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WHY - AND WHICH - MANUFACTURING MATTERS:

INNOVATION AND PRODUCTION IN THE UNITED STATES

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P R O C E E D I N G S

MR. KATZ: I just want to say welcome to them.

My name is Bruce Katz. I'm vice president at The Brookings Institution. I'm co-director here at the Metropolitan Policy Program. And welcome today for this forum on "Why -- and Which -- Manufacturing Matters."

So, first of all, I just want to thank my colleagues Mark Muro and Howard Wial for their leadership and their scholarship on this important topic that has brought us to today.

The timing of this forum could not be more propitious. The severity of the recession, the sluggishness of the recovery are triggering a robust and, frankly, a long overdue debate in the country about the future of manufacturing. It's happening, obviously, not only in op-eds and blogs and editorials from some of the most eminent economists in the country -- Christina Romer and Laura Tyson recently had pieces in the *New York Times*; Jared Bernstein had a blog earlier this week -- but we also have Rob and Howard and Sue and other folks here today. But also we have CEOs of major global production companies: Jeff Immelt of G.E., Andrew Liveris of Dow Chemical, Boeing. They've been particularly forceful in articulating the need for national manufacturing policy to build off the strong base we already have in the United States.

So, three things I want to highlight at the beginning. As you'll hear today, there's a lot at stake in this debate as the U.S struggles to not just create more jobs but better jobs and retool our economy in the aftermath of the

recession. As Howard and Sue Helper will demonstrate, manufacturing is a special sector, because it delivers quality jobs, fuels innovation, drives exports, reduces the trade deficit, enables the United States to be at the vanguard of the clean tech revolution. A country that produces more innovates more. A country that produces less frankly should worry about its long-term prospects.

Second is essential post-recession, that the U.S. develops and implements a national manufacturing strategy. I use the word “national” rather than “federal” deliberately, because all levels of government play critical roles in supporting, buttressing, leveraging, manufacturing. The federal role is obvious, given the impact of trade, tax, and currency levels on manufacturing and given the range of federal government investments and innovation in human capital and infrastructure.

But the states have brought powers over such market-shaping policy areas as infrastructure, innovation, energy, education, and skills training. And cities and metro areas are critical, because they house the institutions that actually do the work: manufacturing firms, large and small; trade associations; our air, rail, and seaports; advanced research institutions; community colleges; high schools that provide career and technical services; so forth and so on. Manufacturing strategy is a federalist act, done in close collaboration with the private sector in supporting civic institutions, and the presence of CONNECT Today is a testament to the profound role that’s played by local metropolitan and regional intermediaries.

And finally, this is the first in a series of forums and reports on

manufacturing that Brookings Metro intends to hold this spring and summer. Tomorrow I'll be in Michigan for the release of a state urban and metropolitan strategy that capitalizes on the manufacturing assets of that state as a platform for future growth and renewal. On March 8th, back in this room, we'll release our report called "Export Nation," which will reveal how manufacturing is driving metropolitan and national growth post-recession. On May 3rd, Howard will return with a spatial geography of manufacturing, which will unveil the concentration of the nation's productive assets -- very distinct productive assets -- in different metros around the country. And then in a series of forums as part of a global cities initiative, we will look at the links between manufacturing exports and skilled workers in L.A. in March, Ohio in May, and Florida in June. We're also embarking with McKenzie on some very exciting work on drilling down on the full federal state and local policy agendas for two advanced industries in two dramatically different states, and that will show the very nature of the federalist task facing two different industries in different places.

So, in sum, our intent here is to undergird the manufacturing debate and policy action with evidence not only about manufacturing performance but the distinct manufacturing assets of different metros and their states.

And looking forward to the discussion today, Howard and Sue's presentation, the panels to follow. I encourage everyone to engage on Twitter as well, with me, Mark Muro, Brookings Metro, hashtag usmfg.

Let me start by introducing Peter Cowhey to give a few remarks.

He's the UC San Diego dean and Qualcomm professor of communications and technology policy of the School of International Relations and Pacific Studies. He's the chair of the CONNECT Innovation Institute. And in 2009, he served as the senior counselor for policy planning to U.S. Trade Representative Ron Kirk. He's been absolutely critical in helping position UCSD as a true metropolitan leader and national model of metropolitan leadership from the university sector on the productive economy working closely with the private sector from idea generation to tech transfer and commercialization in advance electronics, medical technology, energy, bio-pharma, and more.

Peter, thanks for coming.

MR. COWHEY: Well, thanks, Bruce, very much for being both a gracious host day to the CONNECT Innovation Institute project and a wonderful partner in thinking about the future of innovation and production and employment possibilities in the United States.

As you hear the discussion unfold today, especially from the participants from the CONNECT project, I hope that you'll walk away with four headlines in your mind. Here is the first headline. The fact that the largest technology organization in Southern California, when the bastions of high-tech innovation cared enough about the problem of production and employment in the United States, to mount a major project with the support of the founder of Gateway Computers and with the presence of Irwin Jacobs, the co-founder and former CEO of Qualcomm. That in itself is a message that should matter in Washington.

Here is the second headline you should think about. The public discussion about innovation in the United States and its implications for growth confuses two types of innovation systems that co-exist in the American economy. The first type of innovation system is what we call novel product innovation. It's knowledge intensive, high value-added innovation. It's Qualcomm's breakthrough chip technologies. It's protease inhibitors. It's nano materials. And in that system of innovation, the United States remains the world's best because of a combination of both entrepreneurial markets and appropriate public policy to support the innovation system. We have to constantly revisit to deal with competitive challenges, but that system is fundamentally sound in its core if we maintain it.

The second type of innovation system, however, is incremental product and process innovation. Think of that as an automobile transmission for most of your cars. Fundamentally, that technology is the same as it was 50 years ago at its core but in terms of its features and productivity, enormously greater because of continuous incremental innovation and process production innovation that makes those features affordable even as they are added upon. That system of innovation in the United States lags even against other high-wage industrial countries, and that should be a source of concern to the United States.

Here's the third headline. Both of those very different types of innovation share the same four fundamental building blocks -- and if we get those building blocks right for novel product innovation and we don't get them so right for incremental product and process innovation.

Let me illustrate the four building blocks with the more familiar field of high-tech technology products. Number one, shared production assets. If you go to San Diego, the smallest startup firm in biotech or electronics, et cetera, can have available to them the most state-of-the-art electron microscopes and mass spectrometers, because within the cluster, anchored by the research university but with the help of organizations like CONNECT, there is an efficient system for sharing those key scientific assets so you don't have to buy them to use them in your early stages of growth. Rental, sharing, a whole series of solutions exist to share key production assets.

Number two, there is an effective networking institutional structure. We all know that innovation is about people and ideas and the circulation of people and ideas while respecting intellectual property. A good innovation cluster encourages that circulation and networking. But it's not just about sharing ideas and sharing people and getting them to move around; it's about building trust in cooperation inside the cluster so that, for lack of a better term, handshake deals are possible at early stages to try things out informally with cooperation among many, leading later to the complex contractual maze that we all have to live through when things scale up.

The third feature of a successful innovation system as a building block is the ability to launch innovative business models. What do we mean by that? Think of the iPod. Before the iPod was introduced, the conventional wisdom in the business press was that content was king and where profit was to be made, hardware was a commodity. Steve Jobs understood that maybe you

could invert that proposition. A slick piece of hardware integrated to a new surface call a store could make the profit on the hardware and commoditize the content and thus revolutionize an entire industry. That is an innovative business model, and that is possible due to a combination of public policy, professional services that support innovators, and a larger permissive environment that spawns that type of creative thinking.

And the fourth feature of a successful innovation group and cluster is really the ability to have appropriate, specialized financial institutions. America reinvented its innovation system in light of the Japanese challenge around small startup companies that eventually became giants like Qualcomm. Those companies were supported by a novel financial system that we call venture capital. But venture capitalists did not drop from God or even from Wall Street. They occurred both in response to a need and in response to public policy innovations such as the Securities and Exchange Commission saying to pension funds that they could put part of their portfolio into high-risk venture investments through venture capitalists. Those four building blocks, we would submit, are lagging as a set of building blocks for incremental product and process innovation in America.

And here's the fourth headline we hope that you'll walk away with, which is the way we got the novel product innovation system and its policies right was by experimentation at the national, local, state, and regional levels. Call them technology clusters that evolved. And the remarkable thing about that is that this policy ecosystem supporting an innovations eco system is supported

broadly in both blue states and red states. It is not a Democratic or a Republican state administration priority. Go to the Southern Governor's Association, they support it. Go to California, California supports it.

The same type of approach at a federalist level combining local initiative with federal support could help rebuild a bipartisan basis for the innovation system and ecology for incremental product and process innovation.

As you hear my panelists today lay out the studies that we've put together -- and that includes Sue Helper in her crossover role between the two projects -- we are going to be delighted to answer your questions and we hope contribute to this dialog that Brookings has been such a trailblazer in.

Thank you very much.

MR. WIAL: Manufacturing policy is the subject of great current controversy. Former chair of the Counsel of Economic Advisors, Christina Romer, recently wrote in a *New York Times* op-ed that a persuasive case for a manufacturing policy remains to be made. Well, today we'd like to make that case.

Our discussion proceeds in three parts. First, we'll review why manufacturing matters. Second, we'll talk about which kinds of manufacturing matters, and that way we build upon other work that has been done, but we talk about which manufacturing matters, because not all manufacturing matters equally. Different firms with different business strategies, different industries matter differently for the achievement of important policy goals. And finally, we'll lay out a policy framework for thinking about a national federal, state, and local

integrated manufacturing policy.

So, why manufacturing matters. Well, between the beginning of 2001 and the end of 2009, the nation lost nearly 6 million manufacturing jobs. Since December 2009, it's regained somewhat more than 300,000. Now, it's possible that small increase in the number of manufacturing jobs is just a bounce back in demand from the recession, but we actually think that there's reason to believe that it could be the beginning of something longer lasting.

The era of mass offshoring is probably coming to an end. Wages in China are rising faster than productivity. There's been a slight increase in the value of the Chinese yuan. Of course it's still manipulated and it shouldn't be, but things have been moving very, very slowly in the right direction.

A wide range or manufacturers, including such prominent ones as G.E. and Ford, are beginning to reconsider the costs as well as the benefits of offshoring, and some companies are bringing work back to the United States.

And finally, the current natural gas boom has been boosting demand for products such as chemicals and machinery needed to extract natural gas.

So, for all those reasons, we think that we could be at the beginning of a manufacturing job renaissance. But we won't be without the right kinds of policy. The bounce-back of manufacturing jobs will remain just a trickle without a more robust federal manufacturing policy, and, moreover, the recent bounce-back of manufacturing jobs has been accompanied by a disturbing decline in manufacturing wages, which has contributed, to some extent, to the

growth of manufacturing jobs recently but, of course, at the expense of manufacturing workers and, more broadly, the nation's standard of living. So, manufacturing policy is needed to address the wage problem in manufacturing as well as to spur more robust job growth.

Manufacturing matters for several reasons. Manufacturing embodies the virtues of a rebalanced and more productive next economy where we think the national economy should be going over the course of the next business cycle upswing. Manufacturing offers high-wage jobs, thereby providing opportunity to a wide range of workers. It contributes (inaudible) proportionately to innovation. It's the key to reducing the trade deficit, thereby creating an economy that is more oriented towards exports and less dependent on imports than our current economy. And finally, it contributes to environmental sustainability and particularly through the reduction of carbon admissions.

Even after controlling for all the worker and job characteristics that influence wages, manufacturing still pays higher wages to workers at a variety of educational levels. It pays about 7 percent more to workers with just a high school diploma and to workers with at least a bachelor's degree and a bit more than that to workers with some college. So, if you move a worker from another industry to manufacturing on average, that worker will get about a 7 percent wage increase if they're in one of these educational categories.

Manufacturing is the major source of commercial innovation. More than two-thirds of domestic R&D spending by companies happens in manufacturing firms. About 18 percent of all that spending happens in the

pharmaceutical industry, about 10 percent in transportation equipment including autos and auto parts, aerospace, shipbuilding, and other areas; and about 14 percent combined occurs in the computers and electronics area, which includes communications equipment. And, moreover, the kinds of incremental product and process innovation that Peter mentioned are also areas in which manufacturing that would need improvement still excels relative to other parts of the economy.

It's a common -- recently a very commonly repeated myth that innovation in manufacturing is the cause of manufacturing job loss. If you compare the 1990s with the pre-recession part of the first decade of this century, the period 2000 to 2007, you see the annual growth and productivity is about the same in those two periods. But annual job loss in manufacturing was much, much greater in the 2000s than in the '90s. So, clearly, there's no necessary or no empirical relationship between manufacturing job loss and productivity growth in manufacturing. So, don't blame productivity growth for manufacturing job loss.

