Session 4 Establishing Benchmarks for the Global Innovation Ecosystem —What is the measure for "Outcome of Innovation" and How to evaluate "Effect of the Policy Instruments"? —

Chair

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Summary

Masahiro Kuroda:

Welcome to Session 4: Establishing Benchmarks for the Global Innovation Ecosystem. Today I would like to invite four eminent professors to be our panelists. The first is Prof. Dale W. Jorgenson, Samuel W. Morris University Professor at Harvard University. The second professor is Hiroshi Ohashi of the University of Tokyo. The third is Prof. Hiroyuki Odagiri of Hitotsubashi University. Finally I would like to invite Dr. Dirk Pilat, Head of the Science and Technology Division, Directorate for Science, Technology, and Industry, Organization for Economic Co-operation and Development (OECD).

I would like to ask the panelists to propose issues for discussion on four topics. The first topic is how to evaluate the outcome of innovation. We have to have some means to measure innovation. In the Global Innovation Ecosystem (GIES), we define innovation to mean not only the implementation of productivity growth by technological progress but also the creation of social value for society. The second topic asks what the new economy is. In the last few decades, we have experienced the strong impact of new technologies such as information and communication technology. We should clarify the impact of such technologies on productivity growth and examine the features of the “new economy.” The third topic asks how we can evaluate the contribution of intangible assets to productivity growth. I would like to summarize the ongoing discussions on this topic and raise some issues that will need to be solved in the future. The final topic looks at what policy measurements should be taken in order to maintain innovation for sustainable development.

I would like to ask Prof. Ohashi to make the first presentation.

Hiroshi Ohashi:

I am going to take Prof. Kuroda’s agenda very seriously, and talk about a measure by which we can evaluate the outcomes of innovation. We all know how important such measurement is, and much work has been done in different disciplines to develop an instrument.

My talk will try to summarize the views of one economist. There are distinguished economists here today, so my role is to try to provide a smooth introduction for the rest of the speakers. I will mainly focus on how to measure improvement in quality of life, economic growth, or social welfare brought about by commercially successful products and services based on innovations.

There are many technological processes embedded in new goods. The economic importance of new goods ultimately lies in their contributions to our welfare or quality of life. In measuring the outcome of innovation, we wish to assess how the way we live and work is improved by outcomes of innovation. The problem is that this cannot be measured directly. In order to quantify the improvement in welfare, we need an analytical framework. The discipline of economics provides one such framework. The framework I will present does not rely on questionnaire data, which is often vulnerable to the subjective views of respondents. The method can also be applied to market transaction data, based on which we are able to infer the effect of innovation outcomes on welfare.

Innovation can be viewed as either product or process innovations. The outcome of product innovation provides something fundamentally new, while process innovation provides an increase in productivity.

To estimate welfare we need to estimate market demand. Since we cannot see demand directly we need to estimate it from consumer transaction data or consumer willingness-to-pay data. There has been a considerable improvement regarding this estimation technique, including a discrete-choice model. Of course, when new products are introduced, prices also change. If the change in such quality-adjusted prices approximates the change in welfare then these prices can be used to construct an index, which is sometimes called the “cost of living” index. There is a large amount of literature on this subject, with a lot of work coming out recently based on the development of micro-econometric methods. So there is an established and currently advancing method for estimating welfare.

In this talk I have provided one view on how to estimate or measure the social value of innovations. Economics provides useful insights on how to measure outcomes of innovation. The method proposed here compliments the existing method used in other disciplines which utilizes questionnaire data. Since welfare is unobservable, measuring it requires modeling assumptions. We therefore need to think about how welfare is actually generated in order to make the index accountable.

With the increasing interest in quantifying the benefits to society resulting from innovation, researchers need to give more attention to market transaction data. Whilst patents and citations are very valuable measures of innovation, we tend to focus on them too much. When we estimate how innovation actually influences society, we should probably pay more attention to market transaction data.

