Chapter 1 Why Do We Need Open Innovation Now?

Chapter 1 describes the background factors that, amid increasingly fierce global competition in the area of innovation, triggered the growing emphasis on open innovation — the practice of actively tapping into knowledge and skills from outside an organization — instead of conventional self-sufficiency (closed innovation). It also explains the concept of open innovation and why it is needed right now, focusing on changes in the environment surrounding companies, universities, and R&D agencies, and taking into account socioeconomic changes such as advances in ICT[1] and the march of globalization.

Section 1 What is Open Innovation?

This section describes the background factors that, amid increasingly fierce global competition in the area of innovation, triggered the growing emphasis on open innovation — the practice of actively tapping into knowledge and skills from outside an organization — instead of conventional self-sufficiency (closed innovation). It also explains the concept of open innovation and provides basic knowledge that is important to understanding it, as well as highlighting some specific examples.

1 Innovation in Transition and Key Players

The word "innovation" was first defined by the Austrian economist Schumpeter. In his book The Theory of Economic Development, Schumpeter states that internal factors such as innovation play a bigger role in economic development than external factors such as population growth and climate change. He also describes innovation as the production of something new or the use of a new method to produce something, where production means the combination of objects or forces. Examples of innovation cited by Schumpeter include (1) developing a new product through creative activities; (2) the introduction of a new production method; (3) the development of a new market; (4) the acquisition of a new resource (or source of supply thereof); and (5) organizational reform. In addition, he states that the destruction of existing values and creation of new values (creative destruction) by entrepreneurs is the source of economic growth.[2]

In Japan, there used to be a tendency to translate the English word "innovation" using characters meaning "technological innovation," due to the perception that the kind of innovation that fundamentally transforms the economy and society often stems from groundbreaking science and technology. However, innovation can also be developed by combining existing technologies in the course of interdisciplinary collaboration or by management reorganization, so attention began to focus on the socioeconomic transformation aspect triggered by the creation of new values.

Looking at Japan's Science and Technology Basic Plans, the 3rd Basic Plan (approved by the Cabinet in March 2006) marked the first time that the loanword "*inobe-shon*" was used to refer to innovation, which the Basic Plan defined as "the innovation generating new social and economic values with advanced scientific findings and technical inventions combined with human insights." The 4th Basic Plan (approved by the Cabinet in August 2011) and the 5th Basic Plan both define Science, Technology and Innovation as

1 Information and Communication Technology
2 2006 White Paper on Science and Technology

follows: "Science, Technology and Innovation (STI) comprises all spectrum of creating intellectual and cultural value based on new knowledge from scientific discoveries and inventions, and technology advancement that expands this information to create economic, social and public value." The definition in Innovation 25 (approved by the Cabinet in June 2007) states, "Innovation is not just confined to technical revolution. It creates new values and brings about drastic social changes by incorporating new concepts and systems that are completely different from conventional ones." The first law to define "developing innovation" was the Act on Improving the Capacity, and the Efficient Promotion of Research and Development through Promotion of Research and Development System Reform (Act No. 63 of 2008; hereinafter "the Research and Development Capacity Improvement Act"), which defined it as "creating new values and creating a major change in economic society by developing or producing new products, developing or providing a new service, introducing a new method of producing or sales of products, introducing a new method of providing service, or introducing new management methods."

In each case, rather than being confined to technological innovation, the definition of innovation encompasses the creation of new social values.

The standard pattern of innovation in days gone by is typified by Edison or Bell, who sold the fruits of their own private research to a large corporation, which then turned them into a business. Large corporations later established central research laboratories to conduct their own research, generating innovations through a self-sufficient approach that saw them carrying out everything from basic research to product development in-house. However, this kind of self-sufficiency rapidly began to decline in the U.S. during the 1980s, since when innovation's center of gravity has shifted away from large corporations toward universities and startup companies.[1] Under the newer model, rather than large corporations handling all processes from inventing and discovering new technologies to producing economic value, universities and public research institutions take charge of creating new technological seeds, startup companies deal with the industrialization of those seeds, and large corporations pick up those which offer promising prospects for technology development or commercialization. Right now, the innovation process is changing into one that involves universities and startup companies, not just a single company, with innovation developed through a variety of what are termed "open" techniques, including processes for introducing technologies from universities and startup companies, joint research and development, and the acquisition of startup companies.

2 The Limitations of Self-sufficiency (Closed Innovation)

The rapid development of ICT and increasingly fierce global competition mean that a sense of speed in research and development for industry is needed now, more than ever. Years ago, the self-sufficient approach was the norm, in which everything from basic research to turn product ideas into reality to product development was carried out by companies in-house (including companies and universities with which the company has a relationship). However, manufacturing is subject to ever-higher requirement levels, due to such factors as the diversification of customer needs, the shortening of product life-cycles, and changes in competitive structures arising from globalization, so the conventional approach of undertaking everything from basic research to product development in-house is approaching its limits. Companies cannot handle

1 Katsuya Hasegawa, "Technology Strategy in the Era of Open Innovation," *Technology and Economy* (2008)

everything in-house if they are to keep pace with the speed required to stay ahead of the competition and create new market value. Accordingly, we are entering a situation in which companies are inevitably forced to go outside their existing networks to source technologies, knowledge, and personnel.

Let us look at the example of Bell Labs, which once belonged to major U.S. telecommunications company AT&T. Having taken over the majority of Bell Labs' functions after AT&T was broken up in 1985, Lucent Technologies pushed forward with the development of next-generation technology, mobilizing all of the internal resources of the laboratories, which at the time boasted the world's most advanced research and development environment. However, rival company Cisco Systems, which did not have any outstanding research and development functions at the time, seized the advantage. Unlike Lucent Technologies, which was a closed structure dependent upon its internal resources, Cisco Systems proactively utilized external resources, by such means as investing in promising startups, M&A,[1] and building cooperative relationships. As a result, it succeeded in developing effective new technologies and bringing them to market, despite not having its own in-house research center. The same phenomenon was seen many times among U.S. companies during that period, such as the way that IBM — the titan of the computer industry — allowed Intel and Microsoft to flourish.

Starting in the 1990s, dramatic advances in the internet and technology accelerated the globalization of market competition and changes in the industrial structure, increasing market uncertainty. This meant that even large corporations began to face a situation in which it was difficult for them to develop products and technologies that would satisfy market needs in the short term and continue to generate profits in the long term using their vertical integration model, which relied on their own company's resources to develop successor models to their existing technologies and businesses. Companies began to feel the impact of the exodus of their high-caliber personnel and ideas due to increased mobility and self-sufficient innovation eventually reached its limit once they had no choice but to depend on external resources.[2]

In his book,[3] U.S. academic Henry Chesbrough called this kind of self-sufficient, vertically integrated innovation model based on selling technologies and products developed in-house to existing clients alone "closed innovation," contrasting it with his newly proposed concept of "open innovation."

3 What is Open Innovation?

Open innovation is a means of breaking free from self-sufficiency. The following outlines Henry Chesbrough's definitions of open innovation, which are used as the general definition, and explains that some areas need to be protected (kept closed) even amid an open model.

(1) Definitions of Open Innovation

In research and development, companies always have to bridge the gap between the level that they should achieve to stay ahead of the competition and the level that they can achieve themselves. At one time, the usual approach was for companies to strive to bridge that gap through their own efforts alone. However, the level required has increased of late, while the time allowed to achieve it is shrinking, so they are starting to switch to the idea of using technologies outside their existing networks to bridge the gap. Taking

1 Mergers and Acquisitions
2 Japan Open Innovation Council, *Open Innovation White Paper* (First Edition) (2016)
3 Henry Chesbrough, *Open Innovation: The New Imperative For Creating and Profiting From Technology* (Harvard Business School Press, 2003) (translated by Keiichiro Omae under the title of "Open Innovation" [The Sanno Institute of Management Publishing Department, 2004])

automobiles as an example, motor vehicle companies have, until now, mainly produced and sold gasoline- and diesel-engine vehicles. However, new types of automobile — hybrid vehicles, electric vehicles, and fuel cell vehicles — are being launched onto the market in quick succession, exposing automakers to fierce global competition. As a result, the level that should be achieved is rapidly becoming more diverse and advanced. Of course, new materials and technologies are required for each type of vehicle and it is virtually impossible for a company to secure all of these under the conventional system of self-sufficiency. At the same time, it is not easy to increase in-house resources in response to this kind of social change, so the gap between the level that should be achieved and the level that can be achieved in-house is expanding. The concept of companies seeking out technologies that they do not have or utilizing technologies offered to them emerged naturally as a means of bridging this gap.[1]

In his books, Henry Chesbrough defined the approach of utilizing technologies from outside a company in this way as open innovation.[2, 3]

- "Open Innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas and internal and external paths to market, as the firms look to advance their technology."[4]
- "Open Innovation means that companies should make much greater use of external ideas and technologies in their own business, while letting their unused ideas be used by other companies."[5]
- "Open Innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively."[6]

The common characteristics of these definitions are the creation of value through the internal use of external ideas and the external use of internally unused ideas, and the fact that open innovation is an innovation strategy drawn up from the viewpoint of companies.

However, based on this alone, each reader's impression might well differ. As such, Hoshino[7] defines open innovation — as something commonly utilized across the globe — as "the resolution of research and development issues that a manufacturer cannot resolve singlehandedly by seeking the optimal solution outside its existing networks and incorporating that solution as the manufacturer's own technology."

Open innovation is a means of enabling organizations seeking technologies to meet organizations that have technologies in order to create new values. It is probably best understood if one imagines it as a kind of matchmaking event at which participants aim to build win-win relationships[8] or find a partner who can compensate for their own weaknesses.

While companies are the actors in open innovation, bringing it to fruition requires a partner to track down the optimal solution outside existing networks. There are high hopes about the crucial role that universities and R&D agencies (and also startup companies formed by universities and R&D agencies) can

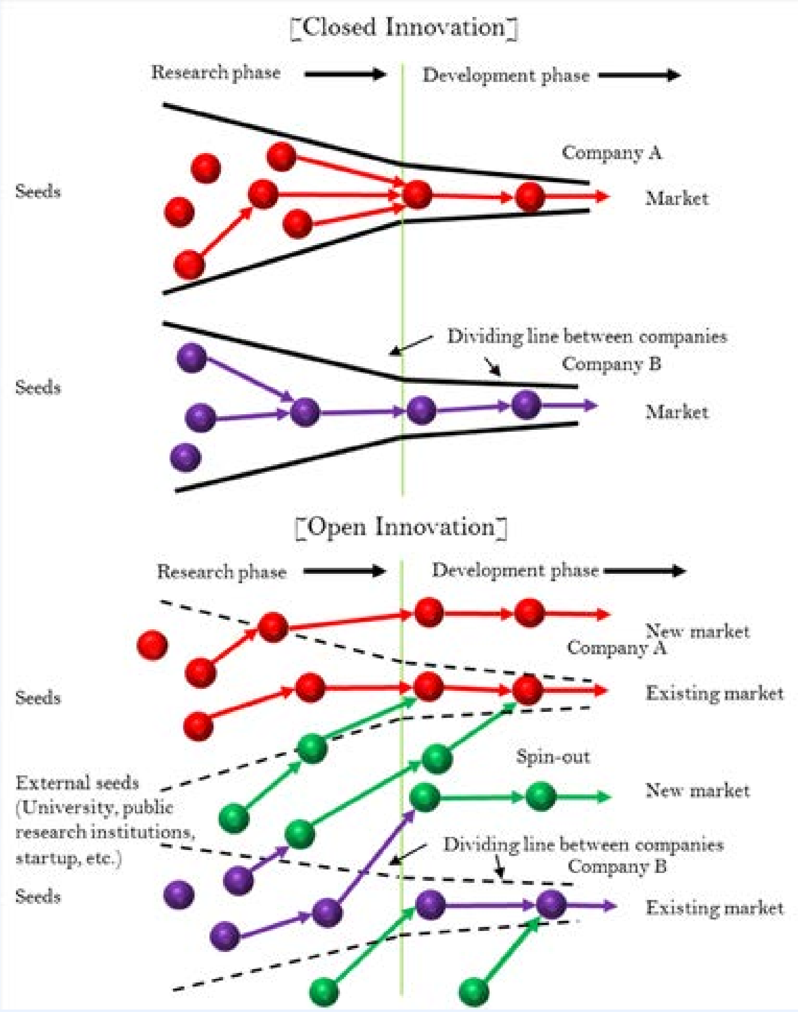
1 Tatsuya Hoshino, *A Textbook for Open Innovation* (Diamond, 2015)
2 Japan Patent Office, Japan Institute for Promoting Invention and Innovation Asia-Pacific Industrial Property Center, *Open Innovation and Intellectual Property* (2010)
3 Henry Chesbrough, *Open Innovation: The New Imperative For Creating and Profiting From Technology* (Harvard Business School Press, 2003) (translated by Keiichiro Omae under the title of "Open Innovation" [The Sanno Institute of Management Publishing Department, 2004]); Henry Chesbrough, *Open Business Models: How to Thrive in the New Innovation Landscape* (Harvard Business School Press, 2006) (translated by Kiyoshi Kurihara under the title of "Open Business Model" [Shoeisha, 2007]); and Henry Chesbrough, Wim Vanhaverbeke and Joel West, eds., *Open Innovation: Researching in a New Paradigm* (Oxford University Press, 2006) (translated by Takahiro Nagao under the title of "Open Innovation" [Eiji Press, 2008])
4 Henry Chesbrough, *Open Innovation: The New Imperative For Creating and Profiting From Technology* (Harvard Business School Press, 2003)
5 Henry Chesbrough, *Open Business Models: How to Thrive in the New Innovation Landscape* (Harvard Business School Press, 2006)
6 Henry Chesbrough, Wim Vanhaverbeke and Joel West, eds., *Open Innovation: Researching in a New Paradigm* (Oxford University Press, 2006)
7 Tatsuya Hoshino, *A Textbook for Open Innovation* (Diamond, 2015)
8 A relationship that benefits both parties.

play in the research and development segment in particular.

This white paper explains open innovation with a focus on the universities and R&D agencies regarding which the industrial sector in particular has such great expectations, from the perspective of their advanced research and development capabilities and human resource development.

The diagram below is a graphic representation of the concept of open innovation (Figure 1-1-1).

■Figure 1-1-1 / Concept Diagram of Closed Innovation and Open Innovation



Source: Prepared by MEXT based on Henry Chesbrough, *Open Innovation: The New Imperative For Creating and Profiting From Technology* (translated by Keiichiro Omae under the title of "Open Innovation")

The top of the diagram above illustrates closed innovation, showing the process from basic research to development and ultimately leading to a new product reaching the market. New ideas are born on the left side of the diagram (research phase) and flow toward the market on the right. During this process, ideas are selected, with those that survive being commercialized and brought to market. Closed innovation is an introspective, self-sufficient process that integrates research and development. Most traditional research and development projects are thought to have taken this form. This process functioned as a means of winnowing out projects that initially look promising, but cease to be so as development proceeds. It is said that projects screened in this way had a high probability of success in the market.[1] Moreover, this closed model is said to remain the mainstream approach in Japan today.

The lower part of the diagram above explains open innovation. Projects can start from both internal and external seeds, with new technologies able to be incorporated into the process at various stages. In addition to sales and marketing by the company itself, projects can be brought to market through spin-offs and various other means. This model makes it possible to bring in ideas via a range of methods during the innovation process and to bring them to market in diverse ways, so Henry Chesbrough called this open innovation.

Ideas are born during the corporate research process, but they leave the company as they develop. Key examples of this include cases in which researchers involved in research and development set up external startup companies and cases in which licenses are obtained or researchers poached by external organizations. On the other hand, ideas born outside the company get brought inside, as well.[2]

(2) Core Realms That Should Be Protected

Open innovation does not necessarily mean making all technology and know-how open. There are realms that should be protected to ensure that technologies and other things that are the source of a company's competitiveness are not copied (these are called "core realms"). In addition, a company needs to delineate how much it will protect (keep closed) as its proprietary technology and how much it will make available (make open) for the purpose of expanding its market.

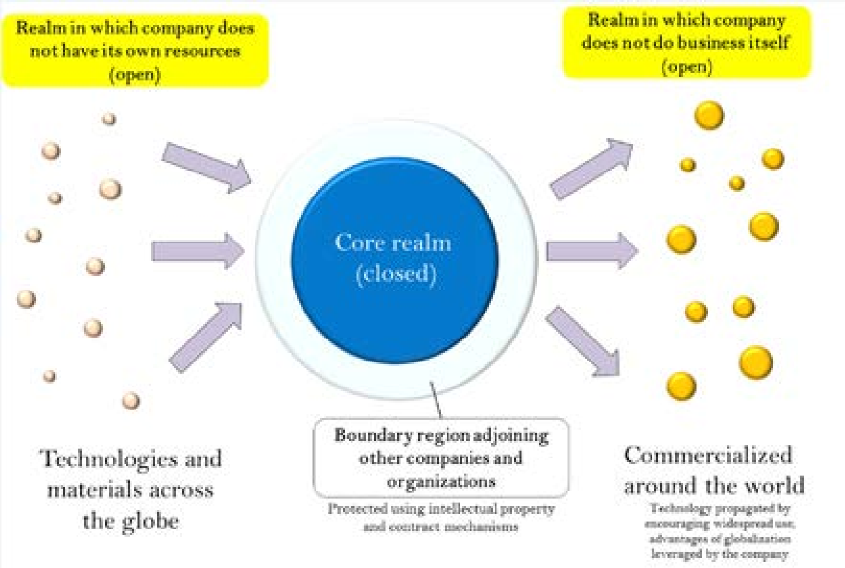
The company protects its core technologies by patents and know-how, ensuring that openness does not encroach on its core realms. At the same time, it searches out technologies and materials for which it has no internal resources in the open environment — that is to say, across the globe — and endeavors to introduce them into the company. In the case of realms where it does not itself do business, the company makes its own technologies available for use by making them open, thereby encouraging their commercialization around the world.

This delineation of realms, which is often also called an open-close strategy, is a crucial element in the promotion of open innovation. The figures below illustrate an open-close strategy (Figure 1-1-2 and Table 1-1-3).