Manufacturing is essential for reducing the trade deficit, because nearly two-thirds of all U.S. trade, imports and exports combined, is due to manufacturing. If we're going to reduce imports by bringing work back from other countries and increase exports, manufacturing is going to be a key to doing that. It's not literally impossible to do it without manufacturing, but it's much, much easier to do it with manufacturing, particularly if we want to avoid a very, very large devaluation of the dollar and its consequent results for our standard of living.

Manufacturing is a huge contributor to environmental sustainability. My Brookings colleagues last year released a report on the clean economy. Jobs in the clean economy are those that produce goods and services with an environmental benefit or that add value to those goods and services, and my colleagues found that the clean economy is nearly three times as manufacturing intensive as the broader U.S. economy. That is, manufacturing accounts for about three times the share of jobs in the clean economy as it does in the U.S. economy as a whole. So, manufacturing is at the forefront of the development of the low carbon economy. And that's not only because renewable energy components, like solar panels and wind turbines and advanced batteries, are manufactured products but also because a whole range of manufactured products are needed to retrofit buildings to make them less energy using.

So, which manufacturing matters? The manufacturing sector is quite heterogeneous. We think about which manufacturing matters in two parts. Industries matter. Some industries have greater potential to contribute to broad national goals, such as the ones that we've outlined here today, than others do. And firms and their business strategies matter as well.

Which kinds of industries are the ones in which the U.S. has the greatest potential to retain or expand jobs? Well, one kind is fairly widely talked about: high-wage manufacturing industries. High-wage industries are either high-tech, high-skill industries, such as pharmaceuticals and computers and electronics, or very capital-intensive industries, such as autos and petroleum and coal products. But we shouldn't also forget about manufacturing industries where

transportation costs are an important part of total costs. Those are also industries in which we're likely to retain or expand jobs. Those are industries where products are heavy in relation to their value, such prosaic industries as wood and paper and food and beverages. In those industries, production has to occur relatively close to consumers.

And finally, over the last couple of years, there's been job growth in a variety of middle-wage durable goods manufacturing industries. And, as we said before, I think there's reason for that to continue in the future.

We point to four industries in particular that make particularly large contributions to critical national goals: chemicals, a category that includes pharmaceuticals; transportation equipment, as we mentioned before, including autos, auto parts, aerospace, shipbuilding, and others; machinery; and computers and electronics, a category that also includes communications equipment and many medical devices. All four of those industries pay wages that are above the manufacturing average.

Looking here on this slide, we see average weekly wages again controlling for all other factors that influence wages.

Those four industries are the four that contribute the largest shares of commercially funded R&D in the manufacturing sector. Three of the four industries -- chemicals, transportation equipment, and machinery -- have had a positive change in their trade balance over the course of the last decade, so they've been moving in the right direction while manufacturing as a whole has not. And finally, transportation equipment, machinery, and computers have been

gaining jobs over the couple of years.

And I will now turn the podium over to my co-author Sue Helper, who will talk about why firms, not just industries, matter.

MS. HELPER: Great.

So, Howard has talked to us about kind of why manufacturing matters overall and that on average manufacturing makes important contributions to national goals in the areas of innovation, wages, the trade deficit, and a clean economy. And then he's gone on to show that particular industries make outsized contributions in these areas. And I want to argue that even within particular industries certain production models have the opportunity to make these great contributions, even within some of the industries we think of as old industries.

So, what do I mean by these production strategies? So, the distinction I want to talk about is sort of between high road and low road. And so in a high road production strategy, firms are going to -- it's basically a win-win-win strategy where firms are able to create high productivity because they're harnessing the knowledge of all their workers, not just the smart Ph.D.'s at the top or MBAs at the top, but everyone. And to that model, a well-trained and thus highly paid workforce is key to generating productivity in a way that I'll show. And so these firms then compete principally on quality and innovation.

And that model then contrasts with what we call a low-road model where we have companies and supply chains, and basically what they're trying to do is profit by squeezing those below them. And so they're competing rather

than by expanding a pie by shifting costs to others. So, a small pie, let's grab my share; it doesn't matter if the way I'm competing is imposing safety costs on workers or environmental costs on communities, I'm going to get my profits.

I want to give a particular example within the automotive stamping industry. This is one of a number of industries I could have chosen, so I'll just stress that this is an example. And this industry, like a number of others, shows the connections between this incremental innovation system and the novel innovation system that Peter started with. So, in automotive stamping, firms take pieces of metal and bang on them with huge presses, sometimes the size of this room, to create every thing from car doors to, say, metal cup holders. It's an old industry. It's been around for a long time.

On the other hand, there's a huge opportunity for innovation here, on the process side. You go to innovative firms in this area and you see robots. You see advanced sensors that can tell you what's going on in that press. You see also on the materials side ability of using high-strength steel -- even non-metallic metals will run through this press -- and there are discussions of metallurgy at the metallic level that go on in these industries. And so that's kind of the high-road firms, the top 10 percent; in some data that I collected for some colleagues at Case Western on the auto supply chain, the top 10 percent of these firms getting value added per worker of almost $100,000. The very most recent data where these firms have recovered more from the recession suggest that the top 10 percent of these firms are more at $150,000 value added per worker.

This takes us up to the level some of what we think of as really high-tech firms. If we think about what does $150,000 value added per worker mean, well, if you think about you're paying somebody at a living wage or even a $20-an-hour wage, we're talking maybe 40-, $50,000 there. But if you're making $150,000 per worker, that's plenty of money left over for capital investment for profits, whereas these low firms -- the firms at the bottom 10 percentile -- $30,000. Even if you took all that money and paid the worker with it, it's not a great wage.

So, what this slide shows is that those firms -- these same firms -- so the firm at the $99,000 value added per worker, their production workers are making $17 an hour on average. One thing I should also say is that these workers are likely to be getting benefits that would increase their total compensation a lot -- health benefits, retirement benefits, et cetera -- whereas in the low road they're making $11 an hour. So, how is it that we have the same job classification and we have differences of 50 percent? What is it that these workers do that's different?

So, one is if we want to think about how are we going to introduce these new innovations, how are we going to get in high-strength steel that requires new design practices, new ways that -- high-strength steel, for example, is thinner and more brittle. It can tear in the press. It can have a problem with what's called spring-back, where it wants to retain its shape.

So, groups of workers can form quality circles. This is a Japanese innovation that has been known for 20, 30 years in the U.S., getting groups of

workers -- so, ranging from the person who's tending this machine but knows its qualities, its problems, what happens when you actually to run that piece of metal through that particular press; interacting with skilled trades people, engineers, et cetera; solving problems so they can reduce defects so they can reduce costs.

They can also reduce revenue by enabling the introduction of higher-tech products and introducing those products more quickly. And so as you can see firms that did this recovered more quickly. This is, again, data from the Case Western survey of automotive suppliers that we conducted last year. Those firms that had these practices saw a small increase in sales; those that did not are still down almost 10 percent in sales compared to 2007.

A similar process or practice that kind of links this incremental improvement economy with the ability to innovate, to introduce new products is preventive maintenance, basically, knowing that your machines are going to be up at all times.

So, firms take different paths to the high road, but I think that the advantages are shared by workers and managers and also communities. You may think, well, geez, how can you pay 50 percent higher wages to your direct labor and make any kind of profit? And a key here is that if you pay 50 percent higher wages, that doesn't mean your costs go up by 50 percent. Direct labor is a very small part of total costs in a modern manufacturing system. Supply chains are very important, so the key costs are actually in the supply chain and purchase parts. So, 65 percent is a typical number as in purchase parts. So, if you have a worker who you know is going to make sure there are no defects,

make sure that the presses are up and running, and make sure that your capital is working for you at all times, that worker can in some sense save you money and is worth far more to you than that small increment in the wage.

However, sort of despite these advantages, we often don't see a lot of firms on the high road. Why not? Two reasons. The first one is what economists call complementary. Certain of these investments don't pay off unless several are made nearly simultaneously. Many of these firms are quite small, so the median firm that responded for a survey is about a hundred workers. A quarter of the employment in the auto supply chain is in firms with less than 500 workers. You have a manager there who's, you know, not only the sales person but the R&D person and the HR manager.

So, if you think about problems within a firm, there's a technique called agile production where you're introducing new products all the time. You can make a great variety of products. There's a firm -- Cardinal Fastener outside of Cleveland -- that can ship you a fastener anywhere within most of the country within 24 hours. They can set up; they can run it. What enables them to do that is simultaneous coordinated investments. So, they have the equipment that's flexible, computer controlled. They can change it over quickly. They can market that they actually have this capability that, you know, you can call them up and they will solve your problem for you -- the IT that schedules this from their website to the shop floor. But then HR is also very key that you have workers that don't just watch machines, they set up and run the machines; they make improvements to the future production.

You can also see these complementarities within a supply chain. So, I mentioned these new materials. This is a really important way that we could be reducing our fuel consumption. Every 10 percent reduction in the weight of a car can cut fuel consumption between 6 and 8 percent. But in order to do that, you need to design differently. So, for high-strength steel, it's not high strength unless it's stretched. So, that means the design has to actually have embosses and various kinds of lines to make sure the steel gets stretched in the press. That means different design practices. It means different tooling. It means different production processes in the stamping firm. All these are now done by separate firms, and so the coordination needs to happen and is actually problematic right now.

A second big issue is externalities, which is the firm owners that are trying to decide to make these investments or not. They don't capture all the benefits. High wages are a big benefit to workers, but that's not captured in the decision making of a profit-maximizing firm.

So, moving on from kind of why manufacturing matters and, in particular, which manufacturing matters. We want to say the particular industries that Howard discussed and also these particular firms, regardless of industries that are using these high-road techniques.

So, how do we get there? So, we think manufacturing policies should address four major challenges. We might think of these as market failures in economist-speak, so we're going to support R&D. Need to improve access to finance. Need lifelong training of workers. And, finally, strategic

investments with high returns to workers and communities.

I want to illustrate how this can happen, not that we need to slavishly imitate anybody. But Germany is one of a number of countries that have shown the way that you can actually compete in manufacturing with high wages. So, lunch is being eaten not just by China but by high-wage countries like Germany. So, Germany pays significantly higher wages, as the chart shows, yet also has doubled the percentage of its workforce in manufacturing compared to the U.S.

So, how does Germany do it? So, there's linked policies, complimentary. I think there's been a discussion now in Washington. People have learned the word "Fraunhofer," which is a set of very valuable institutes that help kind of cross the boundary from getting innovation out of the lab and into the shop floor at scale to be produced. But part of the reason this works is because it's linked with several other pieces of policy.

So, a second one is vocational training where people -- the reason that these innovations are able to be implemented is that there's a highly skilled workforce that can handle different ideas and change on the shop floor. So, one of the policies that links the Fraunhofer with the vocational training is a program that allows or subsides the presence of Ph.D. students on the shop floor in medium-sized companies so they can take the information from the Fraunhofer Institute to the firm. Why is it even interesting for a Ph.D. student to be in these firms? Well, because they're going to be surrounded by people with other kinds of skills. So, in 2008, almost 60 percent of the entrance to the German labor

force had an apprenticeship. So, it's not just in manufacturing. This is overall.

Plus, on top of that, 75 percent of German workers have the right to spend 5 days every year in continuous improvement. They have five days that they can spend in learning to improve themselves on their job.

A third thing is stable access to finance. Some issues with this system now, but what it has provided in the past and currently provides better than the current U.S. system is -- there's a combination of a house bank system where you have specialized banks that know about manufacturing and how to value assets and also knows the particular manufacturers that they're lending to. And then this is added to by some government funding, both national and province level.

Finally, sturdy worker protections. And so workers are typically unionized in Germany, and these unions have a role in making decisions about production and investment as well. And I think in general this topic of worker protections is really important. If you think about the first three of these, you can think about these as kind of paving the high road -- you know, generating these investments that are subject in many ways to these externalities where individual firms don't make them because they're not capturing them.

This last one you can think of as blocking the low road. And I think it's important for a couple of reasons. One is, I think as a nation we have a national goal of rebuilding the middle class. And, second, it's also important for keeping this innovation machine going, to make sure that firms profit by investing in innovation rather than by figuring out ways to use ever lower skilled workers.

So, together these policies then provide both the incentive and the capability for firms to adopt these high-road solutions that strengthen long-term competitiveness.

So, what we think is kind of as a result of our research and we discuss in the paper is that U.S. manufacturing should do the following things. It should promote high-road production. It should operate at multiple levels -- so, the entire economy; the industry; the firm; federal, state, and local -- and promote the shared responsibility and also shared gains among employers, workers, unions, and government.

And so to conclude our answer about why does manufacturing matter, we think that manufacturing matters to the extent that it serves important national goals. Already the manufacturing that we have today pays higher wages on average, innovates more, contributes to reducing the trade deficit, contributes to our participation, our generation of a clean economy. We think that policy should maximize the extent to which manufacturing does that until we need not just sort of generic policies but also specific policies specifically for manufacturing that promote coordinated investment. So, if we think about this lightweight materials issue, we need some coordination that if I invest as a small tooling company in learning how to make tools that work with high-strength steel there's going to be a demand for those things.