Masahiro Kuroda:

The topic of evaluating the impact of innovation on welfare is a very interesting and difficult subject. Recently, a major issue has been how to measure human happiness. If anyone has ideas on measuring the outcome of innovation as social value then please discuss this topic.

Tsutomu Miyagawa (Gakushuin University):

The presentation was very interesting. I would like to talk about the characteristics of information technology (IT) innovation, which many economists recognize is a general purpose technology. This type of innovation provides a great deal of value to the entire economy. I would like to know how this kind of technology is evaluated in Prof. Ohashi's framework.

Hiroshi Ohashi:

I think that is a very important topic. There are two issues: first, how to assess IT, and second what you want to know about the IT revolution. My talk leaned somewhat towards the consumer side, i.e. how much welfare is generated by purchasing technology. However, if you are looking at the diffusion of technology then you have to look at complimentary innovations as well. In order for the benefits of IT to diffuse, workplaces also have to adopt the same technologies. So you have to think about how those technologies of the IT revolution make us happy.

Deepak Bangalore (Samixa):

Modern technology is getting more complex. A computer does not simply act as a day planner or calculator; there are many aspects to it. Given that, I would expect the functions you described to be extremely non-linear. I do not think that the model will be as accurate when applied to real data.

Hiroshi Ohashi:

As you say, the uses of computers have been changing over the years, so we need to map impact over a time-span. The value of computers has changed considerably as the complimentary technologies developed over time. Right now we cannot model this, but in the future I hope that we will be able to do so.

Masahiro Kuroda:

Prof. Jorgenson, do you think it is possible to use this approach to measure the outcomes of innovation?

Dale W. Jorgenson:

I think it is possible, but I believe that an approach based on measurements of productivity growth is easier to implement. However, both methods are complimentary and both are very interesting.

Masahiro Kuroda:

Thank you. I would now like to invite Prof. Jorgenson to give his talk.

Dale W. Jorgenson:

I think that one of the very important issues in innovation measurement is how this can be carried out within our existing system of economic measurement. Every country spends a lot of money and a lot of effort collecting data from national accounts, and there is a real opportunity to integrate innovation measurement into the national accounts.

I want to focus on the measurement issues. In 2001 the OECD convened a productivity measurement panel. One consequence of the panel was that the OECD promulgated a productivity manual. A consensus document was written describing how to measure productivity. This had tremendous impact and had the effect of standardizing measurements. That gave rise to a project in the EU, the Capital, Labour, Energy, Materials, Services and Output (KLEMS) project, which is now being completed. The KLEMS data can now be downloaded for a number of OECD countries. The data becoming available for innovation research are growing very rapidly. This has really caught on and is now spreading around the world. As a result of work by Prof. Miyagawa and his colleagues, Japan is particularly well developed in this area.

The OECD work was a key step towards the creation of an innovation measurement system as part of national accounts. This work has been taken up in Japan and the United States. In the United States we have the Innovation Metrics Panel, comprised of five economics and 10 non-economists. In Japan, legislation is creating an integrated measurement system, so this is a prime opportunity for GIES to play a role in ensuring that the innovation measurement issues discussing here are implemented as part of the Japanese national accounts.

I would now like to turn to the practical issues of implementing innovation measurements within national accounts. In the United States there is a system of computer price indexes for measuring the prices of computers, communications equipment, semiconductors, software, and so on. In Japan, people are very interested in IT prices. One of the units sponsored by the Ministry of Economy, Trade and Industry, the New Media Corporation, which specializes in IT, has collected the same kind of data for Japan that has been collected for many years in the United States. This has been incorporated into measures of productivity. We have incorporated Japanese price indexes that are based on Japanese data. That is important, because much of the work that has been done on international comparisons of productivity has so far used US prices. However, the main difficulty for harmonization of Japanese and US data occurs in definitions of software, which are incomplete in Japan.

