Setting the Tone

"Three-tiered framework to make Global Innovation a reality"

Speaker

Dale W. Jorgenson
Samuel W. Morris University Professor, Department of Economics, Harvard University

Summary

Dale W. Jorgenson:

I would like to extend the discussion to information technology. Your question is: what is the "current global innovation ecosystem?" We just learned a minute ago that there are very important examples of ecosystems already in existence. Information technology is a perfect illustration of a global innovation ecosystem. No industry is more global than information technology. In fact, in the World Trade Organization, information technology is subject to a special international agreement to reduce barriers in international trade. These barriers include tariff barriers and also non-tariff barriers like standards that are set in such a way as to obstruct trade. In the year 2001, after many years of hard work and negotiation, the World Trade Organization created a special Information Technology Agreement that includes 70 leading countries in the information technology industry. These are countries that are not limited to advanced countries like the US and Japan, although the US and Japan are the clear leaders. There are also many developing countries which are very prominent in information technology, like Singapore, Malaysia, Taiwan, South Korea -- the Asian tigers. This is a prototypical industry for the deliberations of this conference. We really need to understand information technology and how the innovation system actually works.

My paper is available on the web.

The first thing that is distinctive about information technology is the behavior of information technology prices. This is a familiar story to economists, but is something that deserves a lot of emphasis. Without the rapid decline in prices in information technology, the global ecosystem for innovation would be very different. The basis for the behavior of prices for information technology, which is propagated throughout the world as a result of the WTO agreement that I mentioned a moment ago, is based on the technology of semiconductors. This is an industry in which Japan has been an international leader for decades. It should be familiar to many of you. "Faster, better, cheaper" refers to the fact that the devices that are produced are indeed faster, have greater capability and their prices decline.

For the economic point of view, the main point is the economic impact. What is the economic impact of innovation? How can we measure the impact of innovation? I want to focus on two channels to illustrate this. These are the same two channels that you would find in any other innovation ecosystem. Channel No. 1 is investment. The mobilization of resources and the deployment of these resources through investment in equipment, and in the case of information technology, intangible assets in the form of software that make use of the latest available technology. Investment accounts for about two thirds of the impact of information technology. Therefore, investment is critical. If we do not understand how to mobilize resources, how to structure capital markets in such a way as to guide the allocation of resources, the global ecosystem simply cannot function.

Channel No. 2 is through productivity growth. Economists use "productivity" in many different senses, which creates confusion and a barrier to understanding. Let me give a definition of the productivity concept I will be using in this discussion. That is the concept of output per unit of input. Productivity is conventionally defined as output per hour worked, but that is not the concept I am going to use. I will use the output per unit of all inputs, including capital, energy, materials, services, everything. Why do I use this definition? Since this is the concept of productivity that is relevant to the measurement of innovation. Let me explain. Output per unit of input can remain fixed and economic growth can take place. The way that that occurs is that existing technologies are replicated. More plants are built using essentially the same designs. These plants expand the output of the industry and economic growth proceeds. What is required is more people, more hours and more resources. But economic growth can certainly take place without productivity growth. Economic growth during the 90s, at least in Japan, actually proceeded as a positive for 10 years without any productivity growth whatever. This was a period of technological stagnation. This is a period that illustrates the concept of growth without productivity increase. The character of economic growth began to revert to a more common pattern after the year 2000, which is that growth driven by innovation and the incorporation of new technologies. Many of these technologies are related to information technology, but not all of them.

I would like to look at the history very briefly. These are familiar ideas, for example Moore's Law. The invention of the transistor in the 1940s led to the development of semiconductor technology. The next major development was the integrated circuit, which took place at Intel and Texas Instruments. Jack Kilby, the inventor of the integrated circuit at Texas Instruments, was awarded the Nobel Prize in physics in 2000. Integrated circuits combine transistors into memory devices and logic devices. A memory device stores information in digital form and a logic device can be programmed to perform computations. The first logic chip was developed at Intel and was produced for a Japanese manufacturer of hand calculators called Busicom. Their idea was to put all of their calculator circuits onto a single chip, which they commissioned Intel to do. Intel then retained the intellectual property rights to this, which was an important move. As a consequence of these developments, the speed of the development of semiconductor technology indicates that the number of transistors on either a logic or a memory chip doubles every 18–24 months.