So -- and this kind of coordinated investment needs to help things like continuous improvement, the incremental innovation. It needs to help with new technologies. It needs to help with developing a clean economy.

So, that's our presentation. I guess I'm supposed to encourage you all to Tweet if you would like, and we also have some time for questions. So, if people would like to ask questions, we have about 10 minutes. If you can state your name and affiliation, and probably what we'll do is collect a few questions and answer them as a group.

Any questions? Good.

MR. WALDMAN: Cliff Waldman from MAPI, Manufacturers Alliance for Productivity and Innovation.

I want to ask you a question about what I have read and perceived to be a weakness even in the novel innovation eco system, and that is supposedly difficulties in the relationship between universities and industry. You often hear that in the United States with major research universities there's a lot of friction in developing intellectual property relationships, and this is one of many things that's causing offshoring of R&D. Universities in Asia are better in forming those kinds of relationships, better cooperation. Can you comment on that?

MS. HELPER: Great. Let's take a few more. I think -- is it Tim? Do you want to -- go ahead, we'll -- I think we'll just -- we have limited time, we'll just two or three questions.

TIM: I'd just like to hear more about the idea -- you all hammer a lot on the wage differential, but you didn't mention earlier that that's been diminishing in these last couple of years. How -- where do you see that going, and at some point if the current trends continue, does manufacturing lose that element of its advantages as an economic sector?

MS. HELPER: And I guess maybe Bob and you. I those will have to be the end. So, thanks. Go ahead.

MR. BAUGH: Yeah, Bob Baugh from the AFL-CIO Industrial Union Council.

I just want to thank you. I think your paper is terrific and is a really need contribution. I guess my question or comment related to it is that it's really striking that you've shown sort of the myths about American manufacturing and at the same time have highlighted another country that actually has a strategy, and I guess I'd like a comment more on that it seems to me that most of the rest of the world actually has strategies around having manufacturing, and what you're pointing out is the failure of this country to have one at all. And I'd like to have that -- I think the German example provided some context for that.

MS. FIREMAN: Karen Fireman, Naval Sea Systems Command.

I look at what you have here. You have a lot of policymakers, very innovative thinkers. I like what you've said. I want to consider -- have you consider the defense industrial base and to consider how do we change the paradigm? We're in a situation of a shrinking budget, which I consider a huge opportunity to change the rules. By changing the rules I mean these innovative, agile companies won't even consider being part of the contracting nightmare and bureaucracy that we enforce and force on companies and where we totally reward the ones that, as you pointed out, push down and squeeze the lower ones as opposed to becoming more innovative. So, I'm looking forward to seeing from you all how do we change that paradigm? How do we change the

rules, requirements, overhead rules, contracting rules, the whole horse blanket we could get rid of and FICM and R&D rules and qualifications and testing?

MS. HELPER: Great, and we need to -- yeah, I think we need to move on, but -- and I will let Howard answer --

MR. WIAL: Well, let me take at least the first couple of questions.

So, the first questioner is quite right that the incentives facing universities in this country are not conducive -- not maximally conducive to pushing intellectual property out into the marketplace, universities, to too great an extent have an incentive to use IP licensing to maximize revenues. Other countries do better at that. On the other hand, there are some competitor countries that do much worse at that. China and some other low-wage countries have basically no intellectual property protections worth their salt. So, whether that problem contributes to offshoring is a somewhat difficult question to answer.

On wages, yes, we're very concerned about the recent declines in manufacturing wages; and, yes, that could erode the overall manufacturing wage advantage. It probably won't erode it completely. There are reasons to think that manufacturing will still offer a wage premium. Manufacturing is still more capital intensive. Manufacturers need skilled and motivated workers to keep that equipment running optimally, and they're always going to be willing to pay a premium to get those kinds of workers.

Manufacturing factories are still larger on average than other kinds of establishments, and so you can't hire enough managers to keep an eye on all the workers in a large establishment. To some extent, workers have to manage

themselves, and manufacturers will pay a premium to get the kinds of workers who will be able to do that. So, I don't think that we'll completely dissipate the manufacturing wage advantage, but it could be reduced, and that's a big concern.

MS. HELPER: Yeah, maybe -- I mean, just thinking on just another approach on the wage differential question, I think one of the things that's an increasingly important part of pay packages is benefits, and it's a little hard to sort of figure out how to value it. Then there's some work being done in the Commerce Department that suggests that if you actually include benefits in the differential rate of benefits offered by manufacturers compared to non-manufacturers, that manufacturing wage differential is either nonexistent or even reversed. So, it's, I think, an open question. But, clearly, I think it's something that we need to work on.

And basically this maybe segues into answering this question about the strategy. I mean, I think what a strategy means is that you have coordinated investments where you kind of think through, you know, for example, how you're going to create both a supply and a demand for a novel product or a trained worker. You know, if you have -- you think about a -- you know, workers that might decide they want to invest in training to learn how to operate computer-controlled machinery. Well, if there's no such machinery in use, then that investment doesn't make sense. Similarly, if you're a manufacturer, you are not going to invest in that machinery if you can't find a worker. So, I think that's a kind of reason why we need a strategy that will help these shared assets that

Peter mentioned. And so shared assets in the form of a skilled pool of workers through apprenticeships, a shared pool of suppliers that understand, you know, the implicit meaning of different kinds of specifications, understand how to work with different forms of materials, these are very important. And I think it's not -- and to say we want to have strategy for manufacturing doesn't mean, you know, we don't also want a strategy, say, for health care. I mean, some of these same issues around investing in new technology and getting workers trained exist in health care existent service industries.

So, a last point, then, I think on this military industrial base and the contracting nightmares, I think, they're not just limited to the military. I mean, I think one of the big issues in the auto industry in fact was their failure to adopt some of the supply chain policies adopted by Toyota and Honda of thinking long term about suppliers, et cetera. And I hope -- you know, that we have kind of an opportunity to restart. We've seen some of that. It's a combination I think of some financial issues that cause short-term thinking, some incentive issues within firms, some of the investments that they've made in systems that help them work with such suppliers, these low-wage small suppliers, as opposed to and don't really give them the benefits of working with these more skilled suppliers. It's a complex question and I think a very important one.

MR. WIAL: So, we turn now to the next part of our program, a moderated panel discussion. The discussion is moderated by Rob Atkinson. Rob is the founder and president of the Information Technology and Innovation Foundation and a prominent policy analyst and advocate on manufacturing and

innovation issues.

Rob.

MR. ATKINSON: Okay. While everybody is getting miked up here let me start. First of all, let me thank Brookings for this really great papers and great event. This is an incredibly timely and important topic. We're going to be hearing sort of very briefly and somewhat more on a dialogue format today from four great speakers who are issuing or presenting four reports from the CONNECT Innovation Institute. The reports are out there. If you haven't seen them I really encourage you to take a look at them.

But before -- let me introduce all our four speakers. I'll make a couple of quick remarks and then we'll just jump right in.

So on my immediate left is Danny Breznitz. Danny is an associate professor at Georgia Tech Institute, Sam Nunn School of International Affairs. And I think I've read every book you've written. So I'm like a groupie. His first book -- and by the way these are all excellent books; I encourage you to read them. His first book was Innovation and the State: Political Choice and Strategies for Growth in Israel, Taiwan, and Ireland. And a very deep analysis of what these countries were doing in innovation policy. And his most recent book, which I think just came out last year, *Run of the Red Queen: Government Innovation, Globalization, and Economic Growth in China*, is a very perceptive analysis of the Chinese innovation policy system. And I'm looking forward to his new book which hopefully he will send me for free since I've said such --

MR. BREZNITZ: Now you'll get two copies.

MR. ATKINSON: There you go. His new book with our colleague John Zysman, *Can Wealthy Nations Stay Rich?*, which was an Oxford Press, and like pretty much everybody on this panel, Danny go this Ph.D. at MIT. This is the "almost all MIT panel" here. (Laughter)

Next is Liz Reynolds. Liz is the executive director of MIT's Industrial Performance Center, which is an interdisciplinary research center looking at the nexus of innovation, productivity, and competitiveness. Her recent work focuses on energy innovation in the U.S. and also advanced manufacturing. Before doing that Liz was the director of the City Advisory Practice for the Initiative for the Competitive Inner City, and she's also a member of the MIT Commission on Productivity and the Innovation Economy. And she also has a Ph.D. from MIT.

Let's see. Erica Fuchs is an assistant professor in the Department of Engineering and Public Policy at Carnegie Mellon University and I think is our only real scientist or engineer on the panel, which I really enjoy and respect Erica's work because she brings this combination of deep knowledge of actual engineering to public policy which at least for me I kind of make up a lot of stuff and have to rely on Erica's work. So her work has been published in a number of prestigious journals: *High Temperature Materials and Processes, Journal of Light Wave Technology, Composites Science and Technology*, and *International Journal of Production Economics*, et cetera. And she has her Ph.D. at MIT as well. I detect a pattern here.

And last is Josh Whitford, who doesn't have his Ph.D. at MIT but,

unfortunately, only has a Ph.D. from the University of Wisconsin. So we'll let that go.

MR. WHITFORD: Flyover land. Somebody's got to come from Flyover Land. Right?

MR. ATKINSON: Somebody's got to do that, understand the industrial Midwest.

MR. WHITFORD: Absolutely.

MR. ATKINSON: Josh is an associate professor of sociology at Columbia and a faculty affiliate of the Center for Organizational Innovation. He's also the author of a book, *The New Old Economy*, about the implications of outsourcing for industrial policy in the U.S. Also a book, *When Networks Fail*, a book on the general theory of network failure. Actually, that's a forthcoming book and *Icons on the Edge*, a book about the prospects and implications of the Fiat-Chrysler Merger.

So before I start, we heard from Howard about the op-ed by Christina Romer. If you haven't read it, it's worth looking at only -- for only really one reason: to understand how deeply embedded the neoclassical ideology is in Washington. This is essentially a view that says manufacturing is no different than massage parlors. They're just all industries. And it sort of harkens back to the days of Michael Boskin for those of you old enough to remember this. And the Clinton-Bush campaign in '92, Michael Boskin famously said when he was chief economic advisor for President George W. Bush, "Potato chips, computer chips, what's the difference?"

So I'm here today to make a bold statement. (Laughter) There is a fundamental difference between these two things. (Applause) When this improves and cuts costs by half every 18 months we get fat. (Laughter) And when this does it we get rich. So that's the difference. That's why we care about this stuff. (Laughter)

So on that note let me start with Danny. Danny, I think one of the things we always hear about, why do we worry about this stuff? Because we're good at innovation in this country. We recently had an event on manufacturing policy and somebody came up to me beforehand and said what are you guys doing on manufacturing? I thought your eyes were about innovation. (Laughter) Well, innovation is in manufacturing, too. And there's sort of this deep view, sort of this innovation thing and then there's this manufacturing thing. And I think what's important about your work, including in this new report, is you talk about that we really have two systems and that our process innovation or incremental innovation system is not anywhere near as good as it should be. Can you say a little bit more about what you found and why you think that?

MR. BREZNITZ: Sure. First of all, thanks Brookings and thanks everybody for being here. And thanks my panelists for joining me on this venture. And yes, we care about innovation and I think both of us and everybody here, because of its impact on economic growth.

In order for innovation to help economic growth, we can't stop just in the act of inventing. We actually have to come with product and services and continuously improve them and make them cheaper. That's where innovation

has its true impact on economic growth. And that is also where new industries, new companies come to often employ people where we just heard with higher wages.

In this country, as Peter has said, we are really, really good in our product innovation. Yes, we should tweak it but we should also remember we are the best in the world and we have a whole system that supports us to stay the best in the world. Where we used to be the best in the world and now we definitely are not, is in everything that happens after the invention and maybe the first product. And Liz will also talk about this and scaling up.

And as Erica will say and Josh will say, this fact also impacts our ability to invent and innovation, the fact that we are no longer good in incremental and production innovation. Make it more difficult for us to come with new products because we need those skills and those capacities.

Also, I would like to say one thing that is important with policy orientation is that the world has changed; our theories and especially the way we think about policies have not. One of the major changes of the new so-called globalization is we have fragmented production. I've seen iPads in the crowd. The iPad is invented in California and manufactured by basically a gazillion companies all over the world. We think about China but even the glass is an American company. Therefore, in order to make an iPad, even to be able to produce it, we have to think about the whole network of companies and innovation have to come together, sometimes extremely quickly within three months to enable a company, Apple, to actually come with a new product.

Unfortunately, most of the way we still think about, we think about companies. One company instead of understanding that if we really want to compete we have to think about subset of companies. We can call them networks. We can call them ecosystems. But we have to move them together; otherwise, we won't be able to come with new products.