In the United States, the IT share of capital input has increased from 1% of current dollar gross domestic product (GDP) in 1960 to over 6% by 2000. The growth in the capital input contribution of non-IT capital services has declined since 1960, while the growth in contribution from IT capital services increased between 1960 and 2000, and has since declined. The contribution of IT-producing and IT-using industries to productivity growth has grown considerably since 2000, overtaking the contribution of non-IT industries.

In Japan the contribution of IT-producing industries is very large compared to their size, and is about the same proportion as in the United States. That is not surprising considering that the IT-producing industries make up about the same proportion of the economy. However, there is very little contribution from the IT-using industries.

Those are the main issues. The appropriate way to measure the impact of innovation is in terms of productivity growth. You can also look at it in terms of welfare, but that is a complimentary story. The challenge now is integrating that with national accounts. It is a fairly short step to do this integration. My proposal is that this should be brought to the attention of the G8. All G8 countries other than Russia have KLEMS-like data for the same time periods, so it is fairly straightforward for them to include the impact of innovation on productivity growth in their national accounts. My second suggestion is that the National Graduate Institute for Policy Studies (GRIPS) could propose that this kind of innovation metric be made part of the Japanese national accounts. I am hoping that Prof. Kuroda will make some comments on this. It is a great opportunity for GRIPS to get involved.

Masahiro Kuroda:

It is very important to measure the impact of IT on productivity growth. The Japanese system of national accounts still needs to be revised in terms of measurement of software and research and development (R&D). We currently only consider customized and packaged software, which are intangible investments. Unfortunately we do not consider the production of in-house software, which I think is very substantial. In addition, in our national accounts R&D expenditures are allocated into the using sectors as intermediate inputs, but not into final demand. This will be revised in the future.

I would like to open discussion to the floor.

Dirk Pilat:

We are unsure how to measure the productivity output of some sectors such as public administration, education, research, or health, which means that we will never see any productivity growth in those sectors. How does that affect the figures Prof. Jorgenson showed us? Also, what is Japan's position on this matter?

Dale W. Jorgenson:

This question was raised a long time ago in the United States, where the statistical community organized an effort to resolve it. In the mid-1990s the United States invested in a program to establish prices for service industries and began to measure these prices. The investment required was very substantial.

Such an investment has not yet been made in Japan, where the Bank of Japan is responsible for measurement of service prices. Service sector prices are inadequate: while the yen value can be accurately measured, the pricing needs a lot of improvement. Given the importance of these service industries, a project to establish service prices should be thought of as a long-term investment.

Masahiro Kuroda:

There are still some problems with prices for the service sector in Japan. It is difficult to define their productivity output. We have tried to do this with the wholesale and retail sectors using the sum total of margin and trade. Every five years we have a survey to gauge margin in these industries. However, errors may be included in those measurements. Measurement of the financial and insurance sectors is also problematic. Recently, major activities of the financial sector have been consulting and financial funding, which are completely different to previous activities. The method of measuring activity in the financial sector could therefore have a big impact on output. I think the OECD is also considering this significant problem at an international level.

Dirk Pilat:

I believe that is the case. I was referring to sectors such as government, health, education, and so on. Particularly in the health sector a lot of technological change is occurring but we do not see its impact on productivity measured anywhere. Another question is how we can see the impact on welfare.

Toshiaki Ikoma (JST):

I have a question for the economist community. How is productivity growth related to innovation? In our IT community, innovation shows up in very clear events such as flat panel displays, transistors, integrated circuits, and the Internet. Listening to your discussion it seems that productivity is equal to innovation. Are you only discussing process innovation? If so, how is product innovation rated?

Dale W. Jorgenson:

The idea is that when a process innovation takes place, the same output is produced using the same input, with increased efficiency. The welfare measurement we heard about is precisely what makes it possible to ask how we should measure output. Prof. Ohashi gave a very good example. From the point of view of measurement, a computer is just a calculator, a day book, and so on because all these functions were done before computers were produced. So the key to measuring change is to measure an economic output that is uniform in terms of its performance statistics. There was no discrete jump in terms of one day suddenly having computers; this is a gradual process. By linking these transitions together one year at a time it is possible to have a consistent measurement of IT, and it produces the results that I have shown.