1 Henry Chesbrough, *Open Innovation: The New Imperative For Creating and Profiting From Technology* (Harvard Business School Press, 2003) (translated by Keiichiro Omae under the title of "Open Innovation" [The Sanno Institute of Management Publishing Department, 2004])

2 Henry Chesbrough, *Open Innovation: The New Imperative For Creating and Profiting From Technology* (Harvard Business School Press, 2003) (translated by Keiichiro Omae under the title of "Open Innovation" [The Sanno Institute of Management Publishing Department, 2004])

Figure 1-1-2 / Illustration of the Concept of Realms in an Open-Close Strategy



Source: Prepared by MEXT based on Yuji Ozeki, “Strategic Approach to Open Innovation by Large Enterprises”

Table 1-1-3 / Specific Examples of Open-Close Strategies

	Apple	Intel
Open realms	• Smartphone manufacturing process • App development (However, apps must be certified)	• PC peripheral manufacturing technology
Closed realms	• Product design • User interface • Integrated software platform (iOS)	• Microprocessors

Source: Prepared by MEXT based on Yuji Ozeki, “Strategic Approach to Open Innovation by Large Enterprises”

4 Examples of Open Innovation

This section profiles some examples of open innovation.

(1) Toray—Uniqlo

One example of a joint development initiative involving private sector companies that has yielded a succession of hit products is the partnership between Toray Industries, Inc. (hereinafter “Toray”) and Fast Retailing Co., Ltd. (hereinafter “Fast Retailing”). This has resulted in such products as the Heattech range of functional innerwear, which was launched in 2003, and the Ultra Light Down range of jackets, which was launched in 2009.

Fast fashion is achieving rapid growth in the global apparel sector, but most of this is deemed to utilize a high-speed, efficient business model facilitated by the radical shortening of supply chain lead times, which allows retailers to first put clothes into stores and then mass-produce those which actually sell well.[1] In contrast, Fast Retailing develops only those items that it has already determined will definitely sell, so

1 Takashi Nawa, “Learning From Fast Retailing About Forging New Connections Through ‘Close Partnerships,’” *Diamond Harvard Business Review* (2013)

rather than competing solely on design, which is very much a matter of personal taste, it starts by developing the fabric. Both Heattech and Ultra Light Down were the result of this approach, which runs contrary to conventional wisdom.

The conventional business model in the textiles sector is regarded as having been inefficient, divided into multiple stages, including fiber manufacturers, cloth manufacturers, sewing companies, and the intermediaries between them.[1] Under this model, it was difficult for fiber manufacturers to become deeply involved in turning their own materials into products that create value for consumers. However, the business model built for Heattech and the like is an integrated covering everything from the original yarn upstream all the way down to the retail stage, which means that even Toray, as a fiber manufacturer, is able to get a keen sense of the value delivered to the consumer.

By forming a strategic partnership in 2006, Fast Retailing and Toray built an integrated product development framework that covers everything from the material stage through to the final product, cutting across the boundaries between fabric manufacturers and the specialty store retailer of private label apparel (SPA) model. Thus, these two companies have broken free from a highly conventional, commonplace business model in which Toray supplied the fabric for products deployed by Fast Retailing, and have pooled their functions to the greatest degree possible to create a total industry that covers everything from fabric development to the product itself, including planning, development, production, and distribution. As a result, they have succeeded in dramatically increasing speed, efficiency, and added value.

This is open innovation that achieves a win-win situation: Fast Retailing uses its own sales channels and customer knowledge as a base, while relying on Toray's technological assets to build in consumption that it was unable to achieve singlehandedly; Toray, on the other hand, uses its integrated textile production technology — covering everything from raw materials to sewing — as a base and tailors it to new customer needs emerging from Fast Retailing.

(2) P&G

This company was the first to declare its intention to embark on open innovation. As an early adopter of open innovation, Procter & Gamble Co. (P&G) has been striving to achieve faster development of innovative products that it cannot create alone by soliciting technologies and ideas from beyond the company's boundaries. Since 2000, P&G has appointed a dedicated executive and expert staff to tap into technologies outside the company, and has also set a target of acquiring 50% of its innovations from outside the company under the name Connect+Develop (C+D), aiming to break free from self-sufficiency and actively apply external innovations to product development. Its innovation partners are highly diverse, ranging from individuals to large corporations — sometimes even its competitors — and include companies, research institutes, suppliers, retail partners, contract manufacturers, and commercial partners. Furthermore, the partnerships cover a wide range of fields, including everything from product-related technologies and knowledge, packaging, manufacturing technologies, and devices to market research methods, marketing techniques, business models, and trademarks. In addition to identifying high-potential partners and bolstering tie-ups with them, P&G has built a globally accessible online system, via which it constantly posts information about its needs and the technologies that it is seeking, inviting suggestions

1 Kobelco Systems Corp., "Case Studies in Manufacturing Goods and Producing Ideas," Special Feature on Manufacturing (2013)

and submissions from potential business partners.

Today, it receives thousands of ideas every year from around the world and C+D generates innovation in a wide range of fields, including not only P&G's new products and packaging, but also everything through to supply chains, production processes, and other business models.

Among the fruits of development undertaken through this kind of open innovation are a clothing detergent in a completely new format, in which the liquid ingredients are enclosed in a water-soluble film tablet. Another is a fragrance product which uses a sheet evenly impregnated with fragrance ingredients, enabling it to emit a scent for a long period. Open innovation is enabling P&G to achieve success in increasing the investment efficiency of its research and development expenditure and speeding up the pace of product development.

(3) Apple

Digital device manufacturer Apple Inc. is renowned for a number of products, including PCs such as the iMac, the iPod portable music player, the iPhone smartphone, and the iPad tablet. In 2001, Apple devised its Digital Hub strategy, which redefined the PC — its main product — as "a hub to which various digital devices are connected." Since then, the company has released a series of products and services, such as the iPod and iTunes, based on the view that its value lies in developing user-friendly digital devices.

Apple went as far as mapping out a service layer over and above the business architecture in which its own products (finished products) are positioned and has built a mechanism for ensuring widespread diffusion without reducing the added value of its products, with intellectual property categorized as either open or closed and used accordingly. Specifically, first of all, Apple defined its exclusive realms (non-public or black box realms that are closed to other companies) as (1) its proprietary operating system (OS) and the music management software that interfaces with it (iTunes); and (2) branding and design, with a primary focus on the user interface of its products. iTunes was originally just a piece of music management software, but Apple's distribution of iTunes free of charge resulted in its widespread adoption. In addition, although iTunes only worked with Apple's iPod portable music player, the 2003 launch of Apple's online music store, which sold songs from major record labels at 99 cents each, triggered the explosive spread of the iPod.

Another mechanism devised by Apple was the construction of closed alliances with manufacturing and component partners, to which Apple supplied its technological know-how. Apple does not have a device manufacturing business of its own and has revealed that it gathers open source information, which alleviated fears among its partners that Apple might steal their technology. Coupled with the appeal of the sheer volume of Apple products, this enables Apple to effortlessly accumulate devices, technologies, and ideas directly linked to products.

Once their product is adopted as an iPhone component, the device manufacturers who partner with Apple have the potential to sell 100 million or more units per year worldwide. Accordingly, device manufacturers submit to Apple devices in the final stages of the research and development process and interesting technologies and ideas seeking an outlet. For example, the "in-cell" technology used in the iPhone 5 had long been lying dormant in the hands of a Japanese semiconductor manufacturer. Apple's discernment in turning its attention to hitherto disregarded technologies of this kind is making open innovation a reality.

Thus, Apple has created a business model that keeps its manufacturing and component partner companies loyal by making the most of the advantages offered by the cutting-edge devices that it has assembled, honing its technical skills in commercializing products, and making the technologies that it has acquired available as know-how.[1, 2]

Section 2 Current Status of Open Innovation

1 Changes in the Economic and Social Background and Roles Required of Universities and R&D Agencies That Have Increased the Need for Open Innovation

This part provides an overview of the background to the growing need for open innovation, describing the changes in Japan's economic and social situation and the environment surrounding Japanese companies, universities and R&D agencies, and startup firms, as well as the role of universities and research and development (R&D) agencies in open innovation that has become apparent as a result.

(1) Companies need to become more competitive through open innovation

Amid the march of globalization and the growing power of emerging economies, the limits of the Japanese success model have long since been pointed out. With the development of ICT bringing about revolutionary change, companies need to create new values under new circumstances that involve responding to economic and social challenges. On the other hand, companies' research and development capabilities have become rather short-sighted as competition has intensified. They need to make a clean break with self-sufficiency and engage in innovation management, which encompasses a variety of sectors, including other companies in the same business.

① Approaches to innovation necessitated by changes in the corporate business environment

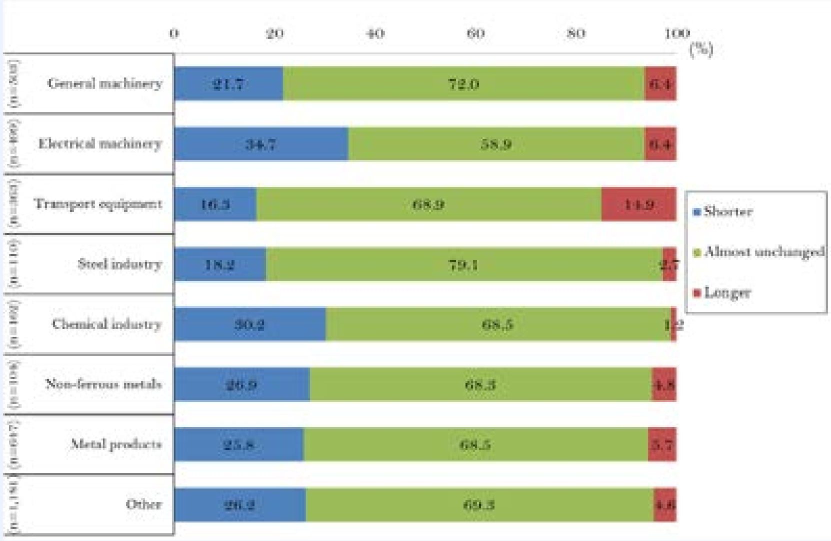
Japan's economy and society is in the midst of a period of transformation and the corporate business environment is also changing. The following provides an overview of the approaches to innovation required to address those changes.

○ Addressing shorter product life-cycles

Many have pointed out the shorter life-cycles of products in recent years. In a Ministry of Economy, Trade and Industry (METI) survey, more companies stated that their product life-cycles had become shorter than that they had become longer, across all categories of business (Figure 1-1-4). The shortening of product life-cycles means that companies lose their competitive advantage within a shorter time, even if they bring new products and services to market.

1 Yonoshin Mori and Kinya Fujita, "Business Model Innovation With Core Technology at its Heart," *Arthur D. Little Side by Side* (January 2015)
2 Ryosuke Morita, "Apple Injects Enthusiasm Into Manufacturing," *Nikkei BizGate* (2013)

■ Figure 1-1-4 / Ten-year Comparison of Product Life-cycles



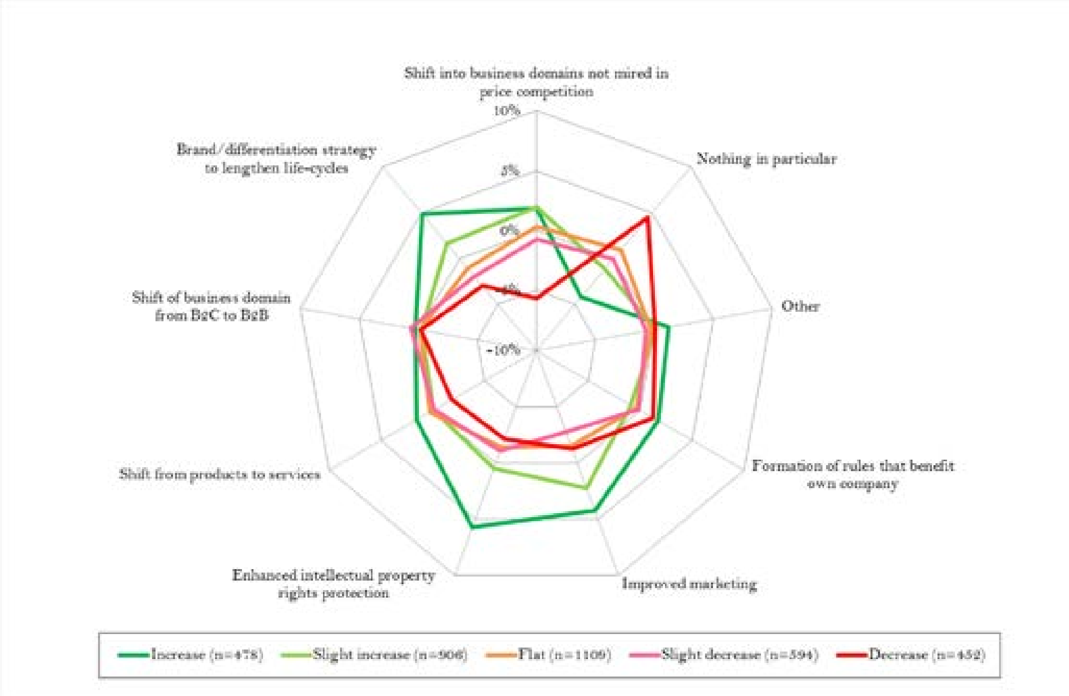
Source: Survey by the Ministry of Economy, Trade and Industry (December 2015)

One conceivable means of addressing this would be to pursue optimized and longer life-cycles. The same METI survey also looked into the measures taken by companies to ensure appropriate product life-cycles and their net sales over the last three years. This revealed a correlation between the two, with companies that do not take any particular measures in this regard seeing a fall in sales. On the other hand, many companies that undertook such initiatives as implementing brand and differentiation strategies, enhancing protection of intellectual property, and improving marketing saw sales grow. In addition, few companies that made the shift into business domains not mired in price competition experienced falling sales (Figure 1-1-5). Open-close strategies are also counted among these measures. Creating a virtuous circle in which initiatives like this are employed to optimize and lengthen product life-cycles, thereby generating profits that are used to fund the next investment and strengthen sales strategies is one means of responding to the situation. Another option is to accept shorter product life-cycles as inevitable and to speed up research and development, along with the pace at which products are commercialized and brought to market. This can be done through open innovation initiatives that leverage not only internal, but also external technical, information, and human resources.

Whether aimed at optimizing life-cycles or increasing speed, open innovation is an important means of addressing shorter product life-cycles.

■ Figure 1-1-5 / Trends in Product Life-cycle Optimization Initiatives and Business Performance (Operating Profit) Over the Last Three Years

The green line represents initiatives undertaken by companies whose operating profit has increased over the last three years, while the red line represents initiatives by companies whose profit fell. Among the group of companies that pursued brand or differentiation strategies to lengthen life-cycles, the proportion of companies that saw increased profits was approximately 5% higher than the average, while the proportion of those whose profits fell was approximately 3% lower than the average.



Note: Graphical representation of the points difference from the overall average
Source: Survey by the Ministry of Economy, Trade and Industry (December 2015)

○ Impact of changes in demographic composition on the market

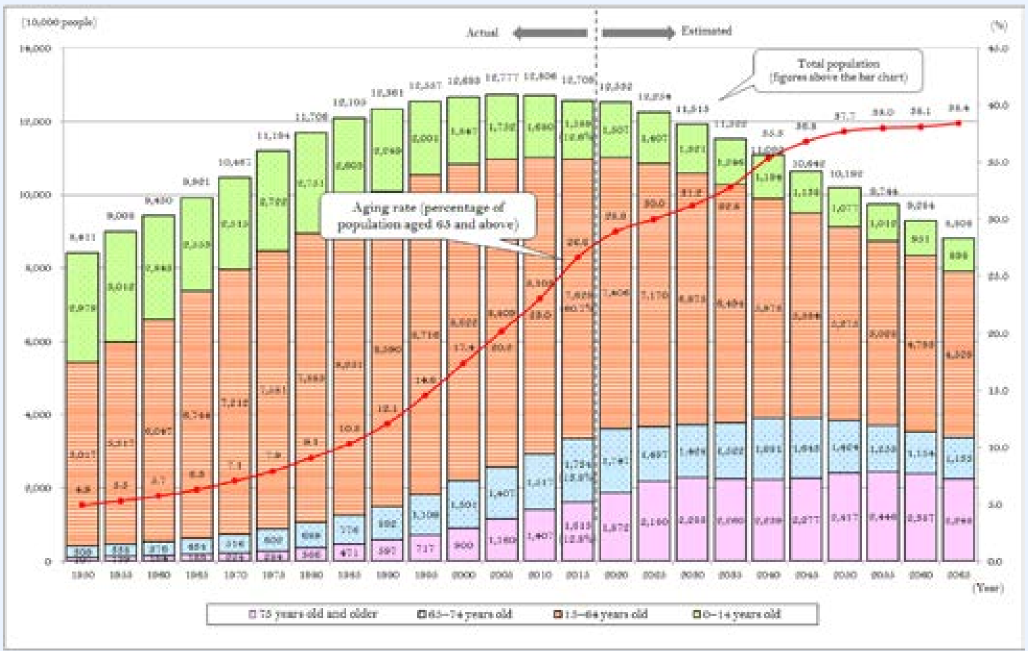
As a nation with few natural resources, people are Japan's biggest resource, but while the global population continues to grow, Japan has become the first developed country to enter full-scale population decline (Figure 1-1-6). As such, it is clear that Japan needs to increase the quality of its human resources. In addition, Japan's high aging rate is unparalleled elsewhere in the world.[1] The advent of population decline and an ultra-aging society means that Japan faces structural issues on both the demand side — such as a shrinking domestic market and changes in the consumer generation — and on the supply side, including a fall in the working-age population. Companies can no longer expect to see a substantial increase in sales amid a shrinking domestic market, even if they do make good products; on top of this, changes in the consumer generation mean that it is not necessarily the case that the products that have sold well until now will continue to do so. On the other hand, even if companies venture into global markets, the declining working-age population will make Japan less productive than emerging economies with growing populations. Consequently, innovation is required to generate new values and use unprecedented means to produce hitherto-unseen products and services.