That also leads to one other part of innovation which we have to think about. We have a lot of rules for invention because we agree that it's basically a semi-public good. Therefore, private companies will not invest enough in it. This is also true in every other kind of innovation. And therefore, we should think about shared assets. We should think about things like a Fraunhofer. If you really think what it does, it's basically provide the semi-public goods off those kinds of innovation to those small and medium size enterprises so they can become more and more profitable and better. And this is, of course, one of the examples we love in this country -- is training and the labor force. And I just have to remind you that one of the things we have to think about once you move to this new policy paradigm is that our labor training program usually looks backwards. If you look at Taiwan, which I know very well, if you even look at China and definitely in Germany, there are future-looking boards. What kind of workers do we need 10 years from now? Not what kind of workers we needed 10 years ago.

The last thing that I want to say to open this panel is to repeat the fact that we have an extremely good financial investment organization, ideas, system to support novel product innovation. We invested the venture capital

industry. We used to have a system that also was able to have the skills and the capacity and the business models to invest in production facilities, and incremental and process innovation. We don't have it. I don't know how many of you remember, maybe our parents, maybe yourself walking around with a credit card that says Chemical Bank. It's now Chase and it lost a lot of what Chemical Banks knew about the chemical industry.

And with that I think I'll stop and let my fellow panelists --

MR. ATKINSON: Danny, let me ask you one quick follow-on which is one of the points you make in the paper which I think is incredibly important, which is that the unit of intervention should not just be the firm; it should be the industry or the sector. Isn't that industrial policy? (Laughter)

MR. BREZNITZ: That's an interesting question because I'm not sure what is not an industrial policy if you take this seriously. I would say that if we care, which I think we should, about innovation and economic growth in this country, we have to realize that the way we produce both services and products, most of them by way of a think tank or combined together, and we want to excel, we have to think about coordination problems among many different problems, especially since coordination problems, semi-public goods, and collective action are things that we know companies have difficulty to overcome.

And the other thing is most other countries that I work with, including countries with a really good novel product innovation like Israel have realized that and they are changing their policies. Maybe we should look around and see whether that's a smart thing to do.

MR. ATKINSON: So this is actually a setup maybe for you now in the sense of you're looking in your study at one particular kind of industry and that it has unique characteristics in part that suggest perhaps some future growth in the U.S. But maybe you could say a little bit more about that. And also with the view that we have to think about industries in a different way that they're not all alike and they don't all need the same policy, if you will.

MS. REYNOLDS: Right. Well, I'm going to -- it's useful to follow Danny because I'm going to talk a little bit about the biomanufacturing industry, which is an excellent case study and a window into the type of advance manufacturing where I think the U.S. has real strength. And at the same time we see some dynamics going on that I think are worrisome for us long-term.

So biomanufacturing is a very complex type of manufacturing. It doesn't necessarily bring about thoughts about the shop floor. We're trying to scale living organisms and that's really difficult. And as a result it's the kind of technology that involves R&D but also M. So research and development is happening here and the U.S. is the leader in the world in this, but at the same time we have to have the manufacturing very close and in great proximity to this so that we can scale this very complex process. As a result, after pioneering this industry, the U.S. has become the leader and dominant in terms of biomanufacturing capacity in all the world. Five of the top 10 locations globally for biomanufacturing are here in the U.S. and that is because we have historically done the pilot manufacturing, the clinical manufacturing, and the commercial manufacturing here because it was an important process for us to scale and get

right.

Fast-forward 25 years and what's happened, like has happened in many industries, is we've become more productive and processes have become more standardized. The standardization has meant that there's ability to move this production offshore, particularly to countries that have the talent and the resources and the infrastructure to do this kind of commercial manufacturing. At the same time there's been a lot of pressure certainly on public companies' profit margins and so they're looking for ways to improve their profit margin.

As a result, we see companies moving commercial production offshore. They're either doing it to head to Asia to new markets potentially; they're doing it because there's a quid pro quo where you go to countries and they say if you want to sell your product here you need to have some sort of manufacturing presence here. But importantly, they've also been going for tax policy reasons. Where we used to see -- the product lifecycle was such that you develop your new product and over time you go find a low cost location, what we see now is, in fact, companies are not heading to places that are necessarily low cost locations but they're low tax locations. So the U.S. is losing this commercial production to places like Ireland and Switzerland, which in fact are higher cost locations but provide significant tax benefits.

And while the first step here is the commercial production which is, as I said, more standardized, the fact is that these countries are very aggressively interested in pulling more and more of the earlier stage production towards the R&D. And that I think is worrisome when it comes to our ability to

innovate both on product and processes.

Now, what's some of the dynamic behind this? I would argue, and I think this speaks to what Danny has been talking about as well, is that there are certain types of manufacturing that we are particularly good at in this country that fall -- that are at risk of this kind of dynamic. They're ones that first have a longer time horizon in their development. If you think about the complexity of some of this new advanced manufacturing where we see the mixing of medical devices and electronics or defense and biopharma, a complex process that takes a longer time than scaling Google or Facebook. It's going to take us over five years potentially, maybe over seven years to develop this kind of process -- complex process.

The second part is that there are also often capital intensive. They're going to take hundreds of millions of dollars for us to build the facilities we need to scale this production, either for demonstration or for commercial production. And I think we see this in aspects of medical devices, biopharma, as well as energy. Our financial markets or sort of our sort of financial resources don't necessarily support that. VCs are interested in exiting in five to seven years. They're not interested in making those kinds of long-term capital investments -- sorry, large capital investments. And we also see the sort of largely -- multinational largely public companies interested in -- not necessarily interested in investing in that process innovation as much as finding the low cost location and sort of maximizing their supply chain. So they're not necessarily going to be investing in this.

So what we have is a situation in which we are developing the product innovation and we're very strong also in a lot of process innovation but we're scaling all of this someplace else. And so we're losing the benefits of that innovation to someplace else. And I think that's something we need to understand as sort of what's the dynamic in scaling and how can we do more of that here?

The one thing I would say is I think there are some bright notes on the horizon and that is involved in innovation itself, that we see a lot of process innovation, again, where we'd have strength. Whole new areas of products and emerging technologies that the U.S. is leading in. We see a lot of innovation in business models. So, for example, in biopharma contract manufacturing organizations that are specializing in the processing side are popping up in the U.S. to support small- and medium-size innovative companies.

And then we see technologies itself. Niche production, sort of trying to find -- shrinking the scale but increasing the productivity, continuous production from pilot to commercial, mass customization, a whole range of ways in which manufacturing and advanced manufacturing is changing. And I think there is an opportunity for the U.S.

So the question I think that we need to address is we have all this innovation. How can we capture it on the side of scaling and what kind of policies do we need to do that.

MR. ATKINSON: Great. Thank, Liz.

So, you know, one of the things you hear a lot among the

apologists for saying we don't need to do anything is, you know, we're good at sort of type one innovation but, yeah, it's just not us. We don't have the capability to do manufacturing so let's just ignore it. But Erica, your work really gets at this point that there's a nexus between those two things that is more significant than people fully understand. Do you want to explain that?

MS. FUCHS: Yeah. I would love to. And hopefully to play off of the tension developed here and Danny's statements and Liz's.

So, first, I would just like to laud and to celebrate this focus currently in Washington on the relationship between manufacturing and innovation. My own work shows using extensive shop floor level data that when firms move manufacturing overseas, whereas the hot new technologies were more economically viable to produce in the United States, the reverse is true when you move to developing countries. In other words, the older technologies are cheaper to produce overseas and the firms follow those economics. They move overseas and they produce there the older technologies.

But what I want to add -- so full stop there. Just let's, you know, this is important. Where you manufacture changes what incentives you have to innovate. But if I take that then a step further, it is not true that in every single industry that I've studied is there back in the United States a tendency to stop innovating. Right? So while those dynamics are true, those economics are true, in, for example, photonic semiconductors, very, very high end products, what you see is the firm's moved manufacturing overseas. If they move only assembly they actually innovate more, not in the new technology but in incremental

manufacturing technologies back in the United States than they had otherwise. The problem is if they move everything overseas, also fabrication which lets them do that cutting edge technology. So we need to think about as we're thinking about policy, what do we want here? Where will the U.S. have comparative advantage?

Likewise, in the automotive industry, while the firms move overseas and abandon there the new technology, they lose an opportunity. They could have manufactured in the United States and overseas, in developing East Asia or China and in Europe and leveraged that to diversify their product development portfolio, to become more innovative.

So we need to think carefully about where we're going to focus our policy incentives, our policy programs, and that brings me to what you see across the literature historically is that small- and medium-sized enterprises that are process based, early stage technology. So you look at photonic semiconductors, the own sort of industry that I studied. They have in the beginning at the very bleeding edge of that technology, 3 percent yields. Three percent of the products they put in the beginning come out the end. And the engineers are constantly down on the production line trying to figure out what's wrong. Why can't we get a product out the door? That manufacturing we need here. Right?

But likewise, pharmaceuticals, early stages, some of the bleeding edge technologies Liz is talking about. That, likewise, you have this tight, tight link between manufacturing and R&D and innovation.

Chemical industry in its early years. If we look back, today semi-conductors, they're not there. Right? Today we can ship overseas in electronics our CAD technologies and have them send back the technology or the product that we want. But 40 years ago that's where semiconductors was. We had very, very low yields if you look historically, and we had this tight linkage between process innovation.

So if I roll back, what do we do now with respect to policy? Where do we go? And for me, when I look at one of my two cases -- at the photonic semiconductor case, what worries me is in today's environment what's different is we can go overseas earlier. We didn't have these bleeding edge companies going overseas and abandoning the new technologies in the earliest, earliest years 20 or 30 years ago. And we do today. And the question then becomes when I look at who went and who didn't, all of the firms that had already gone public after the dotcom bubble bursts move overseas because they need to lower costs. They need to get products out the door. And the firms that are here innovating for the next market, for taking this out of telecom to computing to biosensors, the technologies that we need are actually still VC or government-backed firms. They are in their earliest stages trying to bring this new technology to market.

And those are fragile indeed. How are we going to keep these firms alive and going to make it to when just maybe three years out we may have a need in computing to continue Moore's Law to bring photonic semiconductors onto the chip. So if I look at what's happening in the innovation ecosystem more

broadly with the decline of corporate R&D labs, as Danny said, the vertical disintegration of the supply chain, if we're trusting in our small- and medium-sized firms now to give us that latest new technology, then the question is what are we going to do with them to support them and bring them forward to the next stage.

MR. ATKINSON: Great. Thank you, Erica.

So one of the points that Christina Romer made in her piece was essentially sort of the same point that all neoclassical economists make which was show me the market failure because there's not going to be market failure. So unless you can prove it to me, I'm not going to support manufacturing. And one of the reasons they are so vociferous about this view that there are no market failures is they look at the world largely as the world is made up of atomistic profit taking firms who act alone in marketplaces. And therefore, they have all the incentives they need to do everything right.

And Josh, your work really goes against that view and it talks about how there are these interlinkages, these system interdependencies that fundamentally are market failures because what one firm does is connected and related to what another firm does. So can you talk a little bit about that?

MR. WHITFORD: Sure. Actually, I want to pick up on a couple things that Danny and then Peter before said, which it's not that market failures aren't a problem. Market failure are a problem, but when you get a fragmented production structure, and Peter said you need an effective network structure, I use the word network a lot because when you say fragmented you say, oh,

there's a bunch of isolated firms. Actually, they have a structure. They are connected in networks and the actual -- the structure of that network can be better or worse. And we need to focus on the notion of the network failure. Right? When you talk -- Sue talked about the Fraunhofer Institute, which is bridging and creating connections between industry and the deliverers, you know, people who deliver our training and services. Right? What they're actually doing is building ties, bridging and things like that.

And so, you know, in academic research we'll often say what's your unit of analysis? What's your unit of analysis? And we'll say, oh, I'm studying the network. Well, there's a policy analog to that which is the unit of initiative. When there's a tendency, you know, Danny talked about forward looking training. Right? There's a tendency to say to the tech school, the manufacturing extension partnership, what firms are you servicing because we can stick them on the news and defend the policy. Right? But that's backward looking. Right? They had a need; we served the need. Right? Allowing the policy infrastructure to be proactive, to be forward-looking requires having them be involved with firms, with groups of firms where they're trying to bring them together and create networks and create this effective network structure. And, you know, looking for where's the market fair. Where's the market fair? Those are a problem but we need to think about the kind of network structure we want to build.

You know, Erica and Liz are talking about the connections between companies and the way they're going to have knock-on effects down

the road. Right? We need ways to think about how we identify and measure network structure and we have some tools for that. Right? But we don't -- then when we go to try and defend what we do, people say where's the market failure? Where's the market failure? Oh, give me a public good.

Well, sometimes the public good is in creating linkages between companies, being the sort of glue in the economy. It's hard to measure. We need to measure it better. That will help us make more effective policy. And one of the other things in terms of manufacturing policy that is a problem in having these bridging institutions is that because we haven't had a strategy, many of the things we have out there in manufacturing extension partnership, ATP, which now TIP, is constantly tenuous. You need to be -- your budget needs to be a little bit safe. If you're going to be a network partner, if you're going to be a broker, companies need to know you're going to be around in three years, in four years, in five years, to create these groups and bring those together.

