NISTEP International Seminar

A New Development in Innovation Surveys: Measurement to Inform Policy Making

On 27 February 2017, National Institute of Science and Technology Policy (NISTEP) held an international seminar entitled "A New Development in Innovation Surveys: Measurement to Inform Policy Making" in Tokyo. Prof. John Walsh (Georgia Institute of Technology) and Dr. Christian Rammer (ZEW), leading scholars in the field of innovation studies, were invited as speakers. This seminar aimed at learning from newly developed experiences in innovation surveys in different countries with a view to making use of them more widely in future.

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How Innovative Are Innovators?: A Multidimensional Perspective

John Walsh
Professor, School of Public Policy, Georgia Institute of Technology, the United States

Professor John Walsh commenced his lecture by mentioning about the new work that he has been doing in collaboration with Wesley Cohen (Duke University) and You-Na Lee (Georgia Institute of Technology). The title of his talk was "How Innovative are Innovators?: A Multidimensional Perspective." He mentioned that the goal of this talk was to try to explore ways to track innovation and consider the different dimensions along which something could be innovative, to help guide data collection and data analysis indicators and policymaking.

Innovation is important for economic growth. The OECD (*Oslo Manual*) and NSF are trying to find ways to improve current practice. Prof. John Walsh explained the Schumpeterian distinction between invention and innovation. The goal was to focus on survey-based measures and propose an approach that considers the different features of an innovation and the potential impacts of each of these and discuss about the possible indicators, limitations, and ways of improvement.

One of the key areas of focus is on tracking firms' R&D expenditures, but one can also think of investment in manufacturing, experience in manufacturing and marketing, marketing expenditure, and division of innovative labor. There is a long literature on learning by doing. There is also a growing literature on non-R&D product innovation. About 50% of the firms that had a new-to-market innovation got the fundamental invention from outside the firm. If the dependence on outside sources increases gradually, R&D may not remain the primary indicator of firms' innovative performance.

A patent could be an intermediate good or invention that can track innovative effort effectively if done within industries. Instead of just using the count of patented inventions, citation weighting is also looked at as a way of capturing the impact of invention. People also look at the originality, the generality, and other indicators to try to make patent indicators more nuanced. The biggest advantage of a patent indicator is somebody else collects the data for you. However, the data collected will have to be fine-tuned and cleaned before it is put into use.

All innovations are not patented and all patents do not become innovations. Even for the ones that become innovations, there is not a one-to-one correspondence and this varies by industries.

He showed a conceptual scheme consisting of various factors that put into practice the Schumpeterian idea. It had inputs like R&D or the division of innovative labor, the ideas coming from that activity, patents tracking these, innovations which the innovation survey is focused on, and the impact which is the effects of innovation.

Further, he spoke about the selection of surveys since there have been a lot of surveys. Some of them are R&D focused like RD-1 and BRDIS. He also mentioned the Yale Survey, and the Carnegie Mellon-NISTEP Survey. In the case of Carnegie Mellon-NISTEP, R&D managers were surveyed and asked a lot of questions about the amount of R&D they do, the R&D process, and the sources of information. The Division of Innovative Labor survey focuses particularly on the sourcing of innovation. However, one of the shortcomings of innovation surveys is their interpretation. Other challenges are knowing about the nature of the reported innovation, the importance of these innovations in terms of profits, social welfare, short run versus long run, and ways to improve the interpretability and precision of these measures.

Prof. John Walsh mentioned that it is important to understand the concept of innovation and what are we trying to measure. These surveys need to be done at an appropriate time as an alternative to the R&D type surveys or the patent data.

Innovations are inventions that are commercialized and novel in the sense of being new to market. Innovation will be viewed as a new offering or a new object. It can be a product, process, or a service that can be judged against the status quo ex ante.

One of the dimensions of innovation is it has to be novel and not obvious. If the technological significance is big enough, a patent can be granted to the innovation. Beyond that, people have tried to measure combinatorial novelty, originality, and other things to figure out how far beyond just patentable is this technological inventive step.

The second dimension is the utility, which includes the incremental improvement to welfare.

A third dimension of innovation is uniqueness. A classic scientific example would be the simultaneous discovery of the calculus which suggests that if one wouldn't have done it, the other one would have. In technology, it could be a Marshallian district where ideas are popping up continuously (low uniqueness), versus a firm which has a special capability that made it uniquely able to generate this innovation.