Looking at it from another perspective, Japan — which could be described as a front runner in the field

1　Cabinet Office, *Annual Report on the Aging Society: 2016* (May 20, 2016) of global demographic challenges — is the market that is the earliest incarnation of the modalities and changes that will come to all countries and global markets in the future. If Japan can thoroughly implement innovation-oriented initiatives and swiftly create economic and social structures adapted to these changes, it will be able to become a global leader as a succession of countries around the world make the transition to becoming aged societies. Open innovation needs to be used to resolve issues stemming from changes in demographic composition and create new values.

Japan must be aware of the need to make use of what one might describe as a kind of advantage afforded to it as a front runner in global challenges, becoming a pioneer in using innovation to generate new values and spreading those values around the world.

■ Figure 1-1-6 / Aging of the Population and Future Estimates



Note: Total figures for 1950–2015 include those of indeterminate age. The aging rate is calculated after deducting those of indeterminate age from the denominator.

(Source) Figures up to and including 2015 are from the Ministry of Internal Affairs and Communications, Population Census; estimates for 2020 and beyond are based on the postulated median birth and death rates from the National Institute of Population and Social Security Research, *Population Projections for Japan* (2017 estimates)

Data: Created by MEXT based on Cabinet Office, *Annual Report on the Aging Society: 2016*

○ The new vision for society depicted by Society 5.0

The 21st century is the age of the knowledge-based society, in which new knowledge, information, and technology are radically gaining in importance as the foundations of activities in all spheres. As a result, new knowledge, information, and technology are being created in every corner of the globe every day and can readily spread worldwide, transcending national borders. The 5th Basic Plan sets out a new concept of social transformation called Society 5.0 (the super smart society) [1] and seeks to enhance the key

1 The Comprehensive Strategy on Science, Technology and Innovation (approved by the Cabinet on May 24, 2016) defines Society 5.0 as a human-centered society in which people can lead high-quality lives full of comfort and vitality, which is achieved by balancing economic advancement with the resolution of social problems through the provision of goods and services that are meticulously tailored to diverse latent needs, regardless of locale, age, sex, language, or any other consideration, and which also achieves the advanced fusion of cyberspace and physical space.

technologies that underpin Society 5.0, including Artificial Intelligence (AI), network technology, and big data analysis.

AI, the IoT,[1] big data and the like are key technologies required by all industries to achieve innovation. The development of key technologies will give rise to a succession of hitherto-unimaginable products and services, generating new business models by blending cyberspace and physical space in sophisticated ways. As well as helping to resolve many social issues, this is likely to bring about a dramatic improvement in the quality of life.[2]

Society 5.0 Concept Diagram
Source: Cabinet Office

Driven by advances in ICT and big data analysis technology, we are seeing the source of new value shifting toward data, so competition over access to data and its use is intensifying, growing both in scale and speed at an ever-faster pace. As a result, we have already plunged into a world in which speed is of the essence and winner takes all.[3] This trend has greatly undermined the so-called Japanese success model — companies pursuing sustainable development by cultivating technologies, know-how, equipment, and personnel within their own organization in the context of a system based on lifetime employment and seniority-based promotion.

In this time of revolutionary change, the blending of cyberspace with physical space is transforming our lives, creating a world in which everything is connected to the internet and thereby giving rise to a society and systems that differ completely from everything that has gone before. To promote Society 5.0 amid this environment, we need open innovation right now, to create new values completely different from conventional ones, through an approach that involves a wide range of researchers — including those in the humanities and the social sciences — and also the general public.

Changes in the industrial and social structure are thus transforming the corporate business environment, so conventional business strategies are no longer capable of securing victory as the pace of international competition hots up. Under these new circumstances, companies need to lead the world in the creation of new values by adopting open innovation as an innovation system that differs completely from traditional approaches.

② Breaking free from self-sufficiency to create new values

The following provides an overview of how companies are changing their approach in order to promote open innovation amid the economic and social changes described above.

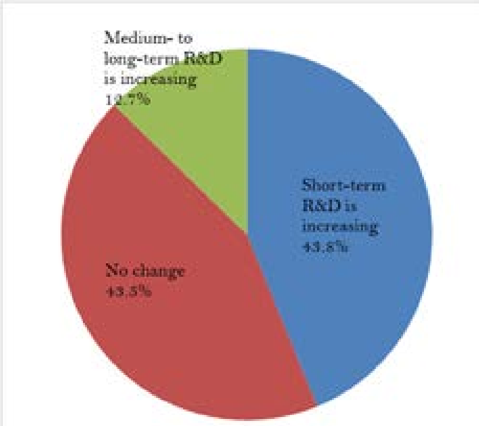
1　Internet of Things
2　Japan Revitalization Strategy 2016 (approved by the Cabinet on June 2, 2016)
3　Industrial Structure Council New Industrial Structure Committee, *Vision of New Industrial Structure —Japan's strategies for taking the lead in the Fourth Industrial Revolution— Interim Report* (April 27, 2016)

○ Changes in companies' inclination to undertake research and development and focus on tapping into external output

Research and development is the source of companies' innovation. Looking first at the length of research and development projects, it has been pointed out that a growing number of projects are short term, so there are concerns about a lack of awareness regarding medium- to long-term research and development investment (Figure 1-1-7).[1] Moreover, looking at the structure of scientific paper production in Japan, the presence of companies began to decline sharply in 1995 or thereabouts, when Japan entered a prolonged recession following the collapse of the bubble economy (Figure 1-1-8).[2] That trend has continued unabated since then, with a fall not only in the percentage of papers receiving the most citations by organization, but also in the absolute number. Amid deteriorating corporate performance, some have pointed out that it is becoming increasingly difficult for industry to devote large sums to basic research and that central research laboratories are undergoing a seismic shift in their mission from basic to applied research.[3]

At the same time, universities have long been the main paper-producing organizations, while public research institutions have had a growing presence in recent years, contrary to the trend among companies.

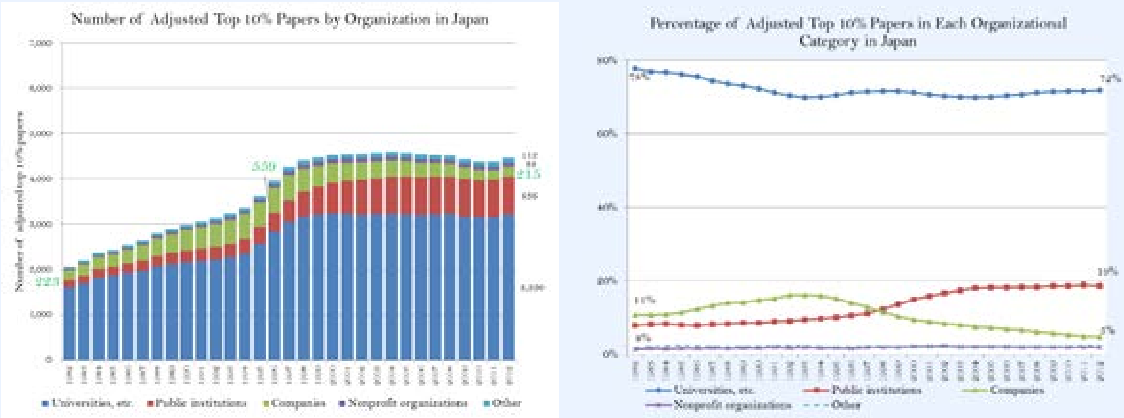
■ Figure 1-1-7 / Changes in the Content of Research and Development by Japanese Companies



Source: Created by MEXT based on METI, *FY2010 Industrial Technology Survey — Survey of Japanese Companies' Quantitative Assessment of Open Innovation in Regard to Research and Development Investment Efficiency* (February 2011)

1 R&D and Innovation Subcommittee of the Industrial Structure Council Committee on Industrial Science and Technology Policy and Environment, *Initiatives for Promoting Innovation (Interim Report)* (May 13, 2016)
2 National Institute of Science and Technology Policy, *Benchmarking Scientific Research 2015 — Bibliometric Analysis on Dynamic Alteration of Research Activity in the World and Japan* (August 2015)
3 Kazuyuki Motohashi, "Features of Japan's Innovation System and Trends in Open Innovation," *Electrical Review* December 2013

■ Figure 1-1-8 / Structure of Scientific Paper Production in Japan



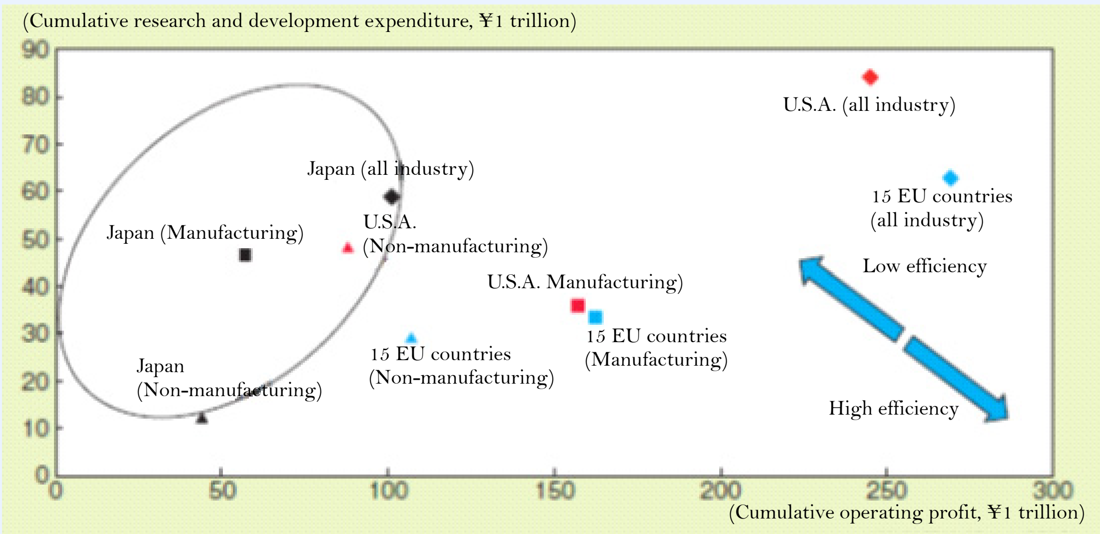
Notes: 1. Analysis of articles and reviews based on fractional count. The figure for 2012 is the average for 2011, 2012, and 2013.
2. The number of adjusted top 10% papers is calculated by taking the top 10% of papers by number of citations in each field each year and adjusting the actual number to one-tenth of the number of papers.
3. "Universities, etc." includes national universities, municipal/prefectural universities, private universities, colleges of technology, and inter-university research institute corporations.
4. "Public institutions" includes national organizations, special public corporations and incorporated administrative agencies, and local government organizations.

(Source) Compiled by the National Institute of Science and Technology Policy from Thomson Reuters, Web of Science XML (SCIE, end of 2014 version).

Data: Created by MEXT based on National Institute of Science and Technology Policy, *Benchmarking Scientific Research 2015 — Bibliometric Analysis on Dynamic Alteration of Research Activity in the World and Japan* (August 2015)

In terms of indicators for measuring research and development efficiency, one can look at the distribution of the cumulative operating profit (2009–2013) and cumulative research and development expenditure (2004–2008) in the corporate sectors of major countries including Japan segmented into manufacturing industry and non-manufacturing industry. These show that in Japan, cumulative operating profit trends low despite high cumulative research and development expenditure and that research and development efficiency in the corporate sector is relatively low, even compared to other countries (Figure 1-1-9).

■ Figure 1-1-9 / International Comparison of Research and Development Efficiency



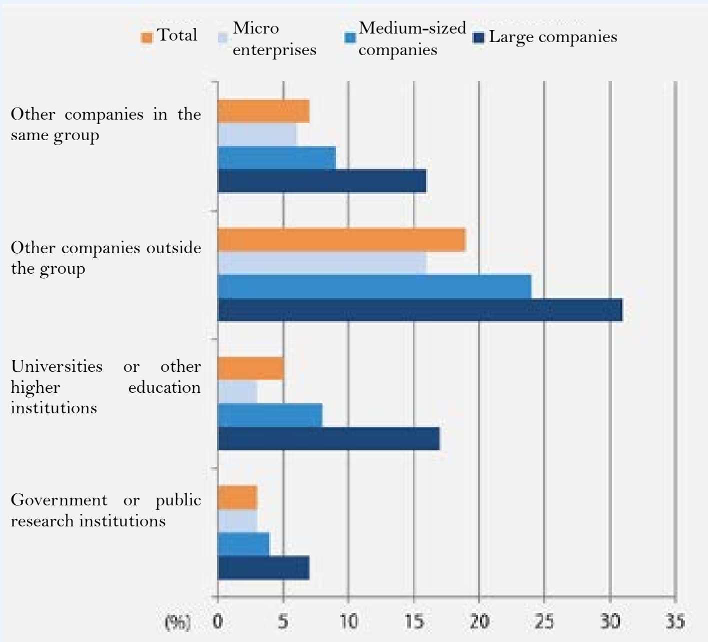
Source: Cabinet Office, *Annual Report on the Japanese Economy and Public Finance 2015* (August 2015)

Corporate research has shifted to short-term applied research, which has low research and development efficiency, so the industrial sector believes that expanding industry-academia-government collaboration is important in order to create realms that differ from existing business through full-scale open innovation. Above all, the sector believes that it is vital for companies, universities and R&D agencies to work together in exploring and sharing visions for the ideal society of the future, mobilizing a variety of resources in a way that cuts across traditional boundaries — such as those between basic and applied research, and between the humanities and science and technology — to accelerate innovation through fully fledged joint research.[1]

In fact, looking at the Report on the Fourth Round of the Japanese National Innovation Survey, one can see that 19% of companies that undertook innovation activities between FY2012 and FY2014 used other companies outside the group as a source of knowledge and technology acquired from outside their company. Moreover, looking only at large companies with at least 250 employees, one can see that 17% of companies used universities or other higher education institutions, which was greater than the percentage of companies that used other companies within the same group (Figure 1-1-10).

Thus, one can see that, with corporate research and development adopting an increasingly short-term perspective and not necessarily demonstrating high levels of research and development efficiency, companies pursuing innovation are seeking to achieve innovation by tapping into external research output, particularly through collaboration with universities and R&D agencies.

Figure 1-1-10 / External Sources of Knowledge and Technology Acquired by Companies Undertaking Innovation Activities



Source: National Institute of Science and Technology Policy, *Report on the Fourth Round of the Japanese National Innovation Survey* (November 2016)

1 Japan Business Federation (Keidanren), *Toward the Enhancement of Joint Research Activities under the Framework of Industry-Academia-Government Collaboration* (February 16, 2016)

○ From vertical collaboration to horizontal collaboration at the pre-competitive stage

This is not an age in which marketing products and services on the basis of their advanced technology generates sales. Consumer needs are becoming increasingly diverse. For example, all cars now meet certain standards for fuel consumption and drivability, so there is little difference between models in this regard. While it is better to have good fuel efficiency and drivability, some consumers might choose a more impressive-looking car for the same money, even if the fuel efficiency is a little worse. Others might choose a car touted as being more environmentally friendly, even if it offers slightly less drivability or comfort. In addition, a preference for advanced technology in individual components does not necessarily mean that hi-tech end products will sell well.

Until now, Japanese industry has achieved success in global competition through a self-sufficient approach, in which companies conduct everything from product research and development to manufacturing in-house. With the global economy going through drastic changes and industry being transformed worldwide in recent years, open innovation has begun to be pursued in Japan, too. However, most of this appears to be vertical collaboration, involving partnerships between companies within the same value chain or between universities and public research institutions that undertake basic research and companies that apply this research to turn it into a commercial product. This approach is seen as making it easy to build win-win relationships, because the business as a whole, from upstream to downstream, is divided between organizations, each of which contributes in its area of specialism. On the other hand, competition between players in the same business is fierce in Japan, which is regarded as the reason why there has been no progress with open innovation based on the horizontal collaboration model. Horizontal collaboration is a cooperative mechanism in which companies in the same field of business work together on common basic/foundational research domains (cooperative aspects), while continuing to compete in areas beyond those aspects.[1]

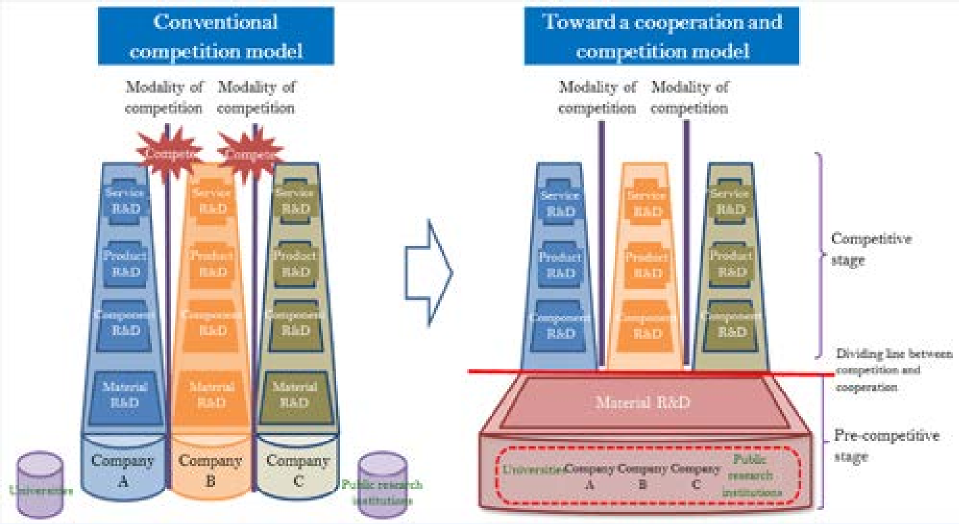
In the case of self-sufficiency or vertical collaboration, improvements to individual technologies or component design are made through comparison, adjustment, and coordination between departments or companies, resulting in a highly specialized end product that is an assembly of optimized components. As such, the individual components are not very versatile. This method was highly competitive at a time when products featuring improved technology were selling well. On the other hand, in the case of horizontal collaboration, the interfaces of components are standardized, enabling a diverse array of finished products to be made by combining components. Consequently, each component can be combined with other components without the need for a redesign, which not only increases efficiency and reduces costs, but also makes it easier to create completely new products through novel combinations. This trend is particularly pronounced in product fields with a greater emphasis on software. At a time like this, when importance is increasingly attached to the creation of new values, the potential for destructive innovation is growing.