That's one of the big reasons for our strategy is you can't just deliver a service. You're a player in the network and we need to be thinking about that going forward. So, yes, the unit of initiative is not just the firm. It's not just the industry. It's a part of an industry that's connected and you want to think about those connections. And we can do things to affect those connections.

MR. ATKINSON: Great. Wonderful. So I'm going to ask a few questions. So you should all be thinking about your own questions here which we'll get to in a minute.

Many of you may have seen the New York Times piece probably

three or four weeks ago about Apple and the production of the iPhone at Foxconn in Southern China, which to me I took two lessons from that. One is that our new national manufacturing strategy is essentially called BLAME. (Laughter) Just blame people and maybe something will happen. But it was pretty clear why Apple was doing that. It was that the entire sort of supply chain -- and Foxconn is one of these huge anchors of that. There's just so much capabilities there you kind of can't be there anymore.

And we have a little bit of that now, Danny, in the U.S., particularly in the Albany-Nano effort, which is a really great effort in semiconductors and nanotechnology around semiconductors. Can you say a little bit more about that concept? Is that a viable concept that we can build upon to gain advantage?

MR. BREZNITZ: So I would just talk about liability. I'll say what is interesting and what, for me, if you read the apple story is that there was a tipping point because all the new innovation, if you remember we're talking about the new iPhone, Steve Jobs, according to his story three months before he went to launch a product said no, plastic is bad; I need glass and I need a completely new different kind of glass. Three months later you have an iPhone to be sold. That glass is an American invention. The reason it moved to China is that anyone who knew anything about how to then produce was already in China, which was not true because this is an area where I visit frequently in Xiang Jing and around it. It was not true even 15 years ago. And those people know it.

So I go to a slightly, not so pleasant place like Dong Wan and you talk with policymakers and they say, yeah, our strategy is to capture the supply

chain because as soon as we manage to capture all of the supply chain, everybody around the world will start to come to produce here. And you have it in industry after industry after industry. And if you want to come with me to China I'll go township by township and township and they'll tell me if this is a supply chain for that product and everything around it. And yes. And I think this is exactly what Liz is talking about.

The reason why Ireland and Switzerland are so hot about biopharmaceutical manufacturing is not just because of biosurgical manufacturing right now. It is what they think they can build around it.

And I think we can actually play the same game. As a matter of fact there's probably the only guy in this panel who now is in the south. Slightly too north for my taste. It's in North Carolina, but that's what North Carolina has been doing. Their strategy was biopharmaceutical production. And they started to think and work with community colleges and all of the community around them thinking about what kind of people you need in order to be able to produce those things 5 years, 10 years down the road. What kind of rules you have. What kind of relationship with the universities and the industry you have to have, and not just the research university but the technical college. And I think this is a very viable strategy and I think that we in Georgia are slightly envious of how North Carolina managed to do that and how San Diego, by the way, with CONNECT has managed to do that in high tech and biotech and wireless. I wish more regions in the U.S. could do the same thing.

MR. ATKINSON: Great. Okay. Wonderful. As a Tar Heel, I think

that's absolutely right.

So, Liz, you mentioned how complex production -- process innovation can be. We visited a Merck facility up in New Jersey a couple of years ago where they were making biologics and it was almost harder to do that than to invent the biologics cancer drug. Incredibly hard to build this thing. And I asked the manager did you get -- did you use that R&D? Did you apply for the R&D tax credit? And he said they didn't because the Treasury interprets process R&D a lot more suspect than product R&D. If you're inventing a drug you can take the R&D credit; if you're doing the process to build it you have a much harder time.

And then you alluded to Switzerland. We just wrote a piece on patient boxes. And you can possibly pay I believe in Switzerland it's 0 percent -- it might be 5 percent -- of all your income from an innovation like that. You pay 5 percent corporate tax or possibly zero instead of 35 in the U.S. Today the administration is going to be coming out, I understand with their corporate tax reform proposal which I haven't read yet. I think it's being released in -- 12 minutes ago. (Laughter)

So my fear, though, and I don't know this for sure, my fear is that at least if they don't do it there will be pressure on the hill to sort of jettison a lot of these good innovation incentives for the goal of just flat old rate reduction. So dump the R&D credit, dump modified accelerated depreciation. What's your view on all of that? What kind of role should the tax system play to do this?

MS. REYNOLDS: Well, I think, you know, it would be too easy for

us to just say, oh, if we just reduce our corporate tax rate, you know, all of this will come back to the U.S. It's not the case. Certainly, we have to be more competitive. OECD average corporate tax rate is in the mid-20s and we need to, you know, make gestures, significant gestures that show we're going to compete because this is now a new tool. I mean, this is an important tool that countries are using and they're using it to great effect. But that's not actually enough in terms of supporting innovation policy and innovation investments.

I find it really fascinating and it really speaks to the CONNECT focus that our R&D tax credit is really tied to, as we've heard from others say, it's essentially a jobs program for scientists. So if we can sort of call somebody a scientist and we sort of know what that looks like and we can feel it in R&D and so we can get that kind of support; we don't actually understand it in process innovation. And in fact, in process innovation we have enormous amounts of R&D going on but it may be that it's got a different feel and look in terms of workforce or in terms of other pieces. So we have to really adapt and change the way we're thinking about this because that integration between the R&D and the process and the manufacturing is really one of our core strengths. And right now we sort of -- we don't play to it in any way in terms of policy support.

MR. ATKINSON: So let me just ask anybody who wants to run it, one of the things that I took away from hearing all your presentations is that this is not as simple as saying let's just do a manufacturing strategy. It's not one size fits all. And, therefore, it requires -- if we have a strategy that is real -- it requires policymakers who have a certain level of sophistication, knowledge, and depth to

figure these questions out. In my view -- I'm biased because I worked in this -- but in my view the only agency in the federal government who can really do that across the economy -- and I think DoD has the capabilities within the defense supply chain -- but across the economy is NIST. And it was intriguing to me looking at the president's budget. There's a little footnote that says there's going to be a billion dollars added to the NIST budget, of which $200 million is wireless innovation from the spectrum and suggested the remainder of $800 million is going to be for a manufacturing innovation agenda, which to me was unbelievably great news. It's unclear whether it'll actually happen but if you were advising the administration, all of you, you've got $800 million or maybe it turns out $160 million, who knows what it'll be, what do you do? What do you tell them we should do with that money?

MR. BREZNITZ: So I will start and then Josh and Erica and Liz can.

I think we should look at what works for the high tech innovation system. And we all claim that there are basically four building blocks and we should -- it would work very well for high tech; it doesn't work that well for process innovation. And one is shared efforts. So it can be in biotech, bio contract manufacturing which I admire, but it can also be shared assets for production and testing. For example, I'm sure many of you started to drink Argentinean wine in the last 5 or 10 years and you didn't drink it before. Partly it's because one region, Mendoza, started a testing law that improved the quality of the wine for all the companies around it and then started the process of

continuous innovation.

I think we have to think about, just like Josh said, how do we build an effective network structure? We do it very well in high tech. We have universities that do that. We have VCs that do that. I can't think about an equivalent. I can think about an equivalent in Germany; I can't think about an equivalent in the U.S. We need a flexible business model structure. Again, go to Denmark, you will find thousands of them from machine to link services, to anything else. It's very hard to think about how you can support that in the U.S.

And we need to have finance. With all due respect, in order to produce and make money, one of the greatest resources that you must have is money. And we don't have the correct vehicles to channel this money to where it can take effect.

MR. ATKINSON: Erica, you were going to offer something?

MS. FUCHS: Well, so if we are -- and we are -- concerned in the United States about jobs, the only place that we are going to have jobs is where we have comparative advantage. So if we believe that the place we have comparative advantage is in a merging sort of early stage process-based technologies that has a set of implications. So first, actually to Tim's earlier question on the declining wage gap, if you look, for example, at photonic semiconductors, where you locate your manufacturing, the wage does not matter. It matters where you can get the highest yields, where you can get the best down times to be most economically viable.

And so when you think about that then that rephrases, you know,

where can we have comparative advantage? And so if we're talking about what then does government do, I would add a couple things here. One is if we're talking about these bleeding edge technologies and that's where we have comparative advantage, then we need to have government representatives who have technical expertise. And I think a place like NIST is a place where that exists, one.

Two, we need to be able to coordinate across the supply chain. Speaking to Josh's comments, we've seen empirically, again and again, that these fragmented supply chains, what they have problems in is long-term technology development. Right? So now you say, well, wait, we don't want the jobs -- we might want jobs for scientists but we don't want jobs just for scientists. So what do we do then? Well, really the issue here becomes, well, what models enable us to create those process jobs and those skills and process jobs if these newest technologies are constantly changing? Right? If it is only 5 years or 10 years on this technology and then we need to retrain workers to be able to work in that next big technology, and how do you do that?

I think speaking of a semitech model is one definite way to do that. We're talking about research consortia that bring sort of countries together throughout the supply chain to do the next big thing to coordinate but there have been other models. Semitech was just looking one to three years out. If we look at the Semiconductor Research Consortium, they're looking 10 years out on how do I create that next big thing and how do I get all the pieces in place to be ready to play there. The training of the workforce on the manufacturing and in the

manufacturing skills as well as the alignment of incentives to go, to continue to be the country that not only creates the bleeding edge but also does the manufacturing for that here, and, therefore, can continue to create the bleeding edge.

MR. WHITFORD: Could I also say something on that?

MR. ATKINSON: Sure, go ahead, Josh.

MR. WHITFORD: I think, well, first I'll also give the props, the same props to NIST, which is an agency I have a lot of respect for and Erica's point that having technical expertise in government is important in terms of if what you're talking about is, I like to use my term, the mitigation network there, you know, these are things that are not that expensive but they're very hard to identify. And one place we know that we can't identify and they're important if you look at what other countries are doing, Liz made the point, of trying to get a supply base. What Sue has called in other work, industrial comments. Right? That has a supply base, an effective supply base that can help companies innovate in fragmented innovation, process innovations, very often that require adjustment across multiple firms in the supply network. They're often not chains. That's why you call them a network because they have multiple entailments basically across production. And they have certain semi-public good properties, which is that they are able to serve multiple companies. You can actually put up, you know, the story about why Apple goes to China. The New York Times story makes this point. Is all this about getting the engineers up, you know, getting them up there right away in this huge production facility and all that stuff.

And there's this moment of deep control over labor. But you read the whole article, the whole second half of the article is why is Foxconn there? Is it really about the workers? Could Fox -- you know, why is Foxconn there and not in Vietnam? They are cheaper workers. And that has to do with the whole system around it, sort of a classic agglomeration story but a lot of agglomeration is really about getting ideas flowing. The innovation comes out of agglomeration because ideas are there and suppliers are there. So I would say you need to really recognize the importance of the intermediate places in production networks.

MR. ATKINSON: Okay. Did you want to jump in?

MS. REYNOLDS: Oh, just two comments because I'm thinking about that $800 million and wondering what they're going to do.

MR. ATKINSON: Fund research at MIT. (Laughter)

MS. REYNOLDS: Well, I actually --

MR. BREZNITZ: Georgia Tech, I'm sorry. MIT has enough.

MS. REYNOLDS: We're all one happy team.

I think that -- so one comment on that is that we are very comfortable with funding R&D. And we have, you know, if you look at the PCAST report, it's all about technology push. We're just going to put these inputs into these great research universities and then we'll have new technologies in manufacturing and all will be well. That is actually not the case. I think the real challenge here is how we scale this and how you take it out of the lab and into our ecosystem.

And so, yes, more money into the R&D but let's call it RD&S. Let's include some scaling there. And that speaks to the importance of the regional platform. And I think that's what this is all about in many ways is that where can we do that? We can do that in some of our regions where we find all of the pieces here. And what I've seen in working in a number of different regions is we can have the best research university and great entrepreneurial ecosystem and we might even have a little federal R&D money but that does not connect the dots around an emerging platform or technology. New process innovation, for example, cell therapies. Enormously great opportunities but right now we have lots of little pieces trying to come around that. So we need to really find a regional platform.

And I'd also just like to say that I'm not sure how this plays out but this idea of scale matters, these large investments that companies are making into commercial manufacturing have a lot of positive spillover effects. And right now our states compete with Germany and Singapore and other places to try and get those there. And I wonder to what extent we could have ha federal role in that.

MR. ATKINSON: Go ahead.

MR. BREZNITZ: I want 15 seconds. I'm a great believer in principle agent theory. If we have to change our policies we must change our observable metrics which we demand from policymakers. Because if you are going to determine change with policy but you're still going to judge them about the metrics of a different policy, how many semiconductor factory people you

train today, we're going to first of all make sure that they had the metrics right and then think about everything else. So if we want to change policy, we have to change our observable metrics by which we judge the policymakers.