Another dimension of innovation is distance. This includes knowing the distance one will have to go further from the current practice to implement the innovation, whether there is a need to invest in new capabilities, new personnel.

The final one is replicability. Some innovations are easy to replicate and others are not, which has important implications for the role of secrecy versus patents in science and technology policy. Hybrid corn versus Bt (Bacillus thuringiensis) corn is one example.

Given these different dimensions of how innovative is this object, there is a need then to analyze which of these are useful to consider and maybe there are others that one might want to think about. Even though the dimensions of innovations are distinct, they may be related to each other. The various impacts such as economic impacts at the firm level, the industry level, the long run technological and macroeconomic impacts are taken into consideration. These different dimensions may affect these outcomes in different ways.

Prof. John Walsh gave a couple of examples to explain that these dimensions are distinct and have distinct impacts. One of the examples he shared was the self-service grocery stores. There was a huge increase in productivity, but the technological significance was basically zero. It had a very high economic value. The goal is if one can distinguish the characteristics of the innovation from its impact, one can start asking questions about what distinguishes these and when does technical significance lead to an impact, when is uniqueness critical, and so on.

He mentioned about a survey which they did, which was very similar to the CIS type, but instead of asking about the firm's activities as a whole, they asked if they had a new-to-market innovation, pick the one that accounts for the most sales, and describe about that one innovation. It helped characterize the size of the innovation, which allowed them to link the answers across different items in the survey.

In order to measure the innovativeness, for technical significance, they asked whether there is a patent associated with this new-to-market innovation. For technology rivals, they asked how many other firms could have introduced this innovation which could be a measure of uniqueness or a measure of replicability. In terms of distance, they asked if there is a need to invest in new marketing capabilities or buy new equipment or hire people with new skills in order to implement this. In terms of utility, they asked what share of sales come from this most important innovation.

One of the important qualifications is the data were not collected for the purposes that they are used for in this analysis. They were originally collected for studying the division of innovative labor. The other problem is some of the measures do not cleanly split between the characteristics of the innovation and the impact of the innovation or the expected impact of the innovation.

Prof. John Walsh further explained about the correlations of the dimensions. At the industry level, almost all of these have a correlation with whether you innovated or not. The more people in that industry innovated, it's also more likely that the sales were higher, that they were patenting more than average, regardless of the investment capabilities. However, these are different dimensions.

He illustrated industry innovativeness rankings based on different dimensions, showing how even high tech industries can be high on some dimensions and low on others.

Prof. John Walsh shared a slide that looked at the share of sales from the most important new-to-market innovations for the manufacturing sector and for software-related industries. It showed that the probability that one innovation accounts for a large share of sales (over 25%) is much higher in software than in manufacturing.

The Arora *et al.* (2016; *Research Policy*, v.45, pp.1113–1128) demonstrated that value can also be measured in different ways and linked to the sources of innovation (i.e., the division of innovative labor). The key finding of this paper was that about half of innovations came from outside the firm, and that, while customers were the most common source, technology specialists (such as universities, engineering service firms and individual inventors).

With regards to the nature of competition, even though we have indicators, we need to distinguish industries where innovation is the core basis for competition from industries where competition is based on some other factor. In the industry model, the industries that are innovation-based, the most innovative industries also have the most imitation. In the ones that aren't innovation-based, the more innovation there is, the less imitation. Similarly, to demonstrate the relation between rivals and how likely the industry is to have imitators and innovators, it can be said that in an innovation-focused industry, the more the innovation and the more imitation, the higher the likelihood of rivals. If it's not an innovation-based industry, there is basically no relation, maybe even a negative relation, between how much innovation and imitation there is and how many rivals there are out

there. Hence, this suggests our indicators need to be sensitive to the context in which they are applied, in this case, to the nature of competition in an industry.

Prof. John Walsh gave some suggestions toward the end of his talk. He stated that it's important to tie innovation to a single product; to add patents to the survey so that some of the bibliometric indicators can be traced to the survey-based indicators; and to come up with a measure of capabilities distance that wasn't directly tied in making the investment in the capability.