The reason that information technology is so important and so fundamental is because of the incredible speed of the development of the technology. We are looking at the entire history of the information technology industry, which extends from the late 60s. It is just a period and about 40 years.

I would like to now turn to economics and translate all of this into prices. I have created data on the relative prices of computers and semiconductors from 1960 through 2005. These have been adjusted for inflation. Prices in 1959 for the first electronic, commercial computer based on vacuum tubes were exactly 10,000 times for a

given amount of computational power compared to what they were in 2000. Semiconductors, memory chips and microprocessor, followed a similar trend. Beginning about 1985, the price of a microprocessor was about 10,000 times what it is today for the same computational power. Over a period of 15 years, the price of a microprocessor fell by over 10,000 times. That is what explains the rapid decline of computer prices. Computers now are basically made up of memory devices and computational devices that are based on semiconductor materials. The year 2001 is critical because this is the year in which the World Trade Organization succeeded in achieving a complete regime of free trade in information technology, including electronic devices, computers, telecom equipment and software, everything. We have a very special situation, and what we can see is that it is characterized by rapid development and by the lack of barriers to international diffusion. These barriers have been removed as a matter of policy by the World Trade Organization through the agreement of the 70 signatories to Information Technology Agreement. These price trends, beginning in the year 2001, are common to the world economy.

We now have a clear picture of why information technology is so important. It is question is, so what? What is the impact?

We can begin by looking at the first channel, investment. I have charted the investment in information technology versus all other capital of the US from 1960 to 1995. The US economy was growing at about 3% per year, about half of which was due to investment. Of that, maybe 20% was due to information technology. Information technology has been quite important for quite a while. Beginning in 1995, however, the scene changed very radically. Information technology investment rose to almost half of all the investment that was taking place. The contribution of capital was about 2.25% out of a growth rate of 4%. Investment in information technology became the critical factor in the American growth surge following 1995. The question you should ask yourself is why this did not happen in Japan.

And what about Europe? The level of investment in Japan and Europe were less than half the United States during this period. This came to an end in 2000 with the famous dot-com crash. Investment in information technology shrank, as did non-information technology. Information technology, however, still accounts for a large role. What we need to know is that over half of the investment has come from information technology.

Turning to the second channel, productivity, I will put the investment component together with the development of human resources and productivity. I have divided my figures into non-IT industry, idea-using industries and IT-producing industries. The producing industries are software, electronic components, computers and telecom equipment. From 1960 to 1995, the contribution to US economic growth of around 2.5% included a major contribution of the IT-producing sector, which accounted for about 2/10 of 1 percent of productivity growth, which overall was a little over 0.4%. During this period, productivity in the sense of output per unit of input was only about 50% of economic growth in the US. In other words, the impact of innovation was modest relative to investment. After 1995, there was a huge boom in the IT-producing sector. Some 3% of the economy is going to information technology production: electronic components, computers, telecom equipment etc. This 3% of the economy accounted for more than half of innovation that took place between 1995 and 2000. The IT-using sectors actually experienced a decline in productivity during this period. The non-IT sector of the economy continued to improve its innovation performance.

However, after the year 2000 and the dot-com investment crash, something remarkable happened. That is that the level of innovation increased again. Innovation went from 0.8% per year to 1.3% per year. The role of information technology producers contracted because they were in a crash. The most remarkable event is that the information technology users had been overwhelmed

by the investment in information technology from 1995 to 2000, for between 2000 and 2005 they emerged as the most dynamic sector of the US economy. Who are these folks? IT-using sectors are a long list. The most important industry participating in this productivity and innovation boom is wholesale trade. Some other industries are also remarkable: service industries, business services, non-business services, transportation services, communication services, insurance. Basically, the innovation focus of the economy shifted radically from the IT-producing industries to the IT-using industries. The industries that turned out to be most important in this innovation will not be communication services as here in Japan, but business services, insurance carriers, air transport, social services, professional services, also trade, radio and TV. Manufacturing industries are much farther down on the chart, though they are traditionally associated with innovation.