MR. ATKINSON: So congressional pay raise is tied to manufacturing output. (Laughter)

So why don't we open it up to questions? I'm going to go -- and a lot of them. So here's my suggestion. Let's keep them short and identify yourself and not everybody has to answer every question.

MR. DIMPLE: Scott Dimple from University of Maryland. My undergrad was from MIT but I'm actually a Josh Whitford groupie.

MR. BREZNITZ: Do you want to join us here? (Laughter)

MR. DIMPLE: My dissertation actually develops metrics to measure the impact of network structure on manufacturing job growth and it picks up the medical devices and pharmaceuticals and so forth. But my question actually is for Josh. The novel innovation uses a certain network structure that has lots of structural holes in it. Process and incremental is much more of a dense-type cliquish network. Could you discuss the differences there and maybe what some of the sociology is behind that?

MR. WHITFORD: Not necessarily in two minutes because you actually kind of nailed the main point, right? Which is that the classic story, oh, you've got a market failure so that's about making sure that people can come up with an idea and not get it stolen. This is the whole problem is people won't invest because they'll have their ideas stolen. Right? There are other kinds of

ideas that are not really that hard to come up with and what you really want them to do is diffuse very, very quickly. Right? So some of the stories about central Italy, right, about process innovation, the industrial districts, which is that -- or Marshall, when he talks about ideas being in the air -- people are getting their ideas from each other. So what you really want is they're incremental. So you want somebody else's little idea so you can come up with a little idea and give it back. Right? But you've got to know you're going to get it back.

And so the different network structure, in technical terms, is lots of structural holes or not a lot of structural holes, you made the point, but you're really looking for things that close -- that don't give people opportunities to exploit brokerage. That they know lots of people. You know, this is what's called a small world network. Right? But you really want information flowing quickly and you want to stop people from holding onto their idea and not sharing it. Yes.

MR. ATKINSON: Good. Thank you. All the way in the back. And then we'll go right here.

MR. McCORMICK: Hi. Richard McCormick, *Manufacturing News*.

We all know how hard it is for policies to change. What are the chances, first, for the policies to change to encourage the development of these networks? And what happens if they don't? So where are we now? Where are we headed if they don't?

MR. ATKINSON: Liz.

MS. REYNOLDS: Well, I was going to actually point to Rob actually on some of this.

I think, I guess this point of what happens if they don't in my mind is, as I said before, we're very strong on the early stage process development and we take it to a certain point and then we've seen it head offshore. All of the places where that's heading offshore have now, as we've seen, they've built these anchors, they've built a supply chain. They've got a very strong sophistication in certain types of manufacturing. And the point is that they are going to start trying to move into upstream toward more of that early stage innovation. And so if we don't figure out what to do about this I think there is a threat to our innovation system per se.

I think it's very hard for the federal government to talk about networks or to act and work with networks. So in the words to, much of what Brookings has put out here, you know, there's a whole bunch of principles we could support about flexibility and decentralization, et cetera, in this process. Others I'm sure have more to say on this.

MR. ATKINSON: Right here and then here and then over here.

MR. JOHNSON: David Johnson from BioCrossroads in Indiana. We're an organization somewhat similar to CONNECT, and we have stressed innovation from the very beginning. We think a lot about venture capital and new companies created, but we always avoided a jobs metric because in our state at least we've lost several hundred thousand auto manufacturing jobs. And we're very hesitant, even with biomanufacturing we have the full sector arrayed there and a lot of growth but we get a lot of questions about can you replace job for job that's lost? And I'm wondering about the metrics that this panel and actually that

this initiative is thinking about because when you start -- I get the linkage of innovation to manufacturing and I really applaud CONNECT and Brookings for doing that, but when you start talking about manufacturing, at least in our part of the country, to policymakers you are talking about jobs just in sheer raw numbers.

And so there's going to be, I think, a real expectation that if, in fact, they're being asked to take steps, adopt new policies, put new things in place, that we're going to suddenly see those hundreds of thousands of jobs coming back. How do you begin to develop a metric for thinking about the jobs that will be created in these types of networks that you're talking about in a globally competitive economy with new industries growing? I got all that.

MR. ATKINSON: Okay. Who wants to take it?

MR. JOHNSON: And I understand it but how are you going to do that?

MR. ATKINSON: Who is going to take that?

MR. BREZNITZ: Josh actually has an NSF study which is specifically aimed to start thinking about that. So Josh.

MR. WHITFORD: Yeah, I mean, we're trying to initially -- so I guess two things. One is, look, when they want you to replace all the jobs that have been lost in manufacturing in the last 30 years in a year and a half you just have to -- I mean, of course you're not going to do that. Right? It's incremental and it's about improvement and it's relative to a counter factual and that's just one you just have to face up to and say it's relative to the counterfactual, right?

But on the metrics, the kinds of things you're talking about is having a robust industry that is maintaining and adding jobs a little bit at a time in supply industries. The NSF project is about trying to start measuring, linking companies that are tied to other companies and how that relates to performance. Right? So it's government responses to network failures and we're starting with a case study of the MEP. But we don't have results yet so please don't ask me for them. Give me a year and a half.

MR. ATKINSON: Okay. I think you had your hand up and then this gentleman right over here after her.

MS. WAGNER: I'm Stacy Wagner. I am with the NIST MEP and I hope we do realize some of that money in the budget. I really have a very sort of quick question that's really about an estimate on your part since you all are experts on this. And I am very curious about if we had all of our wishes come true and we could begin to implement these networks and support commercialization, et cetera, et cetera, how long do you think our timeline would be until we could see some real measurable success that would then drive continued growth?

SPEAKER: That's a dangerous question.

MR. WHITFORD: Academics here so you're --

MR. BREZNITZ: Then I will take it. I will take it because actually are trying to do that through Georgia Tech. So I did -- one of the things that I did for this project was a case study of Atlanta. And we discovered that the main problem for Atlanta to come up with a lot of new innovation including we used to

lead the world in data communication before CISCO and Silicon Valley stole it -- (Laughter) -- is we are extremely fragmented. So we couldn't create those networks. And then we now have an initiative to try to create those networks. And when we think about and people bring -- it's public-private so you have people that give money and they demand money to have results -- we immediately said we hope to have something to show for you in about three years, much more in about five years. In 10 years we will really know whether we were successful or not, but not in a year.

MS. FUCHS: So I'm going to go with an example from Carnegie Mellon. We have an advanced battery start-up company at Carnegie Mellon. Faculty came in. In five years now he is about to put out his full-on, full scale manufacturing line. Right now -- so he will start that this summer. Right now he has about 50 employees. Those 50 employees probably came onboard within three years. So he had the invention. There years later he had 50 employees, who are now, you know, they've got their pilot manufacturing scale line and five years out they're about to build a full scale line in Western Pennsylvania. So that gives you one scale. I'm not going to say that's going to replicate to all scales but they will now we hiring hundreds of people.

MR. ATKINSON: I'm going to ask everybody for a vote on it. If, for example, out of miracle of miracles we could get the neoclassical economics profession to come in and bless this initiative so it passes in Congress this year and we do everything we need to do -- we get Fraunhofer, we get a better tax policy, we do training, we expand the MEP budget, we do all this stuff. When we

start to really see it in the real economy in the macro numbers and all of that, 3 years, 5 years, or 10 years? You get one vote.

MS. FUCHS: Ten.

MR. ATKINSON: Who says three? Ten? All right 10. Five?

MS. REYNOLDS: Well, wait. Are we just seeing any numbers or are we seeing --

MR. ATKINSON: No, no, enough that you'll notice.

MS. REYNOLDS: What scale of numbers?

MR. BREZNITZ: I will say three to five years. Enough that you notice. Ten, it's fruition.

MR. ATKINSON: All right.

MS. REYNOLDS: I'm going to go right with Danny.

MR. WHITFORD: Three to five.

MS. REYNOLDS: No, no, I like the 3 to 5 with 10 to fruition. I think that was nuance there.

MR. BREZNITZ: Three to five.

SPEAKER: Something that you can plausibly claim as a clue.

SPEAKER: Three and a half years.

MR. BREZNITZ: Three to five you should have enough that it is politically viable for whoever starts.

MR. ATKINSON: Okay.

MR. WHITFORD: Enough to make the case.

MR. ATKINSON: Enough to make. Okay. I think the consensus

here, except for Liz who is the outlier, three to five years.

MS. FUCHS: I was playing it safe.

MR. ATKINSON: All right. We'll go right here and then Peter and then I think we probably need to close. This gentleman has had his hand up.

MR. BRODSKY: Marc Brodsky, retired physicist.

You make a lot of emphasis on building the infrastructure and creating jobs and manufacturing around high tech and you need networks for that. Don't you think it's an important ingredient of that network which these other competitive countries have to some large extent to have commodity, low cost, large employment-based, low wage manufacturing? Otherwise, the whole system doesn't work.

Also, on the comment earlier about one reason to do manufacturing is to reduce the trade benefit by exporting, you also reduce the trade benefit by manufacturing for domestic consumption, probably just as large. And that has seemed to be ignored. Can you comment on that?

MS. REYNOLDS: I agree with you. I mean, I wouldn't say I have any sort of sense of the actual balance there. But there's no question that a lot of these countries, you know, what we're offshoring is high quality, high volume, low cost production. And there's no question why we can't do that in the U.S. P&G does 95 percent of their manufacturing in-house and a good percentage of that is in the U.S. And that's very sophisticated systems that are based on commodity products but are very highly innovative and high quality. So I think you're absolutely right. That's important and we have some examples of how we could

do that.

MS. FUCHS: I want to underscore the high quality aspect of what Liz is saying and then I want to take that sort of one step farther in terms of if we come back to the question of where we may be able to have comparative advantage or where manufacturing may just need to be here, right? There are certain cases where transportation costs are very high and manufacturing is going to stay here or we have problems with, for example, that we don't have the knowledge base elsewhere so maybe in these high quality cases. So I think we need to think about which of those we can compete in here and which are going to have to be here.

MR. WHITFORD: Also, to be clear, low cost does not necessarily mean low wage. And that's a point that Sue made. And the answer is yes, sometimes. And that's part of why we need to understand better the structure of particular supply chains. What, if you lose it, it's going to pull other industries. Absolutely you need to think about what base supports, you know, you will lose the innovation. That's essential to figure out. More work on that is needed badly.

MR. ATKINSON: Peter.

SPEAKER: So, Rob, two comments. The first is I'd like to say that we've had a historic turning point this morning which is that we've observed that an MIT research cluster is now a subsidiary of the University of California, San Diego. (Laughter)

The second point deals with this issue of political viability which we all understand is important for any sustained initiative. And it seems to me

that's why the notion of building off of the regional cluster model for the high tech innovation is so vital for this initiative because, in fact, that question of building support and belief in the payoff, at the grassroots level in technology it's come because the stakeholders at the local level are participants in designing the program and the priorities and they see day-to-day, month-by-month, the growth of these industries. Even though if you looked at San Diego, which is one of the success points, it wasn't 50,000 jobs in 5 years. But people could see the growth of the companies that they could believe in and they had chosen.

So if this process works right, the various areas around the country will identify where these clusters are, whether it's in auto components or in areas like biopharma and start to gravitate around that and build those pieces together. And they're the basis of the support and that's where suddenly the growth factor comes that people can understand and believe in.

MR. ATKINSON: And Peter, just a point on that, you know, your point about politics to me, one of the things I think that's so important about what Brookings is doing here is brining in the state and the regional because there really, as far as I can tell, are not very many partisan differences between these policies. I was on a panel -- I moderated a panel last year with Ed Rendell, then governor of Pennsylvania; Tom Ridge, former governor, he's a Republican; and Dick Thornburg, former governor. He's a Republican; Rendell is a Democrat. If I didn't know their political affiliation I would have no clue which their political affiliation was because they were just talking in very pragmatic terms about the importance of innovation, he importance of manufacturing, training, networks, et

cetera, et cetera.

And I think what's most frustrating, at least for me, and maybe Bruce you will fix this, is why those voices are not much louder in Washington because they are very good at the state level to say that we're all in this together. I worked for a Republican governor of Rhode Island, the most Democratic state in the country. We all worked together to do these things. And we can't do this in Washington but we've got models out at the state and the local and regional level. So Bruce, I'm going to count on you in the next year to completely change the political dynamic for this. Okay. Thank you. Thank you.

So we now have to switch over to our keynote speaker, Irwin Jacobs, so please join me in thanking a great panel this morning. (Applause)

MS. WALSHOK: Mr. Jacobs studied at MIT and got his Ph.D. there, taught there, and then was recruited to the UC San Diego campus, where I work, and was a professor for seven or eight years, but began to develop some consulting company, LINKABIT, which was acquired. And then with six friends, I guess, I remember the story that we didn't know where a market might be, but we knew we had a good technology, and they created a company called Qualcomm, and the rest is history as they say.