To conclude, he stated that there is a need to develop the surveys. It's useful to conceptualize innovation, its drivers, and its impact separately and think of the dimensions, including the technical significance, the distance, uniqueness, replicability, and utility. These correlate with the rates of innovation but they are distinct. The rates vary by the nature of competition, whether innovation based or not. There is a need to develop measures of the impacts and how these dimensions relate to the outcomes and hopefully come up with better measures.

Innovation Surveys and their Policy Implications in Germany and Europe: Measurement of Innovation Outputs and Outcomes

Dr. Christian Rammer

Deputy, Department of Economics of Innovation and Industrial Dynamics, Centre for European Economic Research (ZEW), Germany

Dr. Christian Rammer commenced his talk by discussing about the link between the level which a country spends on R&D, and the sales it generates with new products by degree of novelty. The results in the previous years was to try to differentiate new-to-the-market products in a more useful way by distinguishing whether it's just new to a regional market or whether it's new to the world market. It is also important to understand the role of process innovation, but there are no measures yet.

It would seem as attempts to measuring innovation output in innovation surveys have not been very successful yet. However, there are ways to use the data and get very interesting and useful results. Dr. Christian Rammer illustrated this with by an example where a firm used innovation survey data to measure the productivity impacts of innovation based on firm-level data.

Another work in this regard is a structural model by Jordi Jaumandreu (Boston University) from Madrid on an analysis on the employment impacts of innovation. This model was developed in collaboration with Jacques Mairesse (CREST) and Rupert Harrison (Institute for Fiscal Studies) and Bettina Peters (ZEW).

When conceptualizating the link between innovation and employment growth, it is important to distinguish process and organizational innovation on the one hand, and product innovation on the other. Process innovation is usually associated with positive productivity effects which reduce the demand for labor. But it is also important to take into consideration the price and quality effects of process innovation, which can easily substitute the negative productivity effect on labor demand. The price effect means that a firm can sell the products at the lower price, hence increasing the demand for that product. There is also quality effect which may allow to raise the price of a product which then substitutes for negative productivity effects.

For product innovation, positive impacts are usually considered from higher demand for a new product. But when dealing with new product development in the firm, cannibalization plays an important role. This means that a firm may lose the same amount of sales it generates from new products with old products because customers switch from old to new products. Employment effects can then be even negative for new products if the productivity of producing new products is lower compared to producing the old products.

Dr. Christian Rammer further talked about the formal structural model based on the firm with two products at two points in time. The basic idea of the main model was to differentiate the production function by these two types of products so that one can differentiate between the effect of old products and new products. Through this, one can have the general efficiency gain from the constant of the model and the effect of starting a new product into the pyramid to look at and the effect of aggregate change in the demand for the old product.

Empirically, one can split the average productivity effect into the specific ones for process innovation, organizational innovation, and then leave the general learning effect. One can also decompose the average employment growth with this empirical approach, looking for different effects of the general productivity trend, the process and organizational innovation effects, and then the output growth of those firms that did not introduce a new product, and the net contribution of product innovation. This model has been mostly used in EU policy consulting and advising over the past years because one can split it by different groups of companies, e.g. by age, types of innovators or countries.

Dr. Christian Rammer illustrated the use of the model by showing data on employment effects of innovation across four phases of the business cycle. A very interesting result for policymakers is that one cannot find significant negative impacts of either process innovation or organizational innovation. This means that negative employment impacts of productivity increases resulting from these innovations are balanced by positive effects. The largest effect of product innovation recently was seen in the boom phase, not so much in the upturn phase. Except for the downturn phase, results differ between small and large firms.

Dr. Christian Rammer finally presented the most recent results of the European Innovation Scoreboard (EIS), an exercise done by the European Commission every year aiming at assessing the innovation performance of European Member States. There is also a comparison against US, Japan, Korea, and some other countries. The EIS uses a multi-indicator approach, distinguishing three areas; the enablers such as the input side, firm activities which is a bit innovation-output side, and the output. The important thing is that from these 25 indicators, six and a half are based on the CIS.

He showed the various EIS indicators which came from the CIS. The EIS also compares Europe with non-European countries which do not have comparable innovation surveys. For this international comparison, one has to use different indicators. Hence, the comparison may be incomplete. This would make a point for establishing better international comparable innovation data.