Although there are many realms in which initiatives that require companies to work together as an industry are needed to bring to fruition a new economy and society, cooperation between Japanese companies is not necessarily progressing, with fierce competition between some players in the same industry, as described above. Taking into account the perspectives of growth throughout Japanese economy and the enhancement of industrial competitiveness amid ongoing overseas competition to build platforms,

1 National Institute for Materials Science, *NIMS NOW* Interview with NIMS President Kazuhito Hashimoto (February 2017)

responses by individual companies are not enough. Rather, it is necessary to strengthen cooperation between companies by identifying the realms that represent the pre-competitive stage and creating an environment in which Japanese industry can take further advantage of its strengths (Figure 1-1-11).

■ Figure 1-1-11 / Illustration of Collaboration at the Pre-competitive Stage



Source: Created by MEXT based on Industrial Structure Council Committee on Industrial Science and Technology Policy Subcommittee on Basic Issues, *Interim Report on Approaches to Innovation-enhancing Industrial Policy: Results-focused Competition and Cooperation* (August 2009)

Looking at the example of motor vehicle manufacturers, one can see that European automakers have built an efficient development system in which the competitive and pre-competitive stages of development are sharply distinguished from each other. Germany's FVV[1] is an association for engine research whose membership includes 169[2] automobile manufacturers and parts makers. FVV conducts research in common basic technology fields, focusing on unraveling physical phenomena and developing analytical technologies. In contrast, Japanese manufacturers have traditionally been rivals. However, "due to a sense of impending crisis that [Japan's automobile manufacturers] would fall behind European automakers — centered on Germany — in engine development if things remain as they are,"[3] eight Japanese motor vehicle manufacturers and one research institute formed the Research Association of Automotive Internal Combustion Engines (AICE) in 2014 (AICE now has nine manufacturers and two institutes as members). Within AICE, member companies undertake basic and applied research that leverages university expertise to address common issues and challenges, using the fruits of this research to speed up development within their own companies (Figure 1-1-12). Initiatives aimed at generating open innovation through horizontal collaboration between rivals at the pre-competitive stage are now getting started.

1 Forschungsvereinigung Verbrennungskraftmaschinen e.V. (Research Association for Combustion Engines)
2 As of January 1, 2017
3 Toyokeizai Online, *Japan's Automotive Industry at Risk: Interview with the President of Engine Research Association AICE* (July 23, 2014) (http://toyokeizai.net/articles/-/42637)

■ Figure 1-1-12 / Example of Collaboration at the Pre-competitive Stage (Research Association of Automotive Internal Combustion Engines (AICE) Initiatives)

Source: Research Association of Automotive Internal Combustion Engines

○ SMEs need open innovation, too

It is not only large corporations that generate innovation through research and development. The same challenges that large corporations face in terms of the business environment and innovation activities also affect SMEs, to a greater or lesser extent. Looking at joint and funded research projects that universities and colleges undertake in partnership with companies, the number of joint research projects with SMEs is growing in comparison with the overall number, albeit only slightly. At the same time, the proportion of SMEs involved in funded research is growing, demonstrating that the tide of open innovation is reaching such companies as well (Figure 1-1-13).

Among SMEs, there is a move to break free from their reliance on subcontracting for large corporations within the confines of the vertical collaboration model, instead cultivating their own unique strengths and adding value. These include firms that have not only secured demand by facing the market themselves, but also tapped into international markets and captured a high share in niche fields (global niche top companies), as well as firms that combine a global perspective with activities firmly rooted in their local community (glocal companies). The 2016 White Paper on Small and Medium Enterprises in Japan, which focuses on the earning power of SMEs, points out that high-profit enterprises make investment positively in a planned manner while preparing for risks. The government needs to put in place an environment that supports such initiatives by proactive SMEs.

Quite a few SMEs have high technological capabilities that would enable them to secure the top market share even in global markets. For large corporations, too, SMEs are indispensable partners. SMEs have outstanding technologies that could become the seeds of innovation, so there are high hopes that those resources can be utilized through joint research in the age of innovation.

■ Figure 1-1-13 / Number of Joint Research and Funded Research Projects at Universities, etc. and Proportion Undertaken in Partnership With SMEs

Source: MEXT, *Survey of University-Industry Collaboration*

As described above, it is becoming difficult for Japanese companies to undertake research and development from a medium- to long-term perspective amid intensifying competition. Amid a trend toward global open innovation, breaking free from the closed system of self-sufficiency, it is necessary to undertake innovation management that encompasses a variety of partners, including other companies in the same industry, through approaches such as horizontal collaboration at the pre-competitive stage.

Going forward, competition with overseas companies that are already working hard on open innovation is likely to intensify further. For example, the medical supplies sector is described as "Japan's most advanced sector in terms of open innovation,"[1] but some have pointed out that signs of a pivot back to Japan are being seen, as "a succession of Western pharmaceutical companies that closed their Japanese research institutes to cut costs embark on joint research with research institutions within Japan."[2] Germany's Bayer is devoting considerable energies to innovation: as well as opening an office in Kyoto University in May 2015, the company plans to hold a symposium on academic-industrial collaboration in Japan in FY2017.

1 Tatsuya Hoshino, *A Textbook for Open Innovation* (Diamond, 2015)
2 Sankei News, *Foreign Pharmaceutical Companies Pivot Back to Japan: Partnerships With Cutting-edge Research Institutes* (July 8, 2015)

Bayer has already held these symposiums in a number of countries, but this will be the first time that it has held one in Japan. Amid the march of globalization, competition with foreign companies is hotting up, even within Japan.

Thus, the economic and social situation surrounding companies is in transition and changes can be seen in the initiatives implemented by companies. Survival in a time of revolutionary transformation like this requires the realization of a completely new society, like the one depicted in the Society 5.0 concept. To make this kind of society a reality, we need to create hitherto-unseen new values. To do so, it will be necessary for companies to adopt a clear open-close strategy and undertake innovation that makes skillful use of open platforms involving representatives of industry, academia, and government, as well as a wide range of members of the general public.

(2) Changes in the Environment Surrounding Universities and R&D Agencies and Their Role in Open Innovation

Universities and R&D agencies play a key role in creating outstanding knowledge, information, and technology (seeds) and personnel that are the source of innovation. These bodies have begun to embark on reforms in recent years, partly in response to social demand. The industrial sector now expects universities and R&D agencies to play a part in open innovation and hopes that they will become platforms for value creation. The following provides an overview of the roles required of universities and R&D agencies in open innovation.

① Linking knowledge, information, and technology (seeds) to society and serving as platforms for value creation

Industry expects universities and R&D agencies to serve as platforms for collaborative value creation by making use of their profound knowledge and insight to map out visions of the ideal future that should be pursued in partnership with society, and also by driving fully fledged joint research with companies.[1]

The 2006 amendment of the Basic Act on Education included an explicit statement that the mission of universities includes not only education and research, but also contributing to society by making available the fruits of its activities in those areas. Feeding back research output into society through industry-academia-government collaboration was thus clearly positioned as part of the mission of all universities, national, public, and private alike.

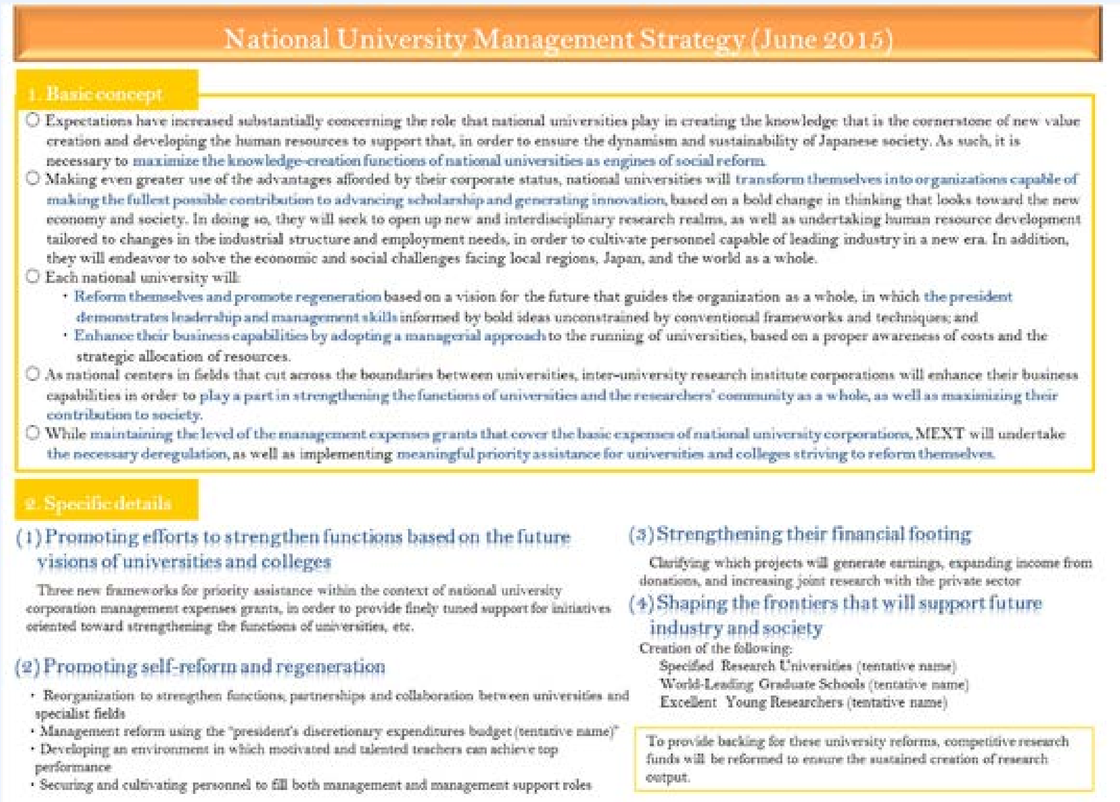
National universities were turned into national university corporations in 2004 as part of a wider process of university restructuring that followed deliberations from the long-term perspective of improving the quality of education and research, while respecting universities' autonomy.[2] The National University Management Strategy formulated by Ministry of Education, Culture, Sports, Science and Technology (MEXT) in 2015 showed universities that adopting a managerial approach to the running of universities, based on a proper awareness of costs and the strategic allocation of resources, would enable them to transform themselves into organizations capable of maximizing their contribution in such areas as the advancement of scholarship and the generation of innovation (Figure 1-1-14). Universities must fulfill

1 Japan Business Federation (Keidanren), *Toward the Enhancement of Joint Research Activities under the Framework of Industry-Academia-Government Collaboration* (February 16, 2016)

2 Final Report of the Administrative Reform Council (December 1997)

their mission to contribute to society within the context of undertaking independent research and education.

■ Figure 1-1-14 / National University Management Strategy



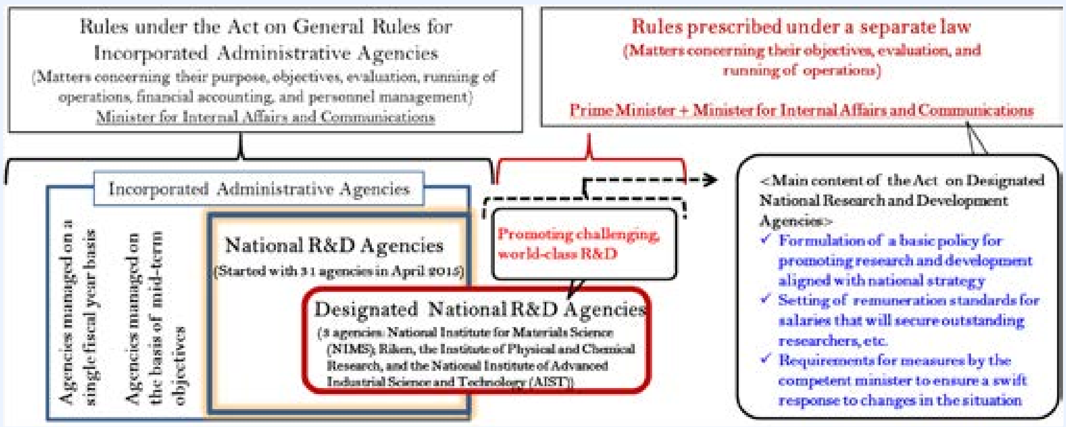
Source: MEXT, *National University Management Strategy* (June 2015)

Under the 2016 amendment of the National University Corporation Act, designated national university corporations will be established. These universities will implement strategic, effective initiatives that generate a virtuous circle by attracting high-caliber personnel who enhance research capabilities, thereby gaining the approbation and support of society. The first designated national university corporations are due to be named in the summer of 2017. Designated national university corporations are required to attract and nurture outstanding academic staff and students; enhance their research capabilities, including the creation of new academic disciplines and integration of fields; cooperate with and contribute to other countries through partnerships with universities and other organizations overseas; feed back the outcomes of education and research to society, including through full-scale academic-industrial collaboration; and enhance organizational governance and the corporation's financial footing in order to carry out the aforementioned activities. The creation of designated national university corporations is expected to enhance research capabilities that will contribute to open innovation and lead to further progress in academic-industrial collaboration.

National research and development agencies are corporations whose purpose is to ensure the maximum results from research and development in order to contribute to the sound development of the national economy and other public interests through improvements in the level of science and technology in Japan.[1] Maximizing the results of research and development means not only maximizing the direct results created by research and development conducted by the agency in question, but also serving as a bridge through partnership and cooperation with other organizations to maximize the results of research and development for the nation as a whole.

R&D agencies began to be formed in 2001, when most national research institutes and special public corporations progressively became incorporated administrative agencies. The Act on Improving the Capacity, and the Efficient Promotion of Research and Development through Promotion of Research and Development System Reform, which was enacted in 2008, positioned the development of innovation in law for the first time and prescribed matters concerning R&D agencies. The April 2015 amendment of the Act on General Rules for Incorporated Administrative Agencies resulted in the creation of 31 national research and development agencies, whose primary purpose is to maximize the results of research and development. Furthermore, the Act on Special Measures Concerning the Promotion of Research and Development by Designated National Research and Development Agencies was enacted in 2016, establishing a system of designated national R&D agencies to enhance the international competitiveness of industry and maximize world-class research and development outcomes (Figure 1-1-15).[2] For example, designated national R&D agencies can set high salaries to attract outstanding researchers; in addition, a special measure was put in place from FY2017, which enables such agencies to conclude negotiated contracts for goods and services worth no more than ¥5 million, as long as certain conditions are met.[3] Thus, the R&D agency system has been enhanced and strengthened to maximize the results of research and development.

■ Figure 1-1-15 / Designated National Research and Development Agency System



Source: Created by MEXT based on Cabinet Office information materials

While it is principally companies that bring innovation to fruition, cooperation with universities and R&D agencies is essential in order to ensure rapid social implementation. As described above, industry

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1 Article 2, Paragraph 3 of the Act on General Rules for Incorporated Administrative Agencies (Act No. 103 of 1999)
2 The National Institute for Materials Science (NIMS); Riken, the Institute of Physical and Chemical Research; and the National Institute of Advanced Industrial Science and Technology (AIST) are designated national R&D agencies.
3 The base amount for low-value negotiated contracts in the case of other R&D agencies is the same as for the government — ¥1.6 million for goods and ¥1 million for services — and negotiated contracts may only be used for sums below the base amount.

expectations regarding the seeds and research capabilities of universities and R&D agencies are growing, particularly in the arena of basic research, but these are not the only expectations. The public and impartial nature of universities and R&D agencies means that they are not simply a partner for companies; rather, they are required to become a platform for value creation, playing a central role in joint research and horizontal collaboration with multiple companies at the pre-competitive stage. They must not stand by with a passive attitude if outstanding research outcomes are created, waiting for companies to spot the seeds of value therein and commercialize them to feed those outcomes back into society. Accordingly, having been positioned as organizations with a crucial role to play in collaborative activities with companies, universities and R&D agencies need to increase their ability to gain an appropriate understanding of corporate needs and to pitch to them. In addition, they must reform their management systems and put in place organizational systems to facilitate industry- academia-government collaboration, by such means as appropriately managing both intellectual resources — in the form of personnel, knowledge, and money — and the risks associated with research activities.[1]

With growing calls for regional revitalization in recent years, universities are increasingly required to contribute to the local community as part of their efforts to contribute to society. Hopes concerning the role of universities in promoting regional revitalization are rising, so provincial universities in particular are hearing ever-louder calls to attract diverse, highly individual personnel capable of playing a leading role in the community.[2] Universities equipped with research staff, facilities, knowledge, and technology are required to function as engines of local innovation through the creation of new industries, by using their research capabilities to produce seeds and teaming up with local companies and local government bodies to commercialize them. There are high hopes that R&D agencies will also use their advanced, specialist research capabilities to lead local innovation, with the transfer of some of their functions to provincial areas currently under consideration.

In order to fulfill their mission of feeding back research output into society, universities and R&D agencies need to enhance their management functions as organizations and develop systems that will enable them to share their vision with companies and the community, and function as platforms for co-creation.

② Producing new knowledge, information, and technology (seeds)

The industrial sector expects universities and R&D agencies to maximize research results with a view to the future.[3]

Academic research and basic research that create diverse and outstanding knowledge that is the source of innovation are mainly carried out by universities and R&D agencies. Furthermore, it is not the case that industry only needs universities and R&D agencies to produce seeds of innovation that can lead directly to immediate commercialization. Rather than half-baked research undertaken with commercial use in mind, industry actually requires them to steadily implement academic and basic research of the kind that it is difficult for companies to undertake themselves, given their need to pursue profits.[4] Innovative seeds are

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1 The Japan Business Federation (Keidanren) proposal *Toward the Enhancement of Joint Research Activities under the Framework of Industry-Academia-Government Collaboration* (February 16, 2016) requests that planning and management functions be established in university and R&D agency headquarters (industrial collaboration management offices, etc.) to build a system that cuts across faculty boundaries and promotes joint research.