Irwin, for those of us who live in California and I would think in the country, is iconic of why this country works. Qualcomm is a little over 25 years old, started with 7 guys over coffee, now employs 20,000 people globally, and has created enormous wealth and benefits in our region and across the country thanks to the philanthropy of the Jacobs family and their commitments. For us

he's a hands-on technology developer and entrepreneur who knows how to navigate markets, regulatory environment, and every day in his career and now as a board member at Qualcomm is addressing the kinds of issues we've been talking about all morning.

So it's really a privilege, Irwin, that you supported us early on in this effort and that you're willing to come and share your perspective. (Applause)

MR. JACOBS: Thank you, Mary. It's a pleasure to be here. This whole area obviously is of great interest and, of course, how do we get more jobs in the country is something that we need to continually focus on.

What I'd like to do is go through a little bit of history, my personal history in a sense, but also it gives some indication how things have changed over this last, well, 40, 50, 60 years I've been at this effort. I also received a Ph.D. at MIT, so I'm part of the group. I taught there for seven years. During the period as a graduate student and on the faculty I was a member of what's called the Research Laboratory of Electronics at MIT. And over the years that I was there it had substantial funding from the Joint Services. It was such that you didn't have to write individual proposals as to what R&D you might do. The money was there, you were free to kind of work at things and then report back on what you did accomplish. And I think that kind of funding had just this huge payoff as far as people that came out of that program and have gone on to develop various companies. Amar Bose was another person that was there at the same time.

I did go out to decide to then, after teaching at MIT, go out to

California. And because of lots of requests for consulting, set up with a couple of faculty from UCLA a consulting company called LINKABIT. But very early we decided that we did not want to be a consulting company. We wanted to do things that were very innovative that developed new products, take those products into manufacture. So we had that whole direction in mind from the very -- almost from the very beginning and did pursue that.

For the first 10 years of LINKABIT, 9 to 10 years, most of the support came from the federal government: from NASA, from DARPA, from the various services. And over those years there were some great advantages to working with the government. You could, if you came up with an idea, submit it and very quickly get back a response and perhaps some funding. And the funding would come along as you worked and, therefore, you didn't need a lot of outside funding, and so it was a way to build and grow a number of ideas.

For example, one of those was -- and I won't get too much detail on the products, but one of those was something we called the dual modem. It was a satellite terminal based on something that later became called the RISC, reduced instruction set computer. Came up with the idea, had enough support from the government -- it was kind of a whole new way of doing things -- to allow us to carry it through development and then actually into production.

The latter was an interesting point. I went up to talk with a general who was the project manager of this particular program up in Los Angeles, and for the first several minutes he pointed out he was a project manager, that it was very critical that the project be successful, that our competitor was a very large

company, had done these kind of programs often. Yes, it -- they didn't quite meet all the requirements, but, you know, they'd been through this before. And he paused and I thought that was the end of things. But then he said, but as a taxpayer I'm going to support your going into production, and we ended up, in fact, winning all that production. So things were, in some sense, a little bit more flexible back in those days.

We then switched over into various commercial products, so we took a lot of things we learned in the government side and applied them onto the commercial direction. One of those was, for example, a competitive program we won against a company in Georgia, in Atlanta, but -- among others, to develop a scrambling system for HBO for satellite-to-home communication. Actually it was initially satellite-to-cable head, but for political reasons it turned out you also had to provide -- that was the first time I really learned about a lot of these political issues -- you had to provide a descrambler that people could use at their home because there was the whole organization of backyard dish owners that said, you know, you can't just shut us out. And so we had to develop that product.

And a couple of things on that. In order to develop that we needed to develop several chips so that we could have something very inexpensive. But at that time, there was no commercial software for developing chips on computers. It was all done by hand. It would have taken forever. Luckily, we had been working with some research universities -- MIT, Caltech was kind of the lead on all of this, University of Washington -- and I had an employee actually spend a term up at Caltech to understand things better. We

brought software back with cooperation from the universities, these research universities. We were starting to do some homework problems to put the software together and develop it, but when this need came up for the home descrambler we simply said, okay, we're going to take a chance and try to develop the chips on this brand-new software. Luckily all three chips worked and so we suddenly had a product.

Then the question was where do you manufacture? And we looked around, went into all the various considerations. At that time, there was a very interesting government program. I think it had been set up for the farmer industry, but that if you manufactured in Puerto Rico, all the value added there was then going to be tax-free in the U.S. when you sold the product. So you follow the rules of the game when these decisions are made, and so we set up our factory in Puerto Rico to manufacture these various units. It turned out to be a super program. Unfortunately, I then -- not unfortunately -- I had sold the company after that was all going. I left, retired for three months. (Laughter) I decided that wasn't much fun and, as was noted, we started Qualcomm.

I might mention that in both the case of LINKABIT and Qualcomm we didn't have any product in mind. We didn't have a business plan, didn't have any spreadsheets. We knew wireless. We knew that digital was going to be important and that we wanted to try to find something innovative, that is not make little steps. What can we do to make large steps in improvements? And so that was the approach that we took.

We thought when we started Qualcomm that, again, we would be

-- probably have a number of years of government program support. We did win one government project. Well, we won some small ones. The SBIR Program turned out to be of significant help to us. We didn't win a number of other small programs, but we did win one that was going on into production with a test range communications system, actually a fairly sophisticated system that we did the R&D and developed it, et cetera. But now it was different than the days when we did the dual modem and were able to go into manufacture ourselves. The DOD then said, okay, this has to go out for competition. It went to a manufacturer who didn't do R&D, didn't have, therefore, a high G&A level, and was able to compete at a lower price. And so we realized that things again had changed a little bit from where we were before.

However, that didn't mean we left the government business. We still have a part of our business with the government, a very important partner from a revenue point of view, but for other reasons. But now it's more taking commercial products and adopting them to the government side rather than trying to do the opposite aspect.

Very early on then we didn't have our products, but we came up with several ideas. One of them I wasn't going to mention, but I'll mention very briefly because industrial policy has come up. You might -- this was the mid-'80s. We started the company in July of '85, Qualcomm. And at that time the government was very worried about high-def television. Japan was going to -- it was already getting close to starting a commercial network, it was going to take over the entire field, that field was basic because of the digital aspects to

computers, et cetera, and we would be left behind. And so DARPA put out a bid for proposals for HD TV, both the transmission and compression. And because of our experience at LINKABIT we bid on that, won one of -- I think there were 128 teams that competed. We were very small, but we did win one of those contracts.

I mention that because a little later the FCC came out with a request for commercial broadcast HD TV. And we're all set to bid this technology that we had developed when the White House came out with an "industrial policy" that said that if you had any government investment in development you could not use it for commercial purposes. Luckily that didn't last too long, but at that point we could not go ahead and propose this HD TV. Actually the VideoCipher product, the one I mentioned, had been bought by General Instrument and they went ahead and proposed a similar product and that's, in fact, the direction it's all taken and the U.S. did end up playing a very prominent role.

We then looked at some various commercial products. The idea for code division multiple access, CDMA, came up very early. Actually it was part of a consulting contract we were talking over and we came up with an idea that there was a better way to do mobile communications. Didn't have the funding at that point to do that. Instead we developed another product for communication among the trucking industry, a satellite communication product that allowed trucks to be -- communicate back and forth with their headquarters and the headquarters would always know their position. That product, by the

way, we first sold in '88 and it's still in significant use. And one of the things that it did accomplish and I think where we may still be ahead throughout the world is that it improved the logistics of our transportation industry. And so the trucking industry and then cooperating multi-modal with railroads, et cetera, has, in fact, ended up being very efficient. When there was deregulation, which occurred about that time, they were able to take advantage of new technology to improve things.

And by the way, it ended up being quite an education because coming from technology what's the economics of transportation and trucking? You had to kind of learn the whole works. What software did you have to put into logistics systems? The whole thing was very interesting.

In any case, after -- that gave us now a cash flow once we sold that product, and we came back and looked at CDMA for the use in the cellular industry. A lot of conflicts that went on -- I won't get into a lot of the details -- as it began to move ahead. There was at one point an article on the front page of the *Wall Street Journal* saying that Jacobs' hype was costing billions of dollars for cellular companies because they were depending on this technology to be usable. And there was a professor at some major university that was saying it violated the laws of physics. There was a little bit of opposition as we went ahead. And I always advise people who are starting new companies and come up with an idea and try to carry that forward to expect this. If it's innovative, there will be others doing things different ways, the old ways perhaps, and there will be lots of objections and problems and arrows in your back. But if you keep waking

up at 4 a.m. and believing that what you're doing is -- you're on the right track, keep pushing and, hopefully, you'll be able to make a success out of that.

In order to prove CDMA worked we had to actually develop the chips that went into phones. We had to then manufacture the phones because nobody else would do that. We had to manufacture some of the infrastructure. And so it was a very long and involved process.

So we're innovating product, but we also had to innovate a business plan. How do you end up paying for all this development? How do you keep it going? I mentioned we had some cash flow from OmniTRACS, but in thinking about that came up with the idea of licensing technology. We're developing lots of intellectual property, a lot of patents. How could we both make that pay off early and make that pay off later? And so we kind of came up with the idea of licensing manufacturers where they would pay us an up-front fee and then, should this ever be successful, we would get a royalty on each of the phones that was sold later.

So it was that up-front fee that gave us the money to go and complete the R&D activities and then we continued that business model. Of course, now there's a very large sum coming in from the royalties on phones. All third generation are based on CDMA, so those are all covered. And we take that funding -- so it's kind of, again, a somewhat innovative business model, though others have followed since -- take that funding, do a lot of R&D to keep the industry moving ahead, the technology moving ahead very rapidly, and make use of that to sell to other companies, the chips and software.

Now, let me come back on that because there was a major strategic decision involved. We were manufacturing phones. The first network went commercial in Hong Kong, the next two in South Korea. All phones for those networks were manufactured in San Diego. So we were, in fact, manufacturing and shipping them out.

But we then had a decision that we had to make: Should we continue to focus on the manufacturer of the phones or should we go and say, hey, the innovation can perhaps best be done by developed -- moving the technology ahead, adding all kinds of capabilities, embedding that in chips and software, and focusing on that pot? So we decided to sell both the phone manufacturer and the infrastructure manufacturing part of our business.

That actually caused us to go from about 12,000 people -- and my numbers may be a little bit wrong, but roughly that -- down to 5- or 6,000 employees. By the way, the conditions of the sales were that those employees would continue to be employed in San Diego, and that did, in fact, continue for many years. So we went down quite a bit. I might say that since then, again, based on innovating not the manufacture of the phones and the infrastructure, but doing the chips, software, et cetera, the company is now about 23,000 people worldwide, about 75 percent of those based in the U.S., although that percentage will probably draw down a little bit because so much of the business is overseas, but still much here.

And, of course, there's always a concern about are we only providing jobs for college-trained people? And by the way, I think the higher

percentage of college-trained, the better we're all going to be, particularly for these incremental innovations. It's better to have well-educated people thinking about those kind of things. But about 15 percent of our workforce, I just checked, do not have a college degree. So, in fact, when you have a company, you have to cover many, many bases and that implies employing many people.

Well, again, our business has been based on innovation, so how do you keep innovation going when you're now at 23,000 versus when it was small you could walk the corridors and talk with everybody? And, of course, that does take a lot of careful thought. How do you continue to move ahead? One of the things whenever I -- I no longer carry them out, but when I used to have employee meetings I'd always tell everybody to think about Qualcomm -- continue to think about Qualcomm as a startup, but a startup with a very good cash flow. (Laughter) And so if you came up with a good idea, in fact, we could follow it up. And so we worked very hard at bringing ideas, keeping the communication links open, being able to accomplish new things.

We also have a venture capital fund that we try to provide long-term patient capital to companies that are set up that have some strategic relationship. I mention that because one of those, for example, was developing a new technology for display devices, and we thought that sounded like a good thing. It was a display device that would use much less energy, could have color, and, in particular, could be seen in bright daylight. And so we provided some venture capital, then our engineers got involved working, and we became more and more intimately involved. We finally ended up buying the company. It's a

product called Mirasol. And so we've gone through a fairly long development cycle.

Then the question is where do you build a manufacturing plant, the foundry for making this product? And we did think about that, obviously, again, rather carefully and decided to build that foundry in Taiwan. Why Taiwan? Well, it's something that people have talked about quite a bit here. There's a -- for the glass industry, for the LCD industry, there's a whole eco-structure there of people that are very knowledgeable about glass, able to work the various manufacturing. This was a little bit of a change on that, but not that great a change. And so there was a lot of expertise already available there, and so that played a key role in the decision.

Now, I might mention one other aspect of the decision that hasn't been brought up here before and that has to do with tax policy. Many companies that have international sales and, therefore, international profits have large amounts of cash offshore. If one brings them back onshore, you have to pay the difference between the tax rate you paid offshore, which is usually much, much lower, and the U.S. tax rate. And so that's a disincentive to bringing that cash back. On the other hand, if you make investments offshore, you can use that cash. And so, in a sense, that was another reason for investing in Taiwan. I would not say that was the key reason, but it's, again, I think something that we need to keep thinking about.