Conclusion: From 1960 to 1995, US economic growth was a little over 3%. During the boom from 1995 to 2000 growth increased to more than 4% and innovation picked up a little bit, but the big story is the story about investment in information technology. There are two channels for the American growth resurgence. One channel is investment in IT; the second, which was much less important during this first phase, was a more rapid rate of innovation. And also an expansion of the labor force, particularly highly trained individuals with a college education. One surprising part of this charge is that after the dot-com crash of 2000 there was a period of unprecedented innovation in the US and the focus shifted. But the sectors where the innovation was successfully achieved were sectors that are almost never discussed in this context.

The question is why this occurred in the US are not in Japan. What are the barriers in Japanese policy for the organization of the sectors that utilize information technology that block any form of innovation? All you have to do is drive around Tokyo and see the consequences of all the inefficient small enterprises that have been maintained as an explicit consequence of government policy. There is nothing natural about it. It is the consequence of barriers to innovation erected by governments. I think that we need to discuss a global innovation ecosystem at this time because things are changing. From 1995 through 2000 it was a classical innovation story based on information-producing sectors. Japan did not fall behind there. It made the same rapid progress in information technology production as the US. The information technology producers in Japan are world-class, internationally competitive firms. These firms have been competing with United States since the middle 1980s. It is a "war" that is not over. The key, however, the successful application of information technology and that is an area where many advanced countries in Europe and the Asia have fallen very far behind. There is a tremendous opportunity for progress in the future.

Toshiaki Ikoma (JST):

Opened for discussion.

Floor:

Your presentation confirms my understanding of the productivity growth in the service sector, particularly in Japan. There is a notion that IT and service do not go together in Japan. I see that not only in the IT-using sectors but the non-IT sector has also grown quite a bit during the 2000-2005 period. My second question is that I get the impression that the US is by far the best user of IT. How can you make that impact known throughout the world?

Dale W. Jorgenson:

If you look at the use of IT, there are countries like the UK that are close to the US, and also smaller countries like Scandinavia and Ireland that are close to the US pattern. What characterizes these countries is that they have policies that encourage innovation, which takes place through the new entrants. The people that are bringing new technology to bear in the bookselling industry are the Amazon.com people, not the traditional booksellers. It is the creation of a single market by Amazon.com, and that is something that has a long history of United States. It has had successes and failures. The relative success of the US is

due to the creation of a single market. You might wonder why Japan does not have a single market here.

Floor:

What are the top five stories of good uses of IT? You just mentioned Amazon.com. What are the big ones that have happened in the US so we see examples of what is not taking place in Japan?

Dale W. Jorgenson:

The great success is Wal-Mart. They have not had a good time in Japan, although they do have some success in China. Wal-Mart succeeded in linking using the bar code to link up the entire supply chain. Data entry for the point of sale is immediately transferred back to the supplier. All of the organizations that were competing with Wal-Mart had to move in line. There was a famous McKinsey study that showed that Wal-Mart's competitors were facing bankruptcy or forced, against their will, to adopt information technology that Wal-Mart had adopted. Wal-Mart has not managed to overload the competition. If anything, the competition often gains on it. That is the leading example, because it encompasses both wholesale trade and retail trade. Is it going directly to China. If Wal-Mart has success in China, it might have success at Japan. But there are tremendous barriers. I was talking to a Wal-Mart person who used to manage the Japanese subsidiary company, and he said the big barrier is government policy. We cannot operate in the way that we do in the US. That is why there is no Wal-Mart to force other Japanese retailers and wholesalers into the new mode of operation.