2 National Governors' Association, *Radical Urgent Measures for Promoting Local Universities* (November 28, 2016)

3 Japan Business Federation (Keidanren), *Toward the Enhancement of Joint Research Activities under the Framework of Industry-Academia-Government Collaboration* (February 16, 2016)

4 The Japan Business Federation (Keidanren) proposal *Toward the Enhancement of Joint Research Activities under the Framework of Industry-Academia-*

created through the steady accumulation of grassroots academic and basic research. For example, Satoshi Omura was awarded the Nobel Prize in Physiology or Medicine in 2015 for his "discoveries concerning a novel therapy against infections caused by roundworm parasites," which has saved many lives. However, Omura did not start out with the objective of developing that specific drug; rather, it was the end result of steady research into the antibiotics produced by microorganisms in soil.

How does Japan's academic and basic research fare when viewed in an international context? While the number of academic papers worldwide demonstrates consistent growth, the number of papers emanating from Japan has remained flat for the last ten years and the increase in the number of papers from other countries means that Japan has slipped down the rankings. This trend is particularly pronounced in the case of high-impact papers, namely the adjusted top 10% papers, which are those receiving the most citations (Figure 1-1-16).

To see how many papers produced led to a patent, let us look at the papers that were cited in U.S.A.-registered patents as a percentage of all papers. Japan is second only to the U.S.A. (Figure 1-1-17), so one can say that papers representing the outcomes of academic and basic research are steadily leading to seeds in the form of patents.

Consequently, it is vital to enhance the research capabilities of universities and public research institutions, which are the principal organizations undertaking academic and basic research and producing papers.

■ Figure 1-1-16 / Number of Adjusted Top 10% Papers by Country/Region: Top 10 Countries and Regions (Fractional Count)

All fields	1992–1994 (PY) (average)		
	Number of adjusted top 10% papers		
Country/ region name	Fractional count		
	Number of papers	Share	Rank
U.S.A.	27,434	49.2	1
UK	4,628	8.3	2
Japan	3,240	5.8	3
Germany	3,220	5.8	4
France	2,586	4.6	5
Canada	2,553	4.6	6
Netherlands	1,393	2.5	7
Italy	1,278	2.3	8
Australia	1,110	2.0	9
Sweden	997	1.8	10

All fields	1992–1994 (PY) (average)		
	Number of adjusted top 10% papers		
Country/ region name	Fractional count		
	Number of papers	Share	Rank
U.S.A.	32,239	40.1	1
UK	6,144	7.6	2
Germany	5,297	6.6	3
Japan	4,593	5.7	4
France	3,569	4.4	5
Canada	2,959	3.7	6
China	2,909	3.6	7
Italy	2,479	3.1	8
Netherlands	1,944	2.4	9
Australia	1,802	2.2	10

All fields	1992–1994 (PY) (average)		
	Number of adjusted top 10% papers		
Country/ region name	Fractional count		
	Number of papers	Share	Rank
U.S.A.	38,964	29.7	1
China	18,052	13.8	2
UK	8,196	6.2	3
Germany	7,827	6.0	4
France	4,924	3.8	5
Italy	4,528	3.4	6
Japan	4,331	3.3	7
Canada	4,296	3.3	8
Australia	3,929	3.0	9
Spain	3,665	2.8	10

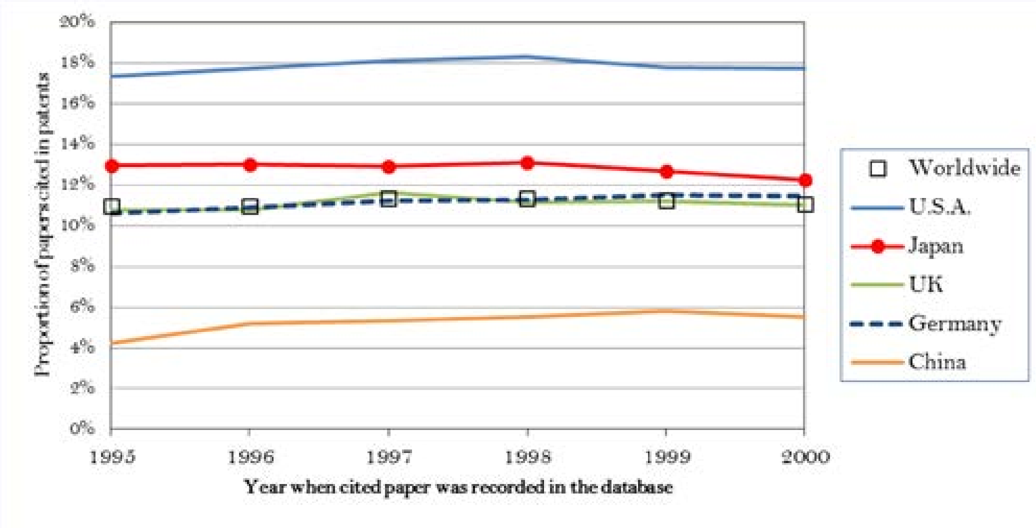
Note: Compiled by the National Institute of Science and Technology Policy from Web of Science XML (SCIE, end of 2015 version). Analysis focuses on articles and reviews. Annual figures are compiled by publication year (PY). Number of citations is the figure as of the end of 2015.

Source: Created by MEXT based on National Institute of Science and Technology Policy, *Science and Technology Indicators 2016* Survey Data 251 (August 2016)

Government Collaboration (February 16, 2016) states, "Amid the transformation of the economic and social structure typified by 'the Fourth Industrial Revolution' and 'Society 5.0,' among others, diverse research activities that fully leverage the comprehensive strengths of universities and R&D agencies — which have the kind of high-level basic research ability and assets in both the humanities and science and technology that companies tend to lack — are becoming increasingly important, in order to generate results that will contribute to the creation of innovative fields."

■ Figure 1-1-17 / Papers Cited in U.S.A. Patents as a Percentage of All Papers

This shows the percentage of papers from each country recorded in the database between 1995 and 2000 that were cited in patents registered in the U.S.A. between 1995 and 2015. Few papers are cited in patents immediately after being recorded in the database and there is a tendency for citations to rise over time, so this graph focuses on papers that were recorded in the database at least 15 years earlier.



Note: This graph shows the number of citations in U.S.A. patents registered between 1995 and 2015, so the data may change in the future. Moreover, it is based on the results of an interim tabulation and may be corrected as a result of more thorough examination in the future. The number of citations by country is calculated by means of the full counting method.

(Source) Created by Hiroyuki Tomizawa based on Web of Science (items recorded 1995–2012) and USPTO Patent Grant Bibliographic Data (items registered 1995–2015)

Data: Hiroyuki Tomizawa (National Institute of Science and Technology Policy), synopsis of general lecture to the Japan Society for Research Policy and Innovation Management: "A Discussion of the Future Prospects of Key Indicators Set by the 5th Science and Technology Basic Plan" (November 2016)

The main sources of funding to support academic and basic research are the management expenses grants paid to national universities and basic funds such as subsidies for private schools, along with Japan Society for the Promotion of Science (JSPS) KAKENHI grants-in-aid for scientific research. Management expenses grants for national university corporations and R&D agencies are dwindling, and even private universities are seeing a slight downturn in the proportion of financial assistance provided through subsidies for ordinary expenditure. Universities and R&D agencies need to shore up their financial footing by engaging in more efficient, effective management based on the strategic allocation of internal resources, while also securing external funding from sources other than the government. The government has indicated that it will enhance frameworks for industry-academia -government collaboration, and will aim to triple private sector investment in universities and R&D agencies by 2025.[1] However, while private sector investment in the form of funding for joint research, for example, is growing, the average sum invested per project remains low (described later in this section, in 2. (2) ①).

As well as organization-wide efforts to strengthen their financial footing by such means as increasing private sector investment, universities and R&D agencies need to maintain and enhance the creation of output as organizations that primarily undertake academic and basic research.

1 The Japan Revitalization Strategy 2016 states that the government will "aim to triple investment from companies to universities and National R&D Institutes and etc. by FY2025, taking it above the OECD average."

③ Cultivating personnel capable of generating innovation

As well as a diverse array of researchers with specialist expertise, universities and R&D agencies undertaking open innovation require a variety of other personnel to facilitate the creation of advance knowledge and promote its social implementation. These include managerial personnel to formulate strategy covering innovation as a whole; entrepreneurial personnel to promote the creation of agile, flexible startup companies; and coordinators to handle technology transfer, in the form of program managers (PMs), who deal with the planning and management of regional development projects, and university research administrators (URAs), whose primary role is to manage research activities as a whole. Universities and R&D agencies have a part to play in clarifying the career paths and statuses of the diverse personnel involved in innovation, while undertaking human resource development and creating an environment in which each individual can demonstrate their abilities by ensuring that the right personnel are deployed in the right place.

MEXT and METI have already jointly organized the Roundtable for Human Resource Development through Industry-University Collaboration (FY2011-12) and the Industry-Academia-Government Collaborative Roundtable on Human Resources Development in Science and Technology (FY2015-16) to enhance the quality and ensure sufficient quantity of science and technology personnel capable of playing an active role in industry. These provided a forum for dialogue between industry, academia and government, to discuss the development of the human resources required by industry and measures for encouraging the personnel cultivated to play an active role in industry.

It is people who spark innovation: when people interact across organizational and sectoral boundaries, they inspire each other to develop and blend a diverse array of knowledge, thereby creating new value. One role of universities and R&D agencies is to generate a virtuous circle of human resources by ensuring that the right human resources are deployed in the right place throughout society, facilitating people-to-people exchange not only within a single institution, but across the boundaries between institutions, fields, and sectors — including large corporations, SMEs, and startup companies — so that innovation can take place swiftly and effectively.

Through the Council for Science and Technology's Committee on Human Resources, MEXT has been engaging in discussions on the direction to be taken in promoting greater mobility among human resources, with a focus on platforms for facilitating activity on a wider stage. These discussions take into account trends in doctoral programs at graduate schools, which are centers for developing knowledge professionals in the form of doctorate holders.

In terms of actions by R&D agencies, the National Institute of Advanced Industrial Science and Technology (AIST) started up its Innovation School in FY2008, employing young postdoctoral researchers and providing them with practical training at companies in order to produce work-ready personnel capable of playing an active role at companies and in a variety of other crucial parts of society. Since FY2015, the Japan Science and Technology Agency (the JST) has been strengthening its bridging functions by implementing a practical program to develop the skills of PMs throughout the program management process by having them propose and implement programs.

Universities and R&D agencies have been playing a major role in feeding back research results to society and generating innovation for some time now. However, in the age of revolutionary transformation that awaits us, when speed will be of the essence, industry-academia -government collaboration based on the sharing of visions with society and seamless implementation of the whole process from basic research through to social implementation will be required. While seeking to further strengthen the foundations, this will need to go beyond the conventional passive, linear model (in which industry picks up any outstanding results for commercialization), in order to produce results that will lead to innovation. Today's universities and R&D agencies are acquiring an even greater role in building the co-creation platforms and developing the innovative personnel required to achieve this.

It is not only within the context of undertaking open innovation that these roles are required of universities and R&D agencies. The primary role of universities is to carry out research, provide education, and contribute to society. For universities, contributing to society does not simply mean providing services or facilities free of charge; rather, it involves making full use of their attributes as seats of learning — in other words, feeding back to the local community the knowledge acquired and transmitted through universities' education and research activities through the mechanism of social contributions. Universities should contribute to society by helping to shape a richer society through joint research and technology transfer based on industry-academia-government collaboration. By fulfilling this role to the fullest extent possible, putting in place systems that will enable them to achieve their mission, and promoting those systems, universities and R&D agencies will be fulfilling their primary role amid social change in the form of efforts to promote open innovation.

(3) Startups Required to Build an Innovation Ecosystem

Startup companies are one of the key sources of innovation for the Japanese economy as a whole, spearheading the creation of innovative technologies and creative business models in a way that is difficult for existing companies. Of these, university startups play an important role in linking the seeds produced by universities and colleges to society.

① The importance of startups in an innovation ecosystem

Startup companies are one of the key sources of innovation for the Japanese economy as a whole, spearheading the creation of innovative technologies and creative business models. In particular, they use the novelty of their technologies and business models as a weapon in taking on the challenge of businesses that present bigger business risks in comparison to existing companies. As such, they have the potential to bring about changes and innovation in technologies and business models that existing companies cannot achieve. For large corporations in countries such as the U.S.A., collaborating with startup companies as part of open innovation is regarded not only as a way to speed up research and development, but also as a powerful means of creating new and future business that cuts across the existing business domains of each company. As open innovation develops in Japan as well, relationships between large corporations and startup companies are evolving from the conventional support model into a relationship between innovation partners, who circulate their management resources to each other to create value. Partnerships in this area are already progressing.[1]

Startup companies that create innovative technologies and creative business models contribute to the

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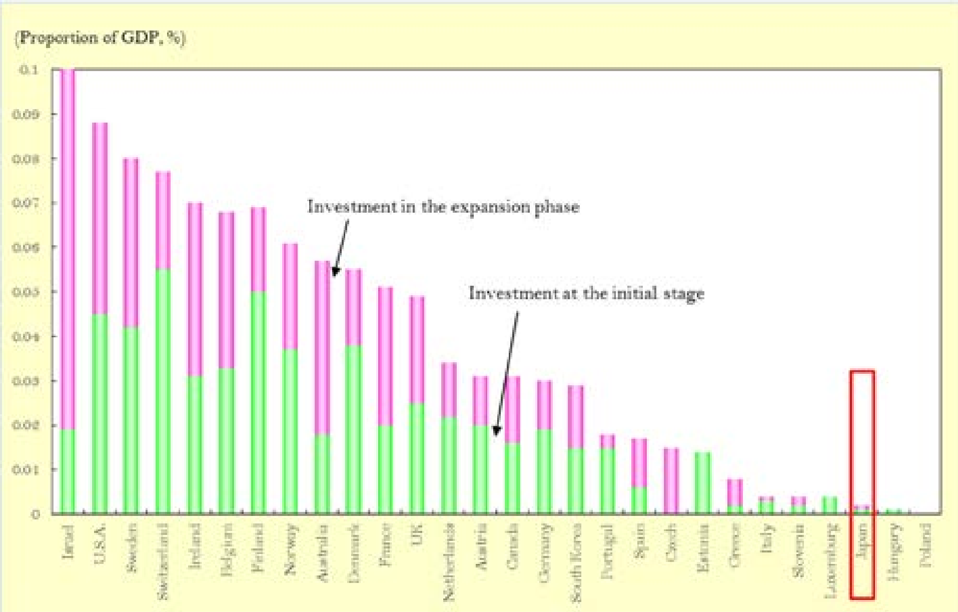
1 Japan Business Federation (Keidanren), *Creating and Nurturing Startups That Can Contribute to the Development of New Key Industries* (December 15, 2015)

growth and dynamism of the economy as a whole by generating new markets. Even in Japan, the awareness that support for starting of businesses plays a crucial role in economic growth is spreading and efforts are underway to enhance the entrepreneurial environment. However, the environment for startups in Japan is still not rated very highly — especially in comparison with the U.S.A., where startups function as a driver of economic growth — and venture capital investment as a proportion of GDP is still extremely low when compared to other countries around the world (Figure 1-1-18).[1]

■ Figure 1-1-18 / Venture Capital Investment in Each Country as a Proportion of GDP (actual figures for FY2009)



Note: The figure for Israel is 0.176

(Source) Created by the Cabinet Office based on OECD, *Science, Technology and Industry Scoreboard* and Venture Enterprise Center, *2011 Venture Business Review and Prospects*

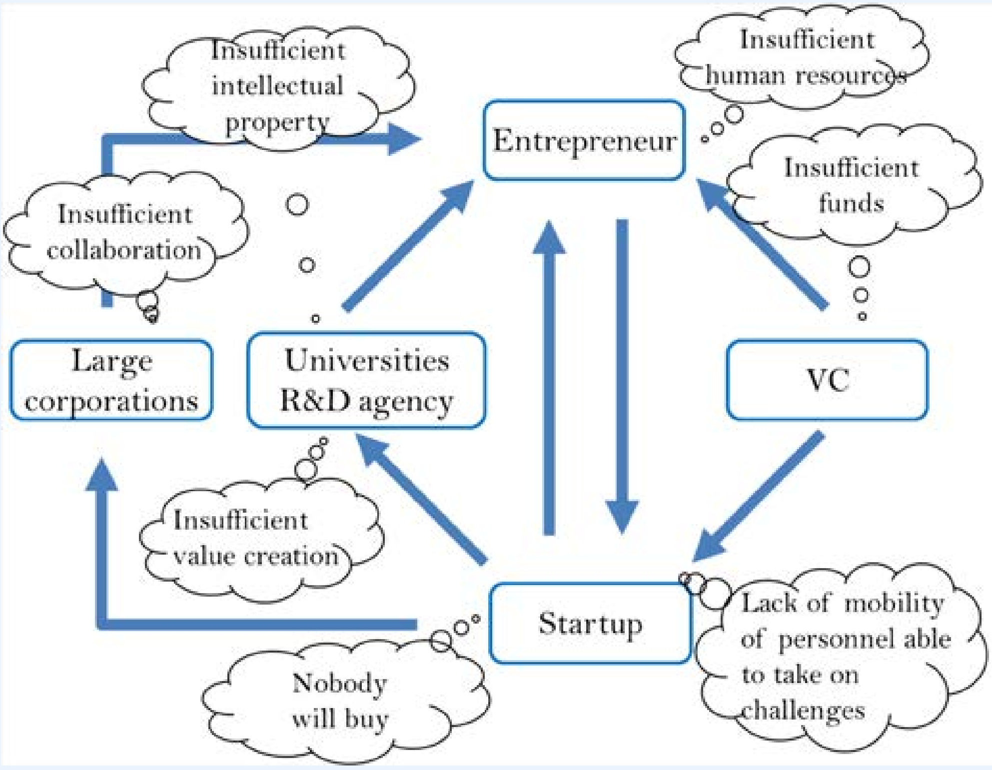
Data: Cabinet Office, *Annual Report on the Japanese Economy and Public Finance 2012* (July 2012)

② Feeding back knowledge into society via university startups

It is anticipated that, in generating innovation, university startups will take knowledge from universities and colleges that would otherwise not be plowed back into society and leverage it to bring new value to the market, thereby creating value for the economy and society. In his 2004 book, renowned university startup researcher Scott Shane asserts that, based on a diverse array of data, university startups create substantial economic value and make a great contribution to employment creation and economic growth.[2] In fact, university startups and other forms of technology transfer from universities played a major role in both the regeneration of the U.S.A. in the 1990s and the economic growth of countries worldwide.[3] It is necessary to build a startup ecosystem in Japan as well (Figure 1-1-19).

1 MEXT, *Anthology of Reference Data on the Medium- to Long-term Prospects for Science, Technology and Innovation in Japan* (January 20, 2015)
2 Kanai Kazuyori, "University Startups: Expectations and Challenges," *Sangakukan Journal* October 2014 issue
3 Kanai Kazuyori, "University Startups: Expectations and Challenges," *Sangakukan Journal* October 2014 issue

■ Figure 1-1-19 / Startup Ecosystem



Source: Created by MEXT with reference to METI explanatory materials at the 2nd meeting of the Startup Council, Council for Advancing Structural Reform, Growth Strategy Council -Investing for the Future (February 23, 2017)

Universities and R&D agencies are expected not only to serve as centers for the creation of seeds that will become the source of innovation, but also to play a role in educating entrepreneurs, developing practical applications for seeds and commercializing them, and feeding back the outcomes of their activities into society. University startups are also active in provincial areas and it is hoped that their growth will stimulate local economies through not only innovation in the community, but also the possibility that this will lead to greater employment opportunities for highly educated research and development personnel. Regional clusters of university startups that commercialize the research results of universities and R&D agencies also have the potential to contribute to the community by triggering the formation of additional industry clusters that will create new value for that region.

Thus, startup companies such as university startups, which use knowledge from universities and R&D agencies to bring new value to the market, are expected to play a key role in generating innovation and also contribute substantially to the growth and dynamism of the economy as a whole. As such, it is necessary to build a startup ecosystem in Japan, as well.

2 Domestic and International Trends in Open Innovation

As well as introducing policies in other countries where open innovation initiatives are underway and examples of advanced initiatives, this part examines Japan's own policies on open innovation and sheds light on the structural problems that our nation faces in undertaking open innovation.

(1) Advanced Initiatives Overseas

While the modality of open innovation differs from one country to another, the countries of the West in particular are implementing policies proactively: in the U.S.A., private sector companies are the main players in open innovation, while in Germany, public research institutions play a major bridging role. The following explains the open innovation policies of major countries.

① Open innovation policies of major countries

The table below provides a summary of innovation policies in major countries, especially open innovation policies, with a particular focus on national strategies and other policy documents (Table 1-1-20). This shows that Western countries are already actively implementing open innovation. At the same time, while they have not formulated such clear policies as Western countries, Asian countries are steadily embarking on moves aimed at open innovation. Thus, while the modalities differ from one country to another, each country is working on open innovation policies.

■ Table 1-1-20 / Trends in Open Innovation Policy in Major Countries

U.S.A.	○ The 2015 Strategy for American Innovation, which was published as a joint document by the National Economic Council and the White House Office of Science and Technology Policy on October 21, 2015, under the Obama administration, refers to open innovation. ○ The strategy highlighted open innovation and declining barriers to entrepreneurship. ○ The FY2018 presidential budget proposal published by the Trump administration on March 16, 2017 cuts science and technology budgets across the board, except in the area of defense technology, but its positioning in the context of open innovation policy is unclear.
EU	○ On June 22, 2015, EU Commissioner for Research, Science, and Innovation Carlos Moedas set out his basic policy on research and innovation in a speech entitled *Open Innovation, Open Science, Open to the World*. ○ A publication describing the European Commission's vision that was based on this speech sets out three key pillars for its policy on open innovation: reforming the regulatory environment; encouraging private sector investment in research and innovation; and maximizing impact. ○ As well as reflecting this policy in initiatives financed by Horizon 2020 and the European Structural and Investment Funds, which provide funding for research and innovation, the EU is undertaking deliberations aimed at the establishment of a European Innovation Council.
France	○ The Ministry for the Economy and Finance is spearheading an initiative called the Open Innovation Alliance, to serve as a framework for promoting open innovation. ○ This initiative will provide a platform for supporting companies as they work together through the whole process of analyzing their own strengths and weaknesses; developing an awareness of the areas that they should make open and the opportunities for doing so; building fair financial, technical, operational, and organizational rules; and embracing risk and failure. More than 100 companies and organizations are already taking part.
Germany	○ The new High-Tech Strategy — the basic policy on science, technology and innovation of the third Merkel administration (2014–2017) — refers to the promotion of open innovation to enhance the innovation environment and the need to incorporate SMEs. ○ In a 2013 recommendation, the Commission of Experts for Research and Innovation — an advisory body to the federal chancellor — stated that international collaboration in research and development aimed at solving global social issues is growing and that one of the reasons for this is the growing global trend for innovation systems to be dispersed around the world (open innovation).
UK	○ The main focus of the current Science and Innovation Strategy, which was published on December 17, 2014, is open access (sharing of research output, data, and information), with no mention of open innovation. ○ One distinctive feature of the British policy-making process is the independent review mechanism; the Dowling Review published in July 2015 made recommendations to the government concerning measures for promoting and enhancing world-class research output and partnerships with companies at British universities. This review also called attention to open innovation models, which have been growing in recent years, and pointed out the significance of industry to industry collaboration across multiple fields in non-competitive realms, along with collaboration between industry and academia (and government).
Netherlands	○ As well as central government, local governments in the Netherlands are taking the initiative in this area. Regional initiatives are deployed in conjunction with the central government's top-sector policy, which is led by the Ministry of Economic Affairs and identifies nine industrial sectors where the Netherlands demonstrates particular strength. ○ On the other hand, the government's vision for science policy through to 2025, which was published in December 2014, mainly focuses on open access, open data, and open science, with no mention of open innovation.
China	○ China's 13th Five-Year Plan on Science, Technology and Innovation (2016–2020), which was announced by the State Council in August 2016, advocates building open and coordinated innovation networks as one task required in order to build an efficient national innovation system.
South Korea	○ The Third Science and Technology Basic Plan (2013–2017), which was formulated in July 2013, positions support for the creation of new industries as one of five strategic fields and advocates support for industry in the form of a policy based on shifting to company startups and the creation of new industries as the purpose of industry-academia-government collaboration.

Source: Prepared by MEXT based on information materials from the Japan Science and Technology Agency's Center for Research and Development Strategy

② Advanced examples overseas

This part highlights examples of universities and public research institutions overseas that made an early start on open innovation. The first example is Stanford University, a U.S. university with thriving entrepreneurial initiatives, in a country where private sector companies drive open innovation. The second profiles initiatives by a public research institution, in the form of Germany's Fraunhofer-Gesellschaft, one of the largest applied research organizations in Europe.

○ Stanford University

Stanford University is a private university located in the heart of California's Silicon Valley. It has approximately 16,000 students and around 2,100 teaching staff.

Stanford University's Office of Technology Licensing (OTL) is a trailblazing presence, even when compared against other organizations in the U.S.A. Institutional technology licensing activities at Stanford University began with the establishment of OTL in 1970. At Stanford University, it is a fundamental principle that inventions based on the outcomes of research at the university all belong to the university. If the inventor wishes to file a patent application for university research output, they submit an application to OTL and a screening panel made up of experts from OTL examines it. Applications passed by OTL become the property of the university, which then covers all costs associated with filing patent applications, including international patent applications.[1]

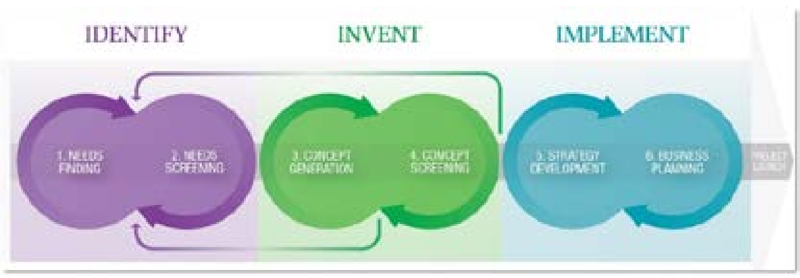
It took 18 years for OTL to become profitable after its establishment, but today it receives tens of millions of dollars each year in royalty income. OTL licenses patents when startup companies are being founded, but because startups have no cash, remuneration is paid in the form of unlisted stock. This means that OTL can obtain cash (profit on the sale of stock) in the event of an M&A (merger/acquisition) or IPO (initial public offering, when stock is first offered to the public). While there are considerable fluctuations in profits on the sale of stock from year to year, OTL sells several stocks every year (Figure 1-1-21).

Since 1970, Stanford University inventions have generated approximately $1.86 billion in license income, but just three — one of which is Google — of the more than 11,000 inventions have generated license income in excess of $100 million, while only 95 have topped the $1 million mark.

After deducting a 15% management fee and any expenses, the remaining royalty income is divided into three equal shares, which go to the inventor, their department, and the university. OTL takes 15% of any profit on the sale of stock, with one-third of the remainder allocated to the inventor and two-thirds going into the university's education and research funds. To avoid the risk of conflict of interest, the stocks are handled by the university's asset management body, the Stanford Management Company, which is independent of the university.

Activities relating to entrepreneurship are also thriving at Stanford University, which engages in everything from cultivating entrepreneurs to supporting startup companies.

To support efforts to produce entrepreneurs, Stanford has the Birdseed Fund, which provides laboratories with funding to develop prototypes of university technology that has not been licensed. It also has the Gap Fund, which provides laboratories with funding to develop promising university technologies to a level at which they can be licensed.[2]



The Biodesign Process

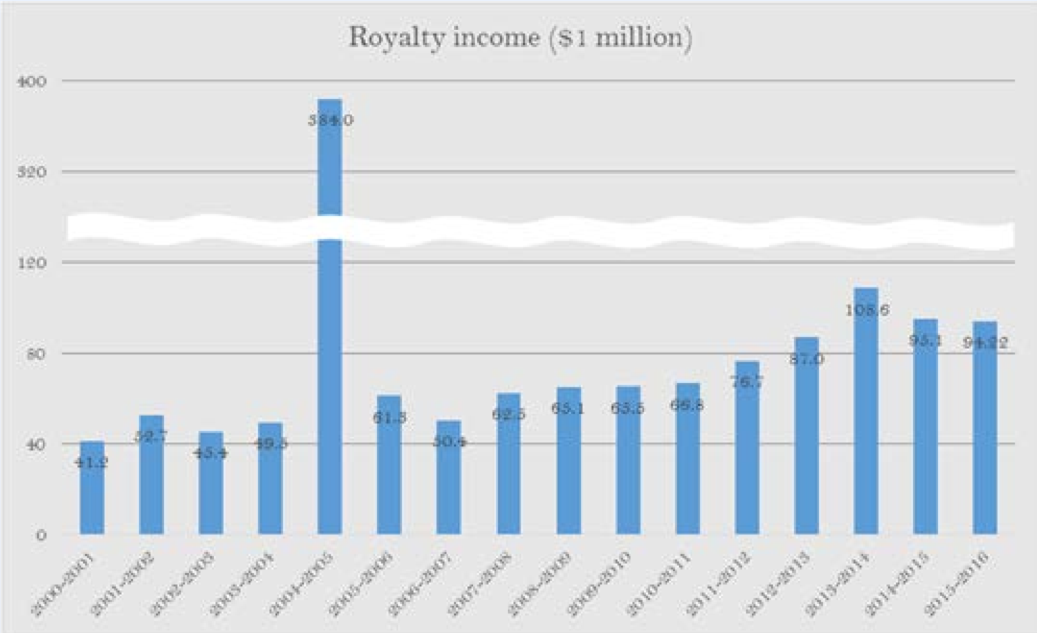
Source: Fumiaki Ikeno, Program Director (U.S.) Japan Biodesign, Stanford Biodesign

1 If the screening panel does not select the invention, the rights to it are transferred to the inventor. This means that the inventor must cover all costs associated with a patent application.

2 Kanto Bureau of Economy, Trade and Industry, *Entrepreneur Production and the Entrepreneurship Support Environment at Universities Overseas*

Among its specific programs is Biodesign, which was launched by Paul Yock and others in 2001 as a human resource development program to drive innovation in the field of medical devices, based on design thinking. This program's key feature is an approach that generates innovation by taking actual clinical needs as the starting point for developing solutions to problems, while examining perspectives from the initial stages of development through to commercialization. There is also a course called a fellowship, which lasts about a year. Entry onto this course is highly competitive, with more than 18 times as many applications as there are places being received from all over the world. Each year, 8-12 people are selected for the course, which has resulted in the founding of 40 companies and more than 400 patent applications over its 14-year history.[1]

■ Figure 1-1-21 / Stanford University OTL's Income From Royalties and Profit on Sale of Stock



Profit on sale of stock ($1 million)	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
	2.1	0.4	0.0	0.7	336.0	3.3	0.5	1.4	0.2	1.3	2.4	1.2	1.0	23.2	3.2	–

Source: Prepared by MEXT based on the Stanford University OTL website[2]

○ Fraunhofer-Gesellschaft

The German public research institution Fraunhofer-Gesellschaft (Fraunhofer) is said to be the world's most famous and successful institution bridging the gap between scientific knowledge and innovation. Fraunhofer was established in 1949 by the state of Bavaria, to promote industrial reconstruction in the aftermath of World War II. Having initially functioned as a funding allocation body, it opened its own research institute in 1954. Thereafter, it underwent a radical change of management structure and currently undertakes applied research focused on practical applications for private sector companies and public organizations alike, aiming to benefit the whole of society. Specifically, it undertakes the following five key activities:

1 Biodesign Japan website (http://www.jamti.or.jp/biodesign/)
2 http://otl.stanford.edu/

a) Research commissioned by companies

b) Licensing of patents acquired on the basis of research output

c) Feeding back research results into society by starting up companies based on its inventions or new services

d) Supplying researchers for industry

e) Providing companies with cutting-edge equipment

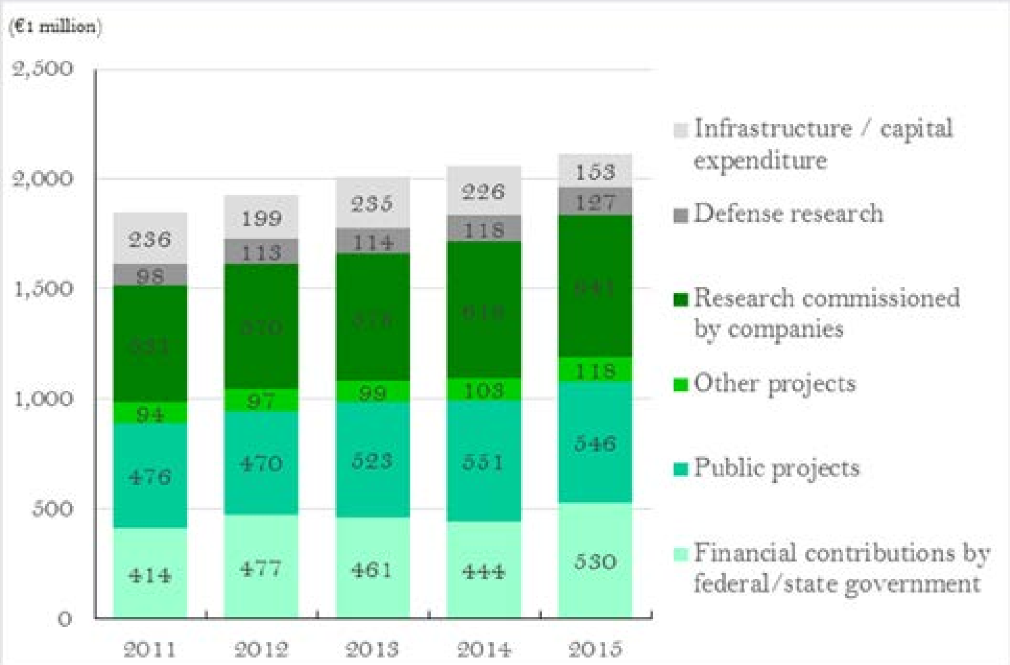
Fraunhofer has 69 research institutes throughout Germany, with around 24,500 staff. Most of its research institutes are located on or near university campuses, with most of the heads of those institutes also serving concurrently on university faculties.

Its total annual research expenditure is approximately €2.1 billion, more than €1.8 billion of which comes from commissioned research; thus, more than 70% of its total research expenditure comes from public projects and research commissioned by private sector companies. The remaining 30% takes the form of management and maintenance costs funded by the federal government and state governments (Figure 1-1-22).

The federal and state government financial contributions are based on a mechanism called the Fraunhofer Model, in which grants are linked to the organization's success in earning commissioned research income from companies the previous year (Figure 1-1-23). Once it has fulfilled its mission as a public research institution to undertake non-competitive research, it accepts commissions for research from companies. The basic funding allocation mechanism consists of four elements, of which Basic 3 is the most distinctive feature (addition of matching funds distributed in proportion to the share of the total actual budget for revenue earned from companies during the previous fiscal year).

Due in part to this institutional grant mechanism, Fraunhofer plays a central role in generating innovation in both Germany and Europe as a whole, as a public research institution with an intermediary function, based on a clear strategy of pursuing applied research and research into near-future technologies.

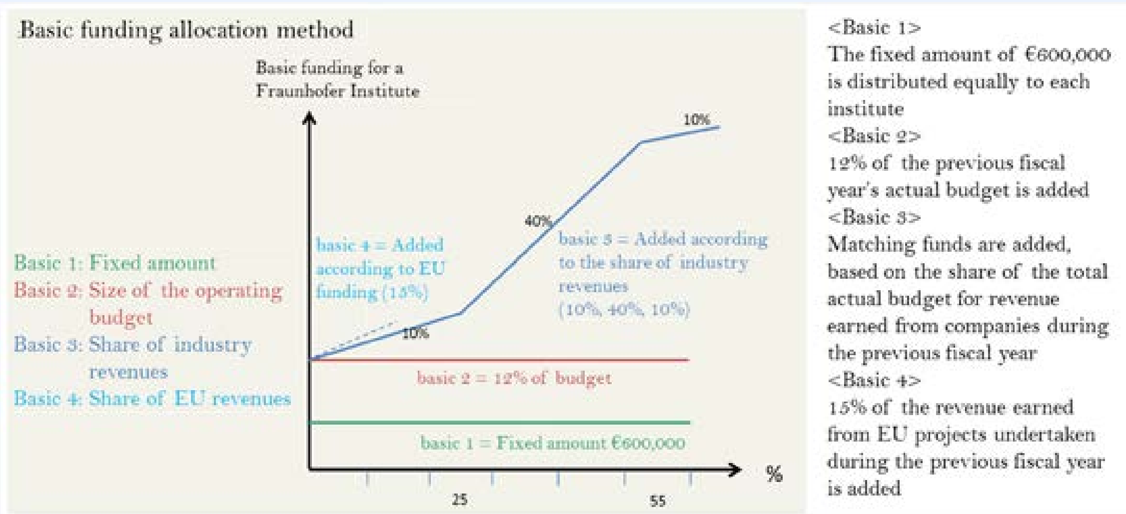
Figure 1-1-22 / Fraunhofer's Research Budget (unit: €1 million)



Source: Prepared by MEXT based on the Fraunhofer Representative Office Japan pamphlet and Annual Report

Figure 1-1-23 / The Fraunhofer Model

Basic 3 is the portion based on income from research commissioned by companies during the previous fiscal year. It is 10% if the income from research commissioned by companies during the previous fiscal year was less than 25% and 40% if that income was between 25% and 55%, returning to 10% in cases where income from corporate research was above 55%.



Source: Industrial Structure Council Committee on Industrial Science and Technology Policy and Environment, information materials distributed at the second meeting of the R&D and Evaluation Subcommittee (February 2014)

In the U.S.A., one often sees a pattern where startup companies spun out from universities serve as an intermediary, while in Germany and other European countries, public research institutions often serve as an intermediary for commercializing technology seeds.[1] Either way, one can see that the ecosystem that has been put in place incorporates universities and public research institutions as leaders in the field of open innovation.

(2) Current Status of Policy and Open Innovation in Japan

While it was in 2003 that Henry Chesbrough first advocated open innovation, initiatives related to open innovation had already been progressing little by little for some time. Let us now look back over Japan's policies related to open innovation. Policies related to open innovation span a wide range of areas, including industrial policy, monetary policy, science and technology policy, and education policy. As this white paper focuses on universities and R&D agencies, this section will look at changes in science and technology policy centered on industry-academia-government collaboration measures, examining the current situation and the effectiveness of those measures.

The Basic Act on Science and Technology was enacted and came into effect in November 1995 as legislation proposed by Diet members. The Basic Act provides that the government must formulate a basic plan in order to achieve comprehensive and systematic promotion of policies to advance science and technology (Table 1-1-24).

1 Industrial Structure Council Committee on Industrial Science and Technology Policy and Environment, information materials distributed at the second meeting of the R&D and Evaluation Subcommittee *Discussion Points Regarding the Overall System of Innovation (Draft)* (February 28, 2014)

■ Table 1-1-24 / Changes in References to Industry-Academia-Government Collaboration and Open Innovation in the Science and Technology Basic Plans

1st Basic Plan (FY1996–2000)	Sought to promote cooperation among industry, academia, and government, including the following: promoting human exchanges between industry, academia and government through the development and use of a fixed-term appointment system and permitting national researchers to undertake outside work; promoting joint use of R&D facilities and equipment; and reverting to individuals patent rights obtained regarding the outcomes of research funded by government investment.
2nd Basic Plan (FY2001–2005)	Sought to ensure that the fixed-term appointment system for young researchers became firmly and widely established, as well as pursuing the reform of systems of information distribution and human resource exchange. Sought to reinforce industrial technology and reform industry-academia-government collaboration by promoting technological transfer from public research organizations to industry and the commercialization of the R&D results of public research organizations. Regarding intellectual property, the plan pursued a switch away from the assignment to individual researchers of patent rights held by public research organizations, in favor of promoting the management of those rights by organizations, as a general rule. The plan also covered the enhancement of the environment for activating venture enterprises (startups).
3rd Basic Plan (FY2006–2010)	Stating that industry-academia-government collaboration is an important means for realizing the creation of innovation, the plan sought to build a system for the sustainable development of industry-academia-government collaboration by promoting autonomous efforts by universities in such areas as developing industry-academia-government trust and positioning industry-academia-government collaboration activities in their operation policies. It also sought to revitalize and enhance the collaboration of university intellectual property centers and technology licensing organizations (TLOs). In addition, the plan aimed to promote the entrepreneurial activities of R&D startups, including startups initiated by universities (university startups).
4th Basic Plan (2011–2015)	The plan advocated the integrated promotion of science, technology and innovation policies as a basic principle. Noting that open innovation initiatives were progressing rapidly worldwide, the plan aimed to further expand industry-academia-government collaboration by enhancing knowledge networks involving inter-university cooperation and partnerships with financial institutions, as well as by creating new places for industry-academia-government collaboration, including the formation of research and development centers that bring together the diverse research and development capabilities of industry, academia, and government. The plan also aimed to put in place an environment conducive to strengthening support for startup ventures based on advanced science and technology.
5th Basic Plan (2016–2020)	To enhance mechanisms for the full-scale promotion of open innovation, the plan stated that the government will push to strengthen initiatives that promote open innovation by industry, universities, and public research institutes; induce a virtuous circle of human resources; and establish spaces for co-creation to collectively mobilize the human resources, knowledge, and capital available to industry, academia, and government. It also covered efforts to enhance the creation of SMEs and startup companies.

Source: Compiled by MEXT

The first Basic Plan in which the term "open innovation" appeared was the 4th Basic Plan. Then, the 5th Basic Plan, applicable from FY2016, set forth that in order to strengthen Japan’s future competitiveness amid the progressing global initiatives for open innovation, an innovation system will be built to ensure the mobility of human resources, knowledge, and capital beyond all kinds of barriers, and keep Japan at the leading edge of worldwide innovation, through building effective collaboration between companies, universities, and public research institutes, and by both creating and strengthening venture businesses. Specifically, the government will promote such efforts of individual companies, universities, and public research institutes to enhance systematic structures for promoting open innovation through management reform, induce a virtuous cycle of human resources through cross-appointment, etc., create such places which are centered around universities and public research institutes by defining appropriate spheres of competition and cooperation, enhance the creation of startup companies, and cultivate human resources with an entrepreneurial mentality.

Let us now examine Japan's science and technology policy related to open innovation from the perspectives of the development of university frameworks, technology transfer via intellectual property, changes in the form of industry-academia-government collaboration, startup companies, securing and cultivating personnel, and the research and development tax system.

① Development of frameworks for industry-academia-government collaboration at universities and R&D agencies

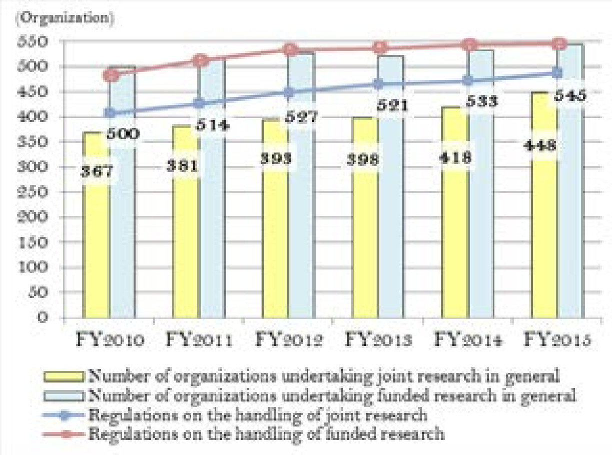
In the late 1970s, universities began to undertake funded research and to accept contract researchers and scholarship donations. In FY1983, systems for joint research with the private sector were put in place at national universities, with joint research centers being established at national universities from FY1987. However, prior to the FY2004 establishment of national university corporations, industry-academia-government collaboration primarily took the form of activities by individual researchers.

Taking advantage of the opportunity presented by the establishment of national university corporations, MEXT implemented a program called "Improvement of Center for Intellectual Property in University" in FY2003–2007, which played a major role in putting in place organizations and frameworks for industry-academia-government collaboration at universities. Following on from this, the Universities Industry–Academia–Government Collaboration Self-Reliance Promotion Program implemented in FY2008–2012 drove steady progress in initiatives tailored to each university's characteristics and the development of coordinating personnel.

This was also the period when the Basic Act on Education was amended in 2006 to stipulate that the mission of universities and colleges in Japan included not only education and research, but also contributing to society by making available the fruits of their education and research. In light of this, universities began to regard industry-academia-government collaboration as part of their mission and embarked on proactive initiatives.

Although organizations and frameworks have been put in place (Figure 1-1-25) and the total number and value of joint research projects accepted is increasing, the scale of joint research per project remains small, at an average of just ¥2.24 million. While the number of large-scale joint research projects worth at least ¥10 million is growing, they still only account for around 4% of the total (Figure 1-1-26), demonstrating that systematic academic-industrial collaboration has not got underway in earnest.

■ Figure 1-1-25 / Changes in the Number of Organizations Undertaking Joint/Funded Research in General and the Number of Organizations With Relevant Regulations



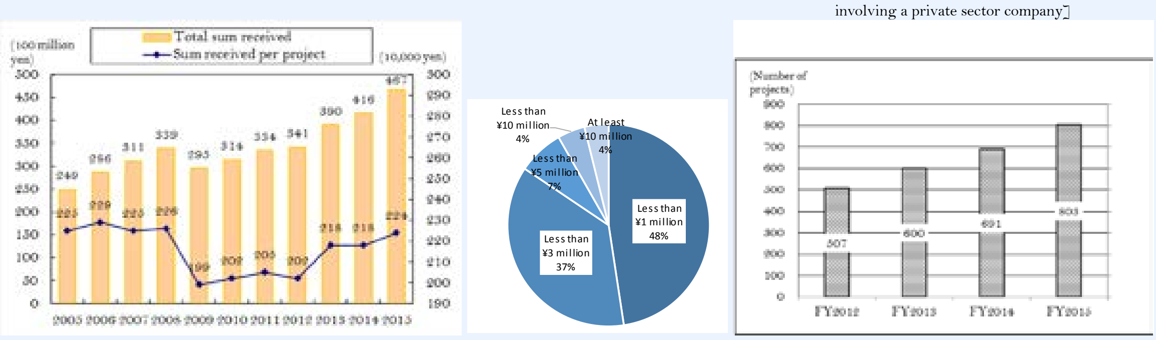
Source: MEXT, *FY2015 Survey of University-Industry Collaboration* (January 13, 2017)

■ Figure 1-1-26 / Scale of Joint Research Involving Universities and Private Sector Companies

[Scale per joint research project involving a private sector company]

[Sum received per project involving a private sector company]

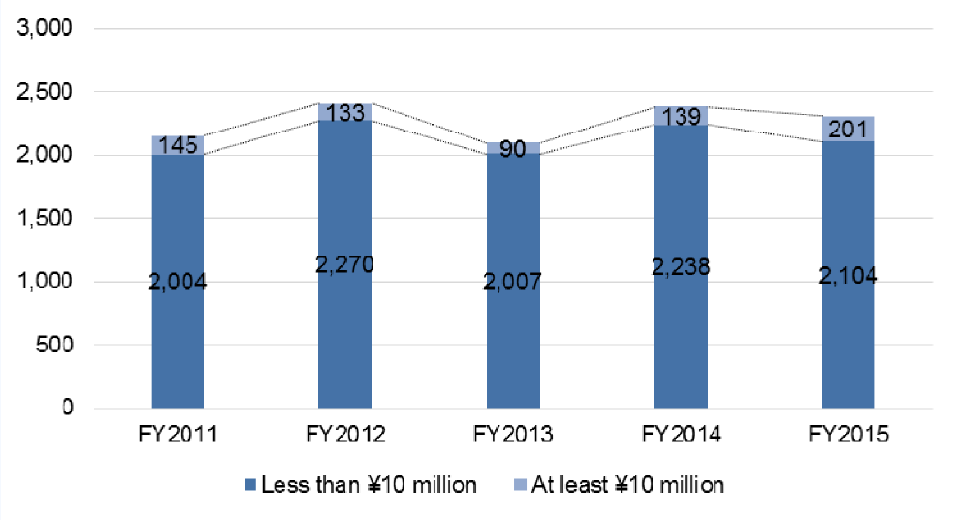
[Number of joint research projects worth at least ¥10 million involving a private sector company]



Source: MEXT, *Survey of University-Industry Collaboration*

The primary purpose of R&D agencies is to maximize their output, so they are expected to play a central role in industry-academia-government collaboration, based on each agency's operating principles. However, even at R&D agencies, joint research projects worth ¥10 million or more only account for about 6% of the total (Figure 1-1-27).

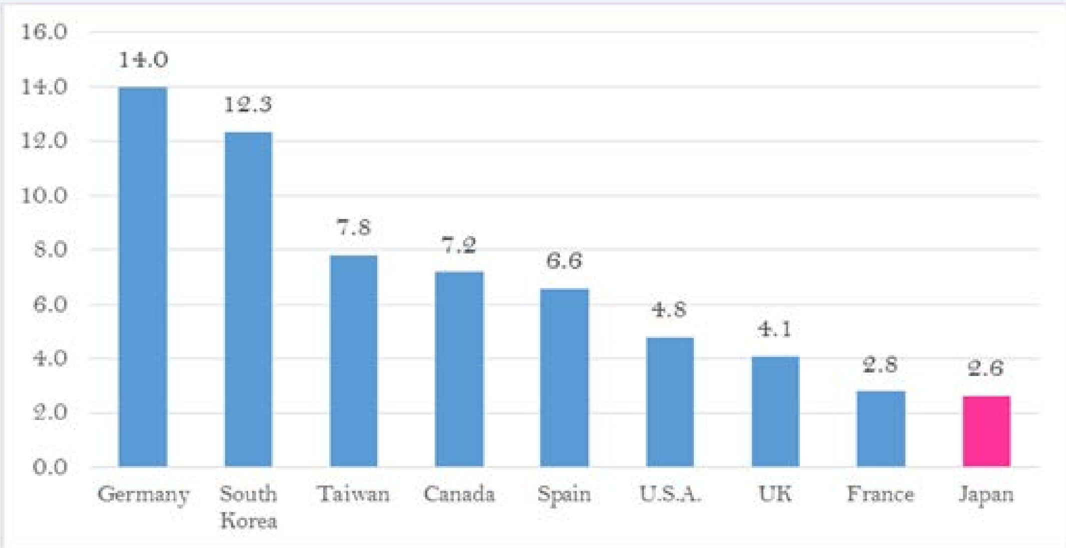
■ Figure 1-1-27 / Number of Large-scale Joint Research Projects Involving R&D Agencies and Private Sector Companies



Explanation: Results for 33 R&D agencies that undertake research and development themselves
Source: Cabinet Office, *Survey of Science and Technology Activities*

Whereas the OECD average for university research activities funded by corporate investment is 5.0% (2010),[1] in Japan it is just 2.6% (2013) (Figure 1-1-28).

■ Figure 1-1-28 / Percentage of University Research Expenditure Funded by the Private Sector (2013)



Source: Prepared by MEXT based on OECD, *Research and Development Statistics*

The Japan Revitalization Strategy 2016 (approved by the Cabinet on June 2, 2016) states that the government will promote full-scale organization-to-organization industry-academia collaboration, developing fully fledged, substantial, sustainable industry-academia-government collaboration (achieving

1 OECD, *Science, Technology and Industry Scoreboard 2013*

large-scale joint research) in which the leaders of universities, R&D agencies, and companies are involved. It also states that the government will aim to triple investment from companies to universities and R&D agencies by 2025. Some have pointed out that Japanese companies conclude large-scale joint research contracts with overseas university partners (Table 1-1-29), so universities need to provide an organization-wide response in order to meet companies' increasingly diverse collaboration needs.

■ Table 1-1-29 / Disparity in Investment in Domestic and Overseas Universities by One Japanese Company

Illustration of contract value where the value of an individual joint research contract with a Japanese university is 1

	Comprehensive contract	Individual contract
Overseas university	50-300	10-20
Japanese university	10-50	1

Source: Materials for the speech by Kazuhito Hashimoto at the 2016 Industry-Academia-Government Dialogue on Shaping the Future (prepared based on materials for the Second Review Meeting on the Diversification of Resources for Innovation)

In light of the Japan Revitalization Strategy 2016, MEXT and METI jointly established the Council of Industry-Academia-Government Dialogues for the Promotion of Innovation in 2016, which formulated the Guidelines for Fortifying Joint Research Through Industry-Academia-Government Collaboration (hereinafter "Guidelines for Industry-Academia-Government Collaboration"). These guidelines set out the challenges that universities and R&D agencies face in enhancing their industry-academia-government collaboration functions, as seen from the perspective of industry, and also offer a prescription for dealing with them. Universities and R&D agencies need to utilize these and make a start on implementing initiatives that accord with their respective management principles.