For example, right now I believe Qualcomm has about $22 billion in cash available of which 16 billion of 22 is offshore. One reason, by the way,

the onshore you can keep working down by giving dividends, by buying back stock, other ways of returning value to your shareholders, which you can't do with the offshore case. So, again, these whole issues of tax policy, tax incentives, various things end up playing critical roles in how you make these various decisions.

Now, I think, again, the issue of trained workforce has come up. Despite the externality issues that do come up, we early on have decided to try to make investments in training of our workforce here in the U.S. as well as elsewhere. This whole issue of K-12 education is a major problem that we have neglected much too long and so a number of years ago we actually have done a couple of things.

One, set up a charter school system in San Diego we call High Tech High. It's now grown to five high schools, four middle schools, a couple of grade schools, and we continue to expand that. Very much project-based education. The thing I want to point out there is -- and I think probably you're familiar with other areas where this may be, other charter schools, true, but despite selecting the kids, the children by lottery across all the ZIP codes in the city, so there's not an IQ test or anything, and educating based on actually a little less per student than the public school systems, we're getting 100 percent graduation rates and going on to college. And one-third of the kids going on to college are studying STEM subjects, science, technology, engineering, math subjects. And so, again, working well. Part of that is because it's very much project-based education, so the kids get a lot of interacting with one another. I

think a lot of the advantage not only with the teachers, which, by the way, are hired without contract and have longer workdays, longer work years, schools years, that there's a lot of peer-to-peer education; that as part of the project-based aspect the kids kind of end up helping one another, and I think that does help the graduation rate.

There's another project we set up actually with four -- initially four high schools in North Carolina. And why it was North Carolina is a long story I won't go into, but where we provided smartphones five years ago initially to kids in several classrooms, helped them and the teachers, et cetera, talked about curriculum. We got some other university help. And then we found some startling results. For example, there was one teacher in one high school that first year, she had a class with smartphones and a class without, teaching Algebra 1. The kids with the phones, 100 percent passed the state exam; without the phones, only two-thirds passed the state exam.

And, again, we were kind of wondering what's going on there. Why would that difference occur? It turned out it was social networking. Kids go home, it was 24/7 availability. Kids go home, have a problem on a homework problem, ask its parent, parent can't help. Instead go back and go on their network and check with other students. So that was kind of a start, peer-to-peer. Students that had good solutions would then go ahead and video themselves using the phones and send those around. And so a year ago when I was back there one of the teachers said that he allows the students the first half of every period to present their solutions while he works with some of the kids that are

having more problems.

I mention that, it's interesting -- and, by the way, the FCC has now set aside funding for a two-year experiment with, I think, there are 20 school districts, experimenting with this use of technology in the classroom. I say that because we -- again, our success in K-12 has been -- could be much better. We've been talking for 20 or 30 years about technology being able to make a difference. I think this decade indeed it's going to make a significant difference. We have to work at that, but I think it's now finally going to be the time. And part of that is devices that the kids can have 24/7 and make use of and get information, e-text, all kinds of potential advantages coming along there.

Just, again, looking forward, what other areas, there are certain things I don't think we're going to get back at this point, such as manufacturing cell phones, manufacturing the iPads, manufacturing devices of that sort, but there's all new industries that will continue to grow, that, in fact, will need product. And one of those I keep thinking about, for example, is health. mHealth is telemedicine; is, again, over this next decade going to make some major changes, major improvements in our health care as well as cost reductions. This involves sensors to make various measurements on the body either remotely or as a smart bandage or perhaps even some internally. You get a lot of noise from these measurements. That gets -- the information can be transmitted to the phone that you always carry with you. It has a huge amount of processing capability and so can filter that out, inform you, inform the parent, inform the hospital. So I think that's going to be a major growth area. Sensors themselves

can be a major growth area. That's one that's still yet to be developed. I think we can go ahead and take advantage of that.

So I think all of the areas that have been discussed today by the panels, the focus on the areas is very, very important. There are government policies clearly that do make a difference. The tax policies and, in particular -- the question what would you do with that money, it was jokingly said give it to R&D universities. I would not consider that a joke. I think that's a great use of the funding. You can't make decisions of which products will, in fact, turn out to be best. But give it to faculty and students that, in fact, will go ahead and make that difference for you.

Thank you very much. (Applause)

I think there's some time for questions. We're running over time, but as long as there's a few people here.

MR. LEVINSON: Hi. I'm Marc Levinson with the Congressional Research Service.

Last I knew Qualcomm actually owned almost no production facilities anywhere in the world. As a matter of public policy should the government be concerned that a manufacturer doesn't actually manufacture in the sense of making things itself?

MR. JACOBS: Well, we actually do own some, but, you're correct, most of the facilities making the chips, we have a very lot -- we're the largest fabless chip manufacturer for cell phones in the world, but those are all made largely in Taiwan. We used to have some made here in the U.S.

Again, I think the question is are we increasing employment? Are we paying large wages? Are we generating resources? Are we doing that in a way -- others might pick other paths -- are we doing that in a way that's successful? And I think the answer is yes, the company continues to grow very rapidly, grows its workforce rapidly, and pays above typical levels.

And by the way, we don't try to farm it out to the lowest-cost bidder. Even maintenance, for example, we brought in-house so that we can handle that. It's an interesting point Mary made earlier to me that when you have a rapid growth of workforce, you then have people spending money in the community. I think we all know this. A great multiplier on the jobs being generated. So there are different ways of doing it. I don't think there's a specific answer.

Would it be better if we had our manufacturing here or there? If it was successful, the answer would be yes, but it didn't necessarily work out that way.

I might add one thing. I mentioned earlier that South Korea was one of the -- it's actually, after Hong Kong, the next two places we launched CDMA. And we managed to go into South Korea -- they actually adopted CDMA nationally -- by arguing that they had almost no production in the cellular industry at the time; that they had some high-tech manufacturing, but it was all commodity. That is, Japanese manufacturers got there first and so they had to compete only in cost. Here was a chance to jump ahead. They took that and, of course, now Samsung, LG, others have major businesses in that direction. So

government can make some of those decisions.

I might add one more while I'm thinking about that. Our government made a different decision. The FCC decided that it would not specify technology for the cellular industry. It would let the market decide. There have been people even very recently criticizing that decision, but, in fact, it had a huge payoff. We were able to launch -- get CDMA and now, although there was competition in the second generation of cellular, all third generation is CDMA. So it gave us a huge advantage.

SPEAKER: Thank you for an inspiring talk and perhaps thank you for the things you're doing in San Diego and elsewhere. I had two questions and both are a bit attitudinal.

In your distinguished career, why is it that people celebrate in Finland what Thecus did for Nokia? Why is it they celebrate in Taiwan what eTree did to set up TSMC with 130 people and Morris Chang and the money? And why is it that no one knows that Qualcomm got SBIR only when it needed it? They point out not after, but, yeah, you got a little big.

And the second attitudinal is we were speaking earlier this morning is you went to Taiwan for good business reasons because there was a superior innovation ecosystem, which they out-subsidized us on, which is fine. You know, they're a difficult -- have a difficult place on the planet. The -- what would it take for us to do that?

And a hard question: What would you think that when you get an R&D subsidies, not SBIRs, but some of these major programs, that the

government asked if it wouldn't be nice if you put 25 or 50 percent of your production onshore, recognizing we'd have to work at that, but something we could do?

MR. JACOBS: All right. On the celebratory aspect, it's something we've worried about at the National Academy of Engineering a bit. How do you -- because so few of our students now go into engineering, and if you look at the graduate schools of engineering, what is it, over 50 percent of the students seem to be -- are foreign born and so we're just not really making enough of a point about engineering being a way to take ideas and make them very useful to humanity. It's something everybody wants to do, but they don't realize that engineering's a good way to do that.

Somehow we do have to make that happen. Even one of the panelists this morning talked about scientists making the difference, but really it's scientists and engineers making that difference. So it's important to get that point across. How we do that better is something we keep thinking through. I think, again, the robotics contests, the different prizes being awarded, but, for example, there is no Nobel Prize in engineering, so we don't get that kind of boost on the engineering side.

And so these are areas that we just have to kind of keep thinking, working, et cetera. But as there's great successes in various companies -- certainly Facebook comes to mind, Google comes to mind, Apple, for sure, comes to mind -- Qualcomm a little less so, even though we have our name on a stadium and most people seem to know us.

The consumer facing products I think you get to know. And I think the success of those, in fact, is encouraging a lot more people to think about software as a career. There may be a slight negative -- in fact, there would be a significant negative to that if students say, hey, I don't have to get even a degree, I can go out and become a very successful business person without that degree. Some can do that. I think most we really do need that much more basic education.

As far as the government programs and subsidies, again, my own belief is that we need to much more strongly support research universities and institutes where a lot of the innovative ideas come from. It's innovative ideas that then launch new industries or grow existing industries. You have to keep working on it.

The incremental is very, very important, but in some sense it's easier if you have the right emphasis and management and you have a reasonably well trained workforce. But it's coming up with the new ideas that's very, very critical and I think a lot of that comes out of people thinking about them in the universities.

SPEAKER: I want to go back a little bit to the question I asked earlier of the panel about the government. And I want you to pretend for us that you woke up one morning and you became a government regulator and you could not not be one of those until you came up with six critical changes that you could maybe instantly or almost instantly make to make the stodgy defense industrial base into something like Qualcomm. What would they be, the six?

MR. JACOBS: Right. Well, one of them, if the procurement policy could go back to the way it was in the ’70s, that would be a major step ahead. That was very valuable when we started. LINKABIT was very different when we started Qualcomm.

The openness of government contracting to new ideas and to allowing commercial approaches to be used for government, I think that can allow one to go a long way. I then mentioned the support to universities, that’s important. The step into manufacture, again, I’m focused on the government aspects, the DOD. They now go to the lowest cost by regulation. It usually ends up in lawsuits, things take forever. The technology doesn’t get out very rapidly. Again, the previous way where we were able to, in fact, take an idea and carry that into manufacturing -- and by the way, learned a lot about it, about manufacturing -- that was something that was a lot easier to do previously that has now become much more difficult, to get the rights to what you’ve developed with the government funding to then carry out into manufacturing. And I think that is an important aspect.

The whole education system that we kind of suicidally have been reducing funding, reducing funding, reducing funding, again, that needs to be done. As far as regulations are concerned, we’ve benefited from some of the government regulations. For example, in Europe, there was an agreement among all of the governments that they could only use one technology -- GSM, time division multiple access technology -- and that worked well for a while, but then when everybody switched to CDMA it kind of set them back a ways. And

so, our policy of allowing any technology to be used as long as it didn't upset existing users, I think, turned out to be a very positive one. There are clearly -- and it varies, different regulation involving employment, et cetera, some of these need to be reexamined, looked at, simplified.

But, again, coming back on the government side, people often talk about the mil-specs as being a negative aspect and indeed, like everything else, you start with a good idea and then it expands and it gets watered down and made more difficult. But when we were doing government manufacturing, the mil-specs turned out to be great. Once you looked and understood what the key original idea was and that particular spec made use of it, it helped us in the government manufacturing. But, for example, the reliability issues, the maintainability issues, the educationalist issues that go along with new products, we've used ever since on our commercial products. So, there's pluses and minuses.

I'm sure there are other -- I'm not up to your full list -- but other things that could come to mind. But I think, again, education turns out to be one of the very key ones. Tax policy that might affect where you place your manufacturer, some advantages there, clearly that can make a difference.

Tax rates, which, of course, are rather controversial right now, I always say I've never met an entrepreneur who decided not to go into business because he might have to pay a higher tax rate later. That is just not an issue.

Thank you all very much. (Applause)

MR. KATZ: I just want to thank Mr. Jacobs and the San Diego

folks for really pushing us to do this. I mean, it just was sort of a coincidence of events that we were able to get Howard and Sue's paper, get Christina Romer to write something in *The New York Times.* (Laughter)

I want to thank Rob Atkinson again for clarifying that there's a difference between potato chips and computer chips, and that manufacturing is not massage parlors. I mean, we still seem to have that problem in the United States. We need *Moneyball* for manufacturing, we need new metrics. There's something about the MIT manufacturing complex which is deeply disturbing to me, but that'll be a research subject for another time.

I think the last piece will be Brookings will continue to do this. We'll continue to do this with Rob and his team. And I think, most importantly, what we've got to do is create that network of states, cities, and metropolitan areas that can innovate and experiment the way they do in our system, replicate across places as they also do in our system, and then ultimately scale up when national politics becomes more sane and sensible.

So this should be a period where we're not waiting for Washington. It should be a period where we get stuff done out there in the country and then bring it back.

Thank you very much. Bye-bye. (Applause)

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