Floor:

One of the reasons behind innovation is to improve the efficiency of the product introduction and development. How do you figure the cost of research and development into the cost of unit input? It seems to me that since 2000, people are benefiting from a bubble that happened between 1995 and 2000.

Dale W. Jorgenson:

This is very critical. After 1995, there was a little bit of increasing innovation, but after the bubble burst and there was a slowdown in economic growth, the rate of innovation increased. What is going on there? This is not something that is linked to the development of the technology, although that was important during the previous period. This is a story of successful application of these technologies and diffusing these technologies. It is that output per unit of input that is so critical to the innovation process. The innovation echoes is probably the story about how you create the iPod. The question is how you create the technology that links the barcode all the way back to the supplier. You have all of these people doing R&D coming to your headquarters in Arkansas and trying to sell their products to you. But most of it is essentially successful execution. That is a tiny fraction of total innovation.

Floor:

Looking at the software sector, there may be one explanation of the differences between the US and Europe or Japan. We looked at occupational employment data for the software sector in the US and it is possible at software least to distinguish not just between users and developers but between users, custom providers and off-the-shelf developers. In the US, less than 6% of programmers were at packaged software providers. About 30% work in the custom software sector; the rest in the in-house sector. Likewise 15% of spending is on packaged software, 40% on custom software and 45% on in-house software. In Europe, there is more money spent on packaged software (20%), and much more money spent on custom software (50%). In-house software is under 50% in Europe. Likewise, the Japan in-house software is under 50%. It probably has something to do with skills diffusion and the structure of businesses there.

Dale W. Jorgenson:

In both Europe and in Japan, the software industry is very large and very sophisticated and well developed. We heard how Microsoft has dominated prepackaged software, but all the other applications that build off the existing platforms that are now internationally diffused are quite specific to the business environment in particular countries.

Part of the story of the slow diffusion of IT has to be the story of barriers to application. Very soon the application of IT will drive the employment of programmers. There are many capable people. It is a question of creating the markets or blocking the markets.

Floor:

I think that after the crash, we reached a maturation stage in Internet technology. Do you think there is something different about IT as infrastructure for society?

Dale W. Jorgenson:

The difficulty is that information technology has evolved many times faster than other technologies. The bubble during the 90s was unsustainable. In Japan, there is a steady increase rather than rise and fall seen in the US. We should not think of the 1995-2000 as the best pattern.

Floor:

In India, the country was flipping some between IT and ITES, the former being the high-growth part of the Indian business. Of this, about 40% is in banking and financial. Maybe we should correlate what is happening in India with the US data to establish better information. I would like to hear your opinion on that. Second, are we agreed that if the war is not over, we are nearing the completion?

Dale W. Jorgenson:

That analogy is not very appropriate, perhaps. My view is that the Great Pacific War is going to go on forever. This is something that will continue. The Japanese firms are very successful, have a very solid technological base and high-quality human resources. They are in this for the long run. I do not think there will be some big event that will change the tide. It will be going back and forth for a very long period of time. India is in a very narrow spectrum, but they are very successful at what they do. China has five times the production of IT of India and is growing much more rapidly because China is not as involved in software, but it is becoming a major force in electronic components, computers. It is a great example of a successful emerging economy in information technology. However, in software, there is no doubt that India has tremendous capacity limited only by the availability of high-quality human resources. Indians can work in India, but they could easily work in Silicon Valley or perhaps even a Japan. They work around the world. It will be difficult to maintain that human resource base in India. But there is no doubt that the quality of the work that they do and the focus on integrating into the global economy is absolutely critical and will be a continuing source of strength for India. These emerging economies that seem poor and underdeveloped are actually very sophisticated; they have very capable people and are in a very strong position in the global innovation ecosystem.

Floor:

Is there a hopeful sign for Africa? Could they apply these technologies in novel ways? They do not have the infrastructure policy issues that would prevent this.

Dale W. Jorgenson:

Africa is one of the most rapidly growing markets. The main technology that is used in Africa is the mobile phone. The PC is coming along, but this will not solve all the problems of Africa development, even though it will make a contribution.