Economics has at least the aspiration of not only incorporating process innovation but also an idea of product innovation that enables one to trace the development of products over time. That methodology is well established. As Dr. Pilat pointed out, there are some challenges in applying this methodology to certain sectors.

Tsutomu Miyagawa:

I would like to provide additional information about our database, the Japan Industry Productivity database. It is used for measuring productivity by industry, and contains 108 industries, of which 60 are service industries. The first version of the database was compiled as part of an Economic and Social Research Institute research project. After finishing the first version we moved this project to the Research Institute of Economy, Trade, and Industry (RIETI), where we finished the second version of our database, which has been published on the RIETI website. Prof. Jorgenson mentioned that the Japan Industry Productivity database is included in the EU KLEMS database. Many Japanese economic institutions use our database and I hope you can use our database for analyzing productivity in Japan.

Our next step is to expand the database. It currently contains data up to 2002, so we would like to extend that to 2005. In addition we would like to study quality of service.

Although it is difficult to compare the quality of service between countries, we would like to conduct a new survey in Japan.

Masahiro Kuroda:

Thank you. I would like to add that Japan's consumer price index has been revised to consider quality adjustment for IT, and is now a very good database. Unfortunately, the wholesale price index is still somewhat problematic, and we have to check it for consistency.

Anagawa (Keio University):

How do you account for globalization in your statistics?

Dale W. Jorgenson:

The prices we discussed are for domestically-produced commodities. As a consequence of globalization, in some areas the proportion of inputs that are supplied domestically in the United States is well under half. Even semiconductors are produced in other countries. So a very substantial part of the price is international price. The prices used on the input side include both a domestic component and an international component. The effect of globalization acts on import prices. You have to think of products that are used in an economy as originating not only from domestic but from international sources. Japan has been the leader in producing integrated flow data and has some of the best statistics to capture the impact of globalization on the Japanese economy.

Masahiro Kuroda:

I think this is a very important issue. The next stage is to measure the technology transfer between countries, which is a big issue about measurement of R&D internationally in the OECD countries and in other countries.

I would now like to invite Dr. Pilat to give his presentation on the experiences of the OECD.

Dirk Pilat:

At the OECD we do a lot of work on policy recommendations for innovation and international cooperation. We also work on the analysis of innovation policies to figure out what are good practices and what we can learn from each other. I will concentrate on the latest OECD work: the development of statistics, indicators, and international guidelines to compare and benchmark innovation. Measurement of innovation is important in order to measure performance and see how policy is linked with performance.

We work closely with researchers to develop new indicators based on commonly-agreed guidelines. We have the Frascati Manual, which covers measuring expenditure on R&D. We have the Oslo Manual, which gives guidance to innovation surveys undertaken in many OECD countries. We are also involved in the discussion about the system of national accounts and are trying to come to an agreement on how R&D will be treated. Measuring intangibles is a good way to get to a better understanding of innovation, but it is not the only thing we are involved with, and I will mention some of the complimentary things we try to do.

There is typically a distinction between different types of intangibles. Software, databases, and R&D will now probably become part of the national accounts. Then there are a whole set of other intangibles such as brand equity, firm-specific human capital, and organizational investment. The decision has so far been that these will not be included in national accounts, although there is ongoing work in this area.

From the US perspective intangible investments are now more important than tangible investments. I think this shows that capital investment will play an even larger role. We have also tried to look at knowledge investment, and have made some broad country comparisons.

Measurement of software is being incorporated into the national accounts, which has raised a lot of problems. In the OECD countries there were insufficient uniform rules or guidelines about how to go about measuring software. Firms have been rather prudent about what they treat as investment, and own-account software has not been counted. An OECD/Eurostat taskforce report recommended how to better measure software using the supply-based method and how to treat own-account software in different countries. We are getting closer to comparable estimates of software investment.

