalist I know encourages their companies to hit homeruns, to swing for the fences; not to do an incremental innovation, not to do something cute.

MS. PRABHAKAR: Because that's how you return to the -- for the LPs. Right? I mean, that's the business modern for the venture capitalist. Exactly.

MR. MCAFEE: Absolutely. That's not part of the problem that we're talking about. I think that's a good thing instead of a bad thing.

MS. PRABHAKAR: Well, but let me translate it to what actually happens when you have a small startup. So you know, actually, the conversation around the board table every single month is about the burn rate.

MR. MCAFEE: Yep.

MS. PRABHAKAR: And that is about not hiring too many people, because you'll run out of runway before you actually get the product built and get revenue generating profit. So, you know, there's never a conversation about, it would be really good if we could employ a few more people. That's only a consequence of achieving that hyper growth, sometimes. Once in a great while.

MS. TYSON: I've heard someone say, and there is a kernel of truth in this, and it goes to your point about globalization, as well. I've heard people say, so the U.S. has the very best incentives -- this is comparatively speaking, until recent things like patent boxes in the rest of the world. We have great incentives to do the research in the United States.

We have weak incentives to do the employment in the United States, and very weak incentives to keep the profits in the United States. So basically, you have a situation where all of the incentive structure in our tax law and a whole bunch of other things says yes, yes, yes. Locate around great universities and start the Google Apples apps, everything of the world, there.

Don't worry too much about employment. In fact, except for the people you have to employ on your premises because you actually have to keep the premises going, you can actually do most of this work some other place. And don't worry about your

revenues, because you can put them in places where they're not highly taxed.

So, I do think this issue of thinking about the employment effect, certainly, is not something which a wealth generation venture capitalist or non venture capitalist has on the top of their agenda. It's not even on the agenda, because labor is a cost.

MS. PRABHAKAR: It's not. Exactly. Yeah.

MS. TYSON: I mean (Laughter), labor is a cost. So, sometimes, their discussion of talent -- and when you talk about talent, well, talent is something you want to acquire. It's not a cost. But labor is a cost, and I think that's -- can I ask a question about DARPA? So, you were both in and out.

Do you think that -- so relative to what John and Andrew are saying, you might think that the rate of diffusion of ideas that are generated in DARPA is slowing down. They're not being picked up. Their private sector is not making the most of it. We used to say -- in the Clinton administration, we were really worried about whether there was enough dual use

technology to spillover.

MS. PRABHAKAR: Yeah.

MR. MCAFEE: Mm-hmm.

MS. TYSON: Now, we believe there's a huge amount of dual use technology to spillover, but is the recipient, the catcher (Laughter) not there to catch? So, what do you think?

MS. PRABHAKAR: We think all the time about how our technologies are going to move out into the world. Some of them are very specific military systems, and they will only move forward through Department of Defense and the defense industrial base.

But a number of the enabling technologies, some among -- you know, we talked about today, but also, in the information technology arena, do depend on graduate students going off and starting new companies or established companies adopting things out of basic research. But fundamentally, at some level or another, a business decision has to be made around a commercial opportunity.

And you know, there was a time in DARPA's

history when we -- you know, we were scaling the Arpanet and the Internet and the Ciscos and the Suns and this huge number of amazing companies was spinning out mostly from the university research that we were funding.

I would tell you that I think that that is a very lumpy thing. DARPA's been around -- we're in our sixth decade, and there were seasons when there was a huge amount of that kind of activity and other seasons where there's only a modest amount. And it just ebbs and flows according to when those markets present themselves and entrepreneurs go seek those opportunities.

MS. TYSON: Sure.

MS. PRABHAKAR: It goes on today, but I wouldn't say it's at that level.

MS. TYSON: There's no secular -- so, some of this is about where there's been a secular decline in the ability of the private sector to pick this up and move it forward.

MS. PRABHAKAR: What I see -- my sense is

that it is much more about when entrepreneurs see market opportunities, and it's more that organic drive that fuels this big burst of activity, or then you know, it moderates -- some of the things I talked about today, we do see entrepreneurial activity, but it's fairly modest, because there aren't you know, 20 companies who see huge markets yet there.

MS. TYSON: Because it's still too far from --

(Simultaneous discussion)

MS. PRABHAKAR: I think it's early.

MS. TYSON: -- the market.

MS. PRABHAKAR: Yeah.

MS. TYSON: Whereas when you had the Arpanet, it got to the market and then blew out. And then of course, in all of the social network -- all of the stuff that has grown up in the last decade --

MS. PRABHAKAR: After that, right.

MS. TYSON: -- yes, would follow that.

MS. PRABHAKAR: Right. And just to finish about -- you know, the Arpanet -- the first decision

at DARPA to put money against the idea of connecting computers was 1968.

MS. TYSON: Wow.

MS. PRABHAKAR: And it was 1993 --

MS. TYSON: Fifty years.