Dr. Christian Rammer concluded his talk by saying that there is a need for better measurement of innovation, innovation output, and a need to distinguish the degree of novelty. For process innovation, there must be some quantitative indicators as well. Particularly when going away from the very high-tech oriented countries like Japan, US, or Germany, process innovation becomes more and more important for competitiveness and also for the entire innovation process. There is also a need for information on new business models which could be specific to those sectors where they do play a big role. Wherever there is digitization in the market, new business models would emerge.

There is also a need for more metrics to better understand the innovation process.

Micro-level data can be used much better than just for fusing aggregate statistics but micro-level analysis can really be a very useful tool for identifying innovation outcomes. There is a need better harmonize innovation surveys internationally to make the results better comparable.

Innovation Survey in Japan: Implications from Country Specific Questions and Results

Tomohiro Ijichi
Director of Research, First Theory-Oriented Research Group, NISTEP, Japan
Professor, Faculty of Innovation Studies, Seijo University, Japan

Prof. Tomohiro Ijichi began his presentation stating that the purpose of his talk would be to give a summary of their innovation survey and to provide some examples of the material which could be used in the following discussion. He also shared the example of Japanese National Innovation Survey questions. He explained the concept and meaning of innovation and innovation activities using a diagram. Innovation is defined as the introduction of goods or subject. Yet, innovation activity

is the process to develop those innovations. Consumers or users play an important role in terms of defining product innovation. This innovation survey is to ensure international comparability.

Prof. Tomohiro Ijichi showed a part of the English translation of the survey questionnaire of the Japanese National Innovation Survey 2015 (J-NIS 2015). In this round, they used only one large-sized questionnaire for the respondents to reply to the questions easier. He also showed a table demonstrating the population, sample size, and response rate.

Most of the indicators resulting from the innovation survey are based on the data at the firm level as unit. In businesses, looking at the R&D statistics, most of the activities are conducted by large companies, especially in Japan. Hence, considering economy at the national level, one has to consider the scale of activities especially in the large-sized firms. However, it should be noted that this kind of indicators do not represent the situation.

Prof. Tomohiro Ijichi illustrated the comparison between the J-NIS 2015 and the previous round of 2012. Some differences were seen. For example, ratio of product innovating firms decreased in total, and especially for the medium-sized firms. These figures suggest that Japanese firms are shrinking and not acting to realize product innovation.

An OECD report used an indicator for international comparison. In terms of the combination of the characteristics of firms, Japan did not change so differently between 2012 and 2015. These indicators suggest that, in Japan, more firms realize marketing or organisational innovation only in comparison with other countries.

He referred to the indicators of explaining the structure of innovation-active firms and the product or process innovating firms, and stated that the product or process innovation might depend on the firms' selection of conducting innovation activities.

He also mentioned the combination of the efforts to introduce new products with higher novelty and the public financial support related to the development or implementation of new product or process. This would provide the characteristics of medium-sized enterprises.

Looking at the indicators by the enterprise-size class, the ratio of the new-to-market product innovating firms in medium-sized classes is lower than other sized classes. The result showed that it was likely that receiving public financial support had not had effects on the market.

Another example would be the developer of the product innovations. This would allow a responder to give multiple answers. In total, 47% of the product innovating firms developed products in-house only, but 35% firms developed innovation in-house jointly with other enterprises or organisations. Hence, this result suggests that there is some kind of innovation phenomenon.

Prof. Tomohiro Ijichi showed that 44% of innovation-active firms performed intramural R&D, out of which only 19% of innovation-active firms performed intramural R&D continuously and 23% of innovation-active firms performed intramural R&D occasionally. Those parts might not be covered in the R&D survey. There is also some advantage of using innovation survey to capture R&D in a large scale.

It is also significant to acquire knowledge and technology in collaboration with partners for innovation, which could be used especially for the progress of innovation activities, for example, the role of public knowledge transfer from universities. The ratio of this indicator is higher in larger firms.

The last example which Prof. Tomohiro Ijichi spoke was about the factors which prevent firms to innovate and the reasons for no innovation activity. Due to limited space for the questionnaire, they combined these two questions and compared innovation-active firms and non-innovation-active firms. One of the factors was lack of competent employees, which was mostly experienced. There were some differences between the innovation-active firms and non-innovation-active firms in terms of the overall characteristics, one of which was difficulty in obtaining external finance. This might suggest that this factor might be not related to innovation activities. Firms who were uncertain about the market demand of a new good or service fall into the category of no innovation activity.