Including R&D in national accounts is the next big challenge. We already have good measurements in place and the Frascati Manual has been available for some time. However, there are a number of problems for compatibility with national accounts. There is an overlap between software R&D and software investment, and it is unclear how much R&D is going to be treated as investment, because it is uncertain how much of it will show up in the market eventually. There is difficulty in distinguishing gross fixed capital formation and intermediate consumption. International trade in R&D between affiliated enterprises is difficult to measure. There is also an issue of the service lives of assets, in determining how long an investment will produce value for a company.

Including R&D in national accounts would add significantly to GDP. Business R&D will mostly be included in GDP, but it is less clear what parts of government R&D can be added to GDP. This will be a significant change to the way we look at GDP.

In measuring R&D in national accounts, you have to make sure that R&D is not double-counted or omitted. A solution has to be found to deal with that. Secondly, if R&D produces no future benefits for its owner it will not be regarded as an asset. The question is how to get a handle on this and break it up. The discussion to answer this question has focused somewhat on asking R&D performers whether R&D really will add a benefit. The alternative is to drop basic research from asset-forming R&D. The discussion has also considered putting such R&D into "satellite" accounts rather than the system of national accounts.

The third issue to address is international trade in R&D. A major source of R&D expenditure is accounted for by foreign affiliates. It is not always clear how well the resulting imports and exports are accounted for in balance-of-payments statistics. A major problem is that much of the transfer of R&D within multinational firms is not priced. What needs to be seen is not so much imports as to what extent a country's own companies are doing R&D abroad. The OECD has undertaken an exercise to compare outward and inward data for some volunteer countries, but there are quite a few problems here that are not very easy to address. The aim is to get a good handle on the trade data, and more work needs to be done to ensure the data is consistent.

The fourth issue relates to price indexes and public-private partnerships. The difficulty is that R&D is very heterogeneous and much of it happens within companies, so there is no price for it. We try to look at input-cost indexes to develop prices, but that typically means that you get little or no productivity growth. Alternatives are being worked on, so there is some movement, but it will take a little time before these are being adopted.

The fifth issue is service lives. Gauging how important R&D is in terms of depreciation rates and asset lives has so far been based on patent renewal data and econometric methods. There are now studies underway to produce direct survey information, which may be helpful.

So, where are we internationally in this discussion at the moment? There has been a lot of cooperation between the Canberra II group and the OECD National Experts of Science and Technological Indicators to prepare the UN decision on capitalization of R&D in national accounts. The next step will be to turn this into proper guidelines, which will include a part on measuring intangible assets. These guidelines, the OECD Handbook on Measuring Intellectual Property, will probably be ready next year.

At the OECD we are not only focusing on the measurement track but also taking a broader perspective, working with analysts on helping to estimate intangible investments that are not covered by the national accounts. These are still of interest to us as they help to enhance our understanding of innovation and growth.

I think all of that will help to provide better insights into how we look at the role of R&D investment for productivity growth. From my perspective I think we need other indicators as well to help us look at that information. An important consideration is that much innovation is non-technological and so will not be fully addressed. Other intangible factors should be looked at as they probably play a role. Some firms succeed while others do not, and these dynamics affect our understanding of overall innovation performance.

A complementary track is the work the OECD does using micro data of innovation. We use very detailed firm-level data to look at the link between innovation and productivity, channels for international knowledge transfer, non-technological innovation, and innovation's link with intellectual property rights. These data are typically confidential, so researchers in different countries are accessing this firm-level data and asking standard questions across countries, which we hope will lead to understanding of the factors driving and affecting innovation performance and cross-country differences.

As the next big step for the OECD, we have been asked to focus even more on innovation, producing new facts and evidence depicting and comparing innovation performance in OECD countries, and to try to explain the differences. We will try to develop a comprehensive and forward-looking policy strategy to strengthen innovation. Finally, we have also been asked by the recent G8 meeting in Germany to start a dialogue on protecting and promoting innovation policies with large non-member economies.

Masahiro Kuroda:

I think we shall begin discussions. Are there any comments?