MS. PRABHAKAR: -- as I recall, was the year that all of the sudden, every business card you got had an email address on it. Right?

MS. TYSON: Right.

MS. PRABHAKAR: That's when the market really started exploding.

MR. HALTIWANGER: So, we've talked a fair amount about the decline in productivity growth in the aggregate statistics. I think it's important to remember that that same data says it's especially the high tech sector that's had a trend break in productivity. So it's declined since about 2003, according to the sort of very nice work by John Ferno.

So, that says in terms of whatever DARPA happens to be doing, it's certainly not showing up in the productivity statistics in 2003.

MS. PRABHAKAR: I really have to caution you. DARPA is 2 percent of federal spending in R&D.

MR. HALTIWANGER: No, I understand.

MS. PRABHAKAR: So, please be careful about drawing those --

MR. HALTIWANGER: Okay, no I just --

MS. PRABHAKAR: -- extrapolations (Laughter).

MS. TYSON: I think that it's -- I'll make the point that I think Andrew can make, which is a lot of people do dispute the measurement of productivity from these kinds of technologies.

MR. HALTIWANGER: Sure.

MS. TYSON: So, we heard this morning about how the retail sector may have, you know, not shown any productivity increase, because you put in the machines and the people left, but there's no productivity.

I would say that the quality of locating the production you want at the price you want has really improved. So, the quality of the shopping experience,

the productivity of the shopping experience has measured by quality may be entirely missing from the productivity number. So, we really have a problem here.

MR. HALTIWANGER: But productivity has actually been growing pretty rapidly in the retail trade sector.

MS. TYSON: Well, that would (Laughter) --

MR. HALTIWANGER: So that statement this morning was off base.

MS. TYSON: All right, well --

(Simultaneous discussion)

MR. HALTIWANGER: And in that case, it was actually -- this is related in a good way to the decline of mom and pops. The shift away from mom and pop to Walmart has actually been very good for the retail trade sector.

MS. TYSON: So, but you would agree that --

MR. MCAFEE: And for the consumer.

MS. TYSON: And for the consumer.

MR. HALTIWANGER: Yes.

MS. TYSON: So, my point, whether the retail sector was the right one to use or not -- it wasn't -- was -- is, do you think that given the nature of the technological changes we're going through, that a lot of this is not going to be measureable in terms of output per unit of input, unless you do a huge amount of improvement on what the output actually is.

MR. HALTIWANGER: I agree with that. We've moved increasingly to parts of the economy that are hard to measure. (Inaudible) Grellickis made this point --

MS. TYSON: Yeah.

MR. HALTIWANGER: -- now a couple of decades ago that says, we're already back at 20 years ago moving, and that's increased. So, I agree. Our productivity statistics need lots of work.

MR. MCAFEE: But the first thing that everyone says when the evidence doesn't support their theory is yeah, the measure -- we have very severe measurement problems. I don't want to rely on that evasion. I think the productivity numbers are weird,

especially in the face of this idea that Erik and I are putting out there, that we're in this technological surge.

So, all I can do is fall back on the other evasion of somebody who's evidence is not supported, is wait and see (Laughter). Because I do think --

MS. TYSON: Well, it's a long time.

MR. MCAFEE: But no, let me go on a little bit. The near future, I believe, is going to look fairly different, even in some of these very labor intensive, low wage, service sectors --

MS. TYSON: Yes.

MR. MCAFEE: -- that have seen growth in employment without much growth in productivity.

MS. TYSON: Right.

MR. MCAFEE: And therefore, big increases in their contribution to CPI, as Larry highlighted in the first panel. You talk about healthcare, which has gone from one hundred to 600. There's a hotel -- sorry, a hospital that just opened up a little while back in -- Laura, in San Francisco, where every meal

has not been cooked by robots, but it has been delivered to patients by robots. The dirty laundry is being carted throughout the hospital by robots. Automation is coming to these sectors, quickly.

MS. TYSON: So, this is a good point on which to draw the panels together, because the positive part of that argument is how much better you are off if you're a patient in one of these places, and you're going to get your food well prepared, on time by somebody who's not going to make a mistake. Okay?

The bad news is that in every projection I've seen for employment growth in the United States and for other countries around the world, care giving and healthcare is a major source of employment growth for, let's say middle educated to low educated workers.

MR. MCAFEE: Yeah.

MS. TYSON: If the robots are smarter and the robots can do it more precisely, then that's where you start to get to the issue we talked about earlier

today. Who is going to be technologically displaced and what do we say as a society, if -- one of the most brilliant lines in the book that Andrea wrote with Erik is, the essence of capitalism is that most people get their income from their labor.

What if machines, what if brilliant machines take away certain jobs altogether and undermine the return to labor for a large fraction of society's workforce? That is a social problem that we have to begin to think about. And I really thank the Hamilton Project for having us all here today. I thank my very distinguished panel for forcing us to think about technology and business models and how could we get this to work better. It's been a great session. More to come. Thank you very much. (Applause)

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