In terms of unit of analysis, he showed an example used in the Japanese National Innovation Survey 2003. This survey was much influenced by the Carnegie Mellon-NISTEP Survey. They asked respondents to think about two types of innovation projects. The first one was the suggestion of new innovation product and the second was the contribution to the implementation of the existing innovation project. In the current survey, the enterprise is used as a statistical unit. However, it could be a specific product or a project. It is also important to find differences between innovating firms and non-innovating firms. In order to better understand the characteristics of innovating firms, it may be important to ask the same questions to the non-innovating firms. There is also a need to collect the actual cases of innovation. This could be useful to verify the appropriateness of the responses.

To conclude, Prof. Tomohiro Ijichi stated that indicators could be further developed by making the combination of several variables.

Q&A in the Panel Discussion:

A New Development in Innovation Surveys: Measurement to Inform Policy Making

Question 1: What is the response ratio in the European or the German survey? Also, is there any comparable data in terms of US and the European countries?

Dr. Christian Rammer

The ratio for the German survey could be as low as 25% and can go up to 100%. The German survey entails a very long questionnaire. It includes a lot of financial data. There is around one page on just cost, personnel, material, investment, training expenditure, and many others. Therefore, there is a comprehensive non-response survey, which means around 60 to 70% of the firms might not respond to the survey, which can be adjusted in the results.

Prof. John Walsh

In the United States, there is an experiment. One example is BRDIS which is a government survey. Even though this survey is mandatory, the response rate is about 80%, which is very good. It is as high as 90% for the large R&D intensive firms. The response rate for our non-government survey is around 30%. In the NISTEP-Carnegie Mellon survey, the response rates were about 50%. The RI-ETI-Georgia Tech Inventor Survey includes questions such as why was there lack of innovation, why it was not commercialized, *etc.*

Question 2: Is it possible to include some question on the innovation project which could be related to any specific new good or product?

Prof. John Walsh

It was possible in the inventor survey because it was started with the patented invention. But in the case of innovation surveys, there may not be a patent; there may not be a publication. It's hard to ask about projects or whether they failed or not unless one gets to some patent or a similar thing. It is important to ask a lot of the questions to the non-innovators which are usually asked to the innovators.

Dr. Christian Rammer

In Germany, there is not so much focus on questions on one specific project but to learn how many different projects a firm is usually conducting innovation. This might vary according to the size of the firm. For some of the large companies, rules will be difficult to follow using enterprises.

Question 3: How can we include the scale effect? Even after receiving good responses from the small and medium-sized companies, there might have been some declined figure of the total innovative companies. Is there any discussion about the factors of the scale of the economies?

Dr. Christian Rammer
In Germany, companies recognize that it's a bit difficult to interpret this share of innovative exercise, especially the small firms. Hence, we calculate the share of employees in innovative firms to get different pictures of how many jobs are for us to innovate. Then, the figure is more stable.

Question 4: As discussed in the advisory committee of the fourth round of the Japanese National Innovation Survey, medical services, health-related services, or patient care and nursing services are actually excluded from the target group of the survey. But from the product innovation, there will not be a central player, but from the viewpoint of a process or marketing innovation, they may be a very significant player in the very advanced IoT or artificial intelligence or robotics. So, in the future, will it be better to include those industries into innovation surveys?

Dr. Christian Rammer
Germany did some kind of competitive testing in this sector in the past. The decision was not to include these industries initially and would not need the attitude of a commercial company, as they are bound by the rules and regulations of a country's policymakers and hence they decided to not innovate. But they have to make innovation in terms of applying a new technology and so on.

Annex - Abbreviations

BRDIS	Business R&D and Innovation Survey
CIS	Community Innovation Survey
CREST	Centre de Recherche en Économie et Statistique
EIS	European Innovation Scoreboard
J-NIS	Japanese National Innovation Survey
NISTEP	National Institute of Science and Technology Policy
NSF	National Science Foundation
RIETI	Research Institute of Economy, Trade and Industry
OECD	Organisation for Economic Co-operation and Development
ZEW	Zentrum für Europäische Wirtschaftsforschung GmbH