Unidentified speaker:

In regard to R&D, in Israel for example the major technology incubator is the defense department. Does that not skew the results?

Dirk Pilat:

That is a good question. The same is true for several other OECD countries. We do have data on military R&D in Israel, so that is being taken into account.

Dale W. Jorgenson:

You showed that the broader concept of intangibles leads to the conclusion that a great deal of innovation is not related to science and technology R&D. This is a very important finding. The question is how this would impact innovation policy. My impression is that in the United States a lot of the discussion presumes that all productivity growth is due to investment in R&D. I think this new information shows that this is far from the case. How do you think this will affect innovation policy in the new OECD strategic innovation initiative?

Dirk Pilat:

The innovation debate is definitely broadening from its previous focus on science and technology. The other element that is increasingly being highlighted is the role of new firms and entrepreneurs. I think that is a trend being seen in many countries. Public science still plays an important role but now the discussion is about how to create the right business environment for companies and how to attract companies to come to the country and produce innovation.

Akira Goto (The Univ. of Tokyo):

Would you tell us about the OECD effort to harmonize the measurement of human resources such as scientists and engineers?

Hiroyuki Odagiri:

We have done a bit of work on the careers of doctorate holders, looking at where they are going and what they are doing. The other area is work on patents, where we work together with the European and numerous other patent offices to get more information out of patent data, because that is a publicly available resource of information that has not been fully utilized yet.

Tsutomu Miyagawa:

R&D expenses consist of materials, researcher payments, and so on. Including intangible assets in R&D investments leads to double counting of intangible assets, so I would like to know how that will be dealt with.

Dirk Pilat:

I do not think there have been decisions on this issue yet. There are international practices and international discussions, but the guidelines have not been fully established. Some good work has already been already done in the United Kingdom and the United States, but there is no agreement yet on all the details of how it should be done.

Duane Robson (Embassy of Canada in Japan):

Do you have an issue with countries considering the available benchmarking statistics and then picking one or two?

Dirk Pilat:

This issue comes up quite a lot. Quite a few OECD countries had a target to get R&D expenditure up to a certain percentage of GDP. That seems to be the wrong approach. You should not be focusing on expenditure as such because you are looking at the inputs rather than the innovation outputs. I think it is particularly important to look at the countries on top of the list of innovations, which is related to the structure of those countries' economies. Benchmarking can help to illustrate where problems lie, but you should always look at the numbers behind the benchmarks.

Masahiro Kuroda:

There are many problems that we should continue to discuss. However, as there is no more time I will move on to our next speaker, Prof. Odagiri.

Hiroyuki Odagiri:

Let me start by talking a little bit about the historical development of technology in Japan. This can be split into three periods. The catch-up period from 1945 to 1972 was characterized by active technology importation. At the same time, Japanese firms increased R&D expenditures, both to absorb imported technologies and to achieve their own inventions. There was also a direct relationship between technology import and R&D expenditure.

During the second period from 1972 to 1990 in which the emphasis was on Japan's own innovations, R&D as a percentage of GDP increased significantly. Patent applications increased. There was also an increasing technology import to export ratio, partly because of royalty receipts from overseas subsidiaries.

The current period of science-based innovations spans from 1991 to the present. I should mention two international comparisons for the current period. One is the active involvement of industries in Japan. The proportion of R&D expenditure funded by industries has been higher in Japan than in any other country. The other side of the coin is that the proportion of R&D expenditure funded by government has been smaller. Secondly, there was a larger role played by big firms, particularly in science-based sectors.

However, the environment is changing rapidly. On the economic side, Japan's catch-up is complete. Market demand and spending were depressed from 1990 until recently. There is also a declining rate of new business establishment.

Looking at the Japanese business system, up until the 1980s it was characterized by ownership, dominated by friendly and stable shareholders, the management was internally promoted and long-term employment and internal training was the norm. That had the consequence of giving an orientation towards long-term growth, so I think it was quite effective for the catch-up period, and also for incremental innovation and kaizen. However, this business system has been changing. The presence of stable shareholders is weakening as banks have decreased their shareholding. There have been hostile mergers and acquisitions, an increase in bankruptcy and dismissal, and production bases have been shifting overseas.