② Technology transfer via intellectual property rights

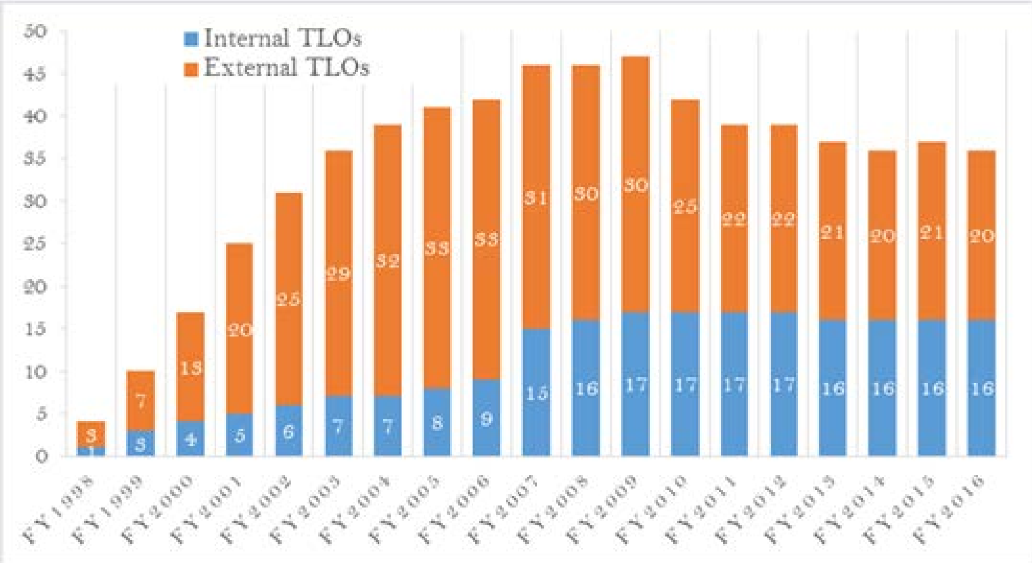
The University Technology Transfer Promotion Act[1] (TLO[2] Act) was enacted in 1998 to promote the transfer of the results of universities' technological research to business operator. TLOs are corporations that patent the research output of university researchers and license them to companies, serving as an intermediary between industry and academia. In conjunction with the enactment of the TLO Act, support such as grants was provided to approved/certified TLOs[3] and various measures are being implemented in accordance with their objectives, such as the reduction in patent fees introduced in 1999 (Industrial Revitalization Special Measures Act[4]).

Currently, TLOs take various forms, with some established within universities and others established outside them; some TLOs even handle the output of several universities across a region. As of March 31, 2017, Japan has 36 approved TLOs and 2 certified TLOs. The number of TLOs is on the decline (Figure

1 Act on the Promotion of Technology Transfer from Universities to Private Business Operators (Act No. 52 of 1998)
2 Technology Licensing Organizations
3 Pursuant to the University Technology Transfer Promotion Act, organizations that have received approval from both MEXT and METI for their implementation plans are referred to as approved TLOs, while organizations that engage in business based on having been certified by the competent ministry to handle nationally owned patent rights are called certified TLOs.
4 Act on Special Measures for Industrial Revitalization and Innovation (Act No. 131 of 1999)

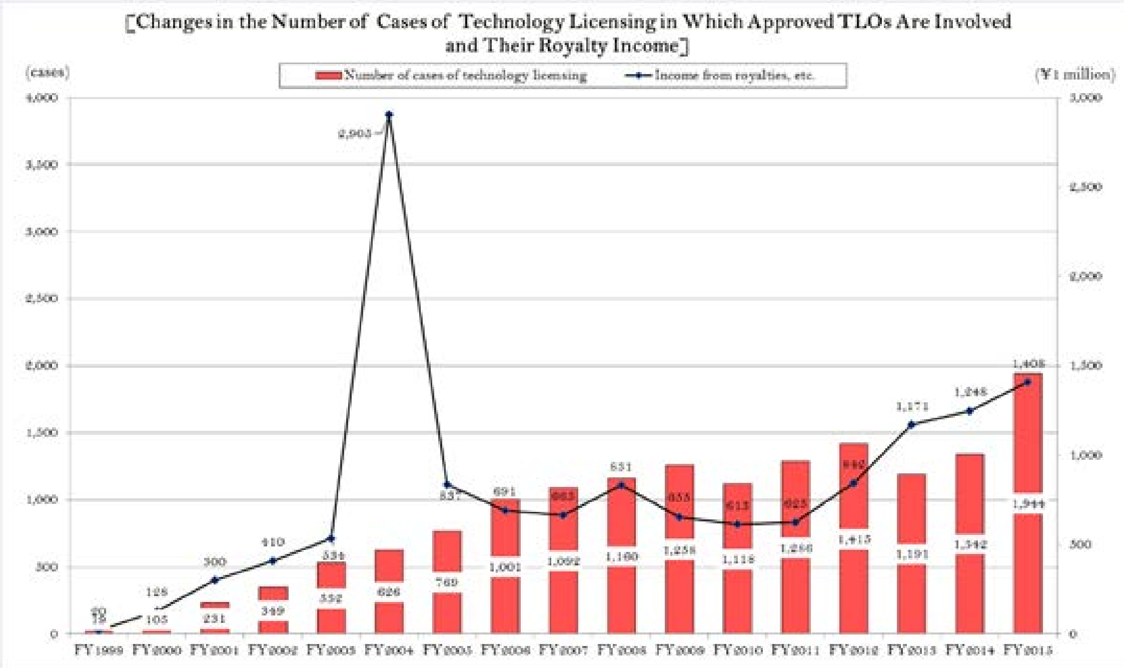
1-1-30), due to changes in universities' own policies on strategic technology licensing and TLO consolidation to serve a wider region. However, the number of cases of technology licensing in which approved TLOs are involved and their income from royalties, etc. are steadily growing (Figure 1-1-31), demonstrating that they play an important role.

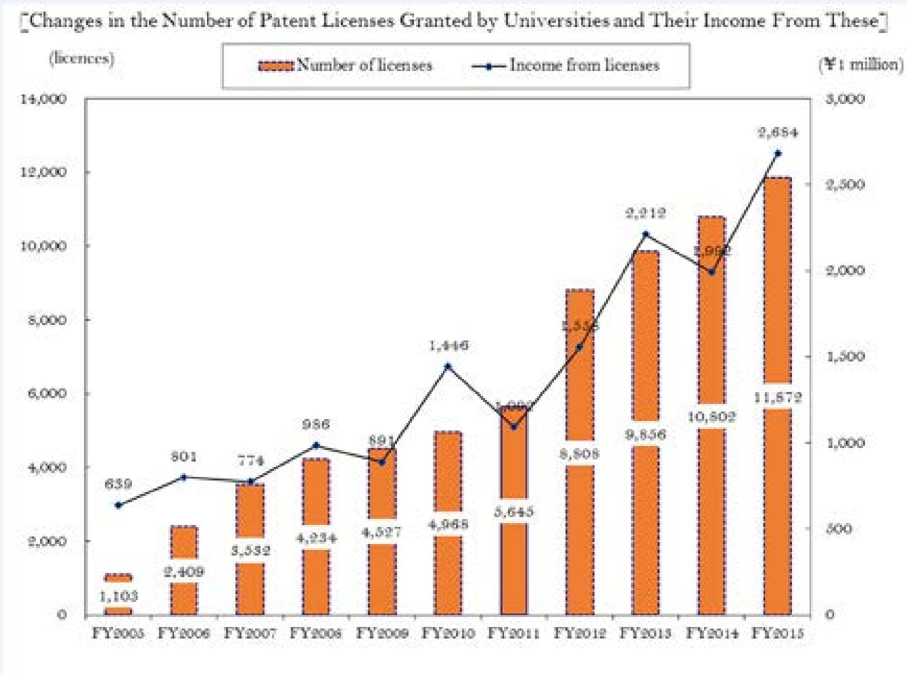
Figure 1-1-30 / Changes in the Number of Approved TLOs



Source: Compiled by MEXT

■ Figure 1-1-31 / Comparison of Changes in the Number of Cases of Technology Licensing in Which Approved TLOs Are Involved and Their Royalty Income and Changes in the Number of Patent Licenses Granted by Universities and Their Income From These





Source: Top: Figures for FY1999–2006 are from a METI survey. Figures from FY2007 onward were compiled by METI based on a joint survey conducted by MEXT and METI
Data: Top: METI website
Bottom: MEXT, *Survey of University-Industry Collaboration*

Regarding the ownership of intellectual property rights, the U.S. Bayh–Dole Act (Patent and Trademark Law Amendments Act) enacted in 1980 assigned ownership of patent and other intellectual property rights arising from government-funded research and development to private sector companies and universities.

As a result, patent acquisition and technology licensing by universities progressed, which had a positive impact on U.S. Industry. Article 30 of Japan's Act on Special Measures for Industrial Revitalization and Innovation (the Japanese "Bayh–Dole" provision) enacted in 1999 was inspired by this and made it possible to assign intellectual property rights over government-commissioned research and development to the party contracted to conduct the research and development concerned.[1]

In the case of employee inventions,[2] the basic principle in Japan before the establishment of national university corporation was that such inventions belonged to the inventor personally, with some belonging to the organization. On the other hand, employee inventions by government researchers at national research institutes and the like belonged to the government or the institute concerned, as a general rule.

In 2002, the Intellectual Property Basic Act (Act No. 122 of 2002) was enacted, with the aim of creating an intellectual property-based nation. The establishment of national university corporations in 2004 enabled each university to handle intellectual property in a flexible way. In conjunction with this move, a 2002 report[3] by the Ministry of Education, Culture, Sports, Science and Technology Council for Science and Technology recommended that intellectual property rights should revert, as a general rule, to the institution and should be managed and used centrally as an institution. Today, most universities have adopted institutional attribution as the general rule. In addition to establishing the principle of institutional attribution of intellectual property, this law made it necessary to contribute to society through research results and facilitating the effective use of intellectual property, so various systems and frameworks were put in place at universities, as described in ① above.

Various initiatives tailored to the needs and trends of the age continued to be implemented thereafter to promote the transfer of research results. These include the requisite amendments made to the Patent Act in 2015, with the objective of encouraging invention and promoting innovation in Japan by putting in place an environment adapted to changing corporate intellectual property strategies.

One of the key indicators set in the 5th Basic Plan is a 50% increase in the number of license agreements on university patents. The Basic Plan states that, to promote their intermediary functions, R&D agencies and other public research institutions need to ascertain the current situation and promote academic-industrial collaboration activities.

Both the number of patents held by universities and the number licensed by them are growing, but the increase in the number of patents held is greater (Figure 1-1-32). Looking at changes in income from intellectual property, one can see that both universities and R&D agencies experience substantial fluctuations from year to year (Figure 1-1-33).

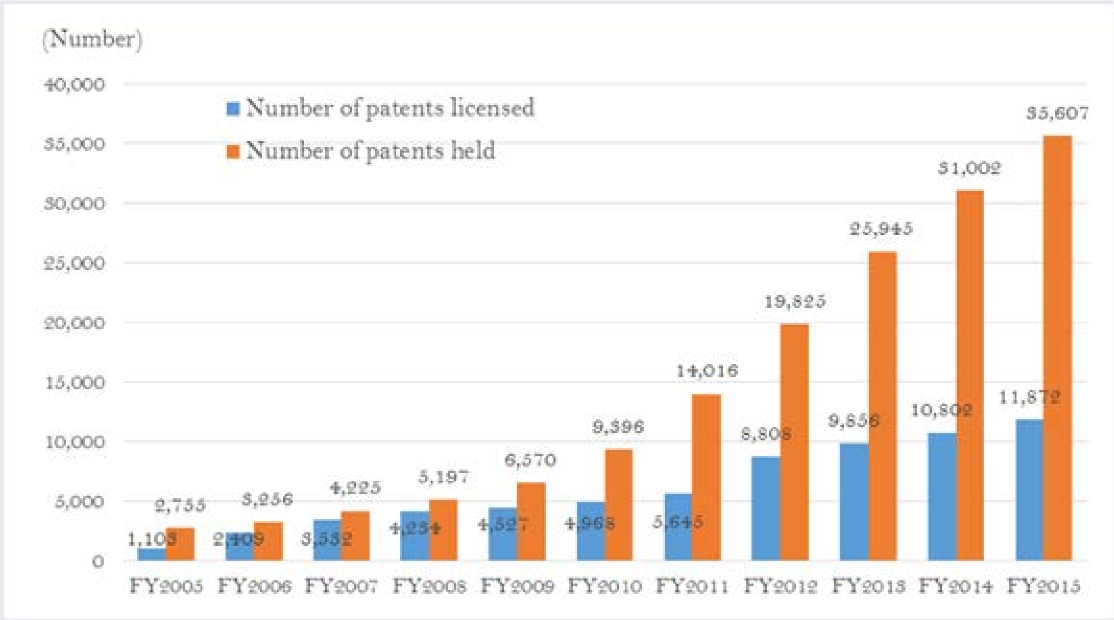
Acquiring and maintaining intellectual property rights incur costs, so universities and public research institutions — which do not do business themselves — need to strengthen their intellectual property management with a full awareness of the need to use those rights effectively.

1 This provision was made permanent in 2007 when it was transferred to the Industrial Technology Enhancement Act.

2 Inventions completed as a result of research and development as part of an employee's job at the company where they work (definition from the Japan Patent Office website http://www.jpo.go.jp/seido/shokumu/shokumu_q_a.htm). More precisely, in law, Article 35 of the Patent Act (Act No. 121 of 1959) defines an employee invention as an invention created by "an employee, an officer of the juridical person, or a national or local government employee (hereinafter referred to as "employee, etc.")" of an "employer, a juridical person or a national or local government (hereinafter referred to as "employer, etc."")," where that invention is one "which, by the nature of the said invention, falls within the scope of the business of the said employer, etc. and was achieved by an act(s) categorized as a present or past duty of the said employee, etc. performed for the employer, etc." Before national university corporations were established, inventions by national university employees belonged, in principle, to the individual, pursuant to a 1978 Ministry of Education notice.

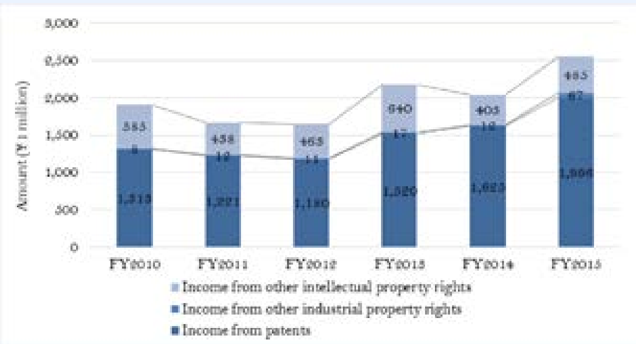
3 Council for Science and Technology, Technology and Research Foundations Section, Industry-Academia-Government Collaboration Promotion Committee, Intellectual Property Working Group, *Report of the Intellectual Property Working Group* (November 1, 2002)

■ Figure 1-1-32 / Changes in the Number of Patents Held by Universities and the Number Licensed by Them



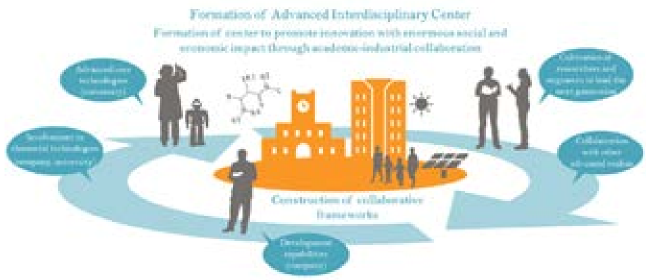
Source: MEXT, *Survey of University-Industry Collaboration*

■ Figure 1-1-33 / Changes in the Income of Universities (left) and R&D Agencies (right) From Intellectual Property



Source: Left: MEXT, *FY2015 Survey of University-Industry Collaboration* (January 13, 2017)
Right: Cabinet Office, *Survey of Science and Technology Activities*

③ Changes in the form of industry-academia-government collaboration and intermediary functions



Creation of Innovation Centers for Advanced Interdisciplinary Research Areas Program
Source: MEXT

Over the years, various projects focused on forming centers for industry-academia-government collaboration have been implemented, with the objective of creating specific new industries or generating innovation using the outstanding seeds held by universities and R&D agencies. This part introduces some of the leading programs, with a focus on the forms of collaboration involved.

In FY2006, funded by the Special Coordination Funds for Promoting Science and Technology program (as it was known at the time), the Creation of Innovation Centers for Advanced Interdisciplinary Research Areas Program was launched with the objective of producing output with enormous impact on advanced interdisciplinary realms, based on matching universities and R&D agencies with one or more companies. Key features of the program include the fact that companies are required to make a commitment to providing funding to match that provided by the government, the narrowing down of the projects supported through re-screening in the third year, and the fact that long-term support (10 years) is provided.

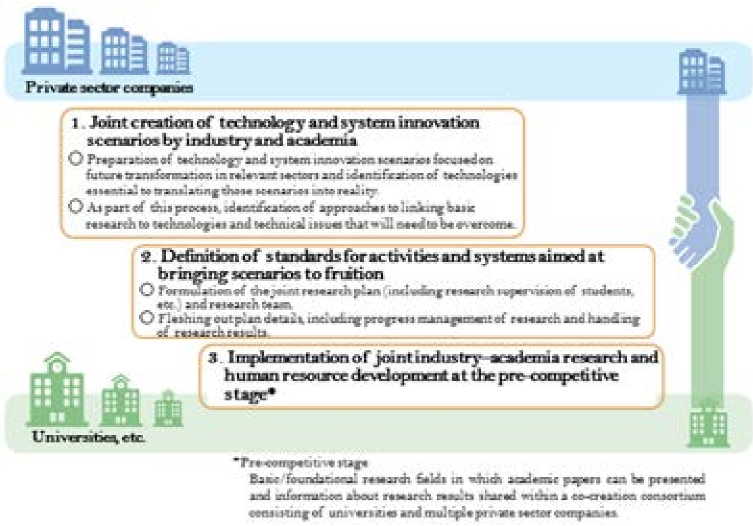
For example, Tokyo Women's Medical University, Dai Nippon Printing Co., Ltd., CellSeed Inc., and Hitachi, Ltd. formed the Advanced Interdisciplinary Center for the Establishment of Regenerative Medicine (FY2006–2015). Under this initiative, the participating organizations built a framework for blending medical, physical, and engineering science and promoting academic-industrial collaboration aimed at