Let me talk about two things that are changing in science and technology. One is the strict enforcement of intellectual property rights by foreign companies, leading to disputes and difficulties in acquiring overseas technology. The other is the increasing science linkages, which is measured by the number of citations of scientific papers by US papers. Science linkage grew greatly between 1985 and 2000. However, Japan has a much lower rate of science linkage than the United States. The science-based industries that have become increasingly important are life science and biotechnology, information and communication technologies, environmental sciences, and nanotechnology and materials.

The importance of scientific knowledge is also revealed in Japan's National Innovation Survey, which was conducted in 2003. At that time I was a member of NISTEP. We sent questionnaires to about 43,000 firms, and had a 21.4% response rate. We looked at the information sources and cooperation agreements for innovations between the manufacturing and pharmaceuticals industries. We concluded that the shift in the Japanese innovation system has been having an important impact.

So, what should be the issues to address? The first issue that I think is important is that the national innovation system and the national economic system do and have to co-evolve. Who are the better performers of science-based innovations: diversifying large firms or startups? What allocation mechanism should be used for finances and human resources? In Japan, 70% of biotechnology patents have been made by large firms, while in the United States the biggest players are startup companies. Should we adopt this Silicon Valley style of business system? Another interesting fact is that in Japan there are quite a lot of chemical or food processing and even textiles companies producing those biotechnology patents, which is not the case in the United States. So there is lot of diversification; that is another way to enter into a new science-based system. It is not clear which system we should use.

The second issue is that the national innovation system and the national education and science system do and have to evolve. We have to promote industry-university collaboration, but at the same time we should not neglect basic scientific enquiries. We also have to ask whether universities should patent their inventions.

On the measurement issue, many studies have been made to measure the impact of commercial R&D, but we still do not know how to measure the contributions of scientific research. My feeling is that the approaches that have been outlined cannot fully capture the impact of scientific contributions. There are long lags and big uncertainties in research outcomes. The scientific linkages have, as I have shown, been used to capture the contributions of scientific research, but only in a limited manner because many scientific outcomes are not related to patent inventions.

My feeling is that the contributions of scientific research are bound to be undervalued. I do not think there is any question that we have benefited greatly from scientific advance in terms of improved health, longer life, and the social impacts of the Internet for example. Also, scientific advances have undoubtedly contributed to the economy. However, such economic returns are just a fraction of the contribution of scientific advances to the welfare of mankind. So I think we have to put more concern and interest on how to measure the contribution of scientific enquiry; just looking at productivity and so forth may undervalue the contribution of science. There is a lot of discussion at this moment about how to measure academic R&D contributions and so forth, but my own feeling is that we should not be in too much of a hurry to measure the impact of productivity and allocate funds to universities and so forth based only on that.

Masahiro Kuroda:

Are there any questions?

Deepak Bangalore:

Why are there so many industries involved in biotechnology in Japan?

Hiroyuki Odagiri:

In Japan a high proportion of R&D is conducted by large companies, so there is a lot of industry diversification. Many of these companies have a tradition of biotechnology research, and have tried to take advantage of this heritage to move into new fields. In addition they want to provide work for their employees. Their industry may be shrinking but they do not want to make their employees redundant, so they have a reason to diversify.

Masahiro Kuroda:

Thank you very much. Our time is up, so I would like to close this workshop. I think it is very difficult to measure the resolutions that have resulted from this workshop. Measurement is very important, and in order to create good measurements we must have international collaboration and develop a network to consider the issues. We are particularly concerned about measuring innovation performance. There are difficulties doing that in some sectors. Innovation in the service sectors will be very important in the future. The problem is how to implement the promotion of innovation in the service sector. The other is how to measure the outcomes of innovation on both productivity growth and on welfare. We would like to consider this topic. This is the first meeting to begin the development of a network between Japan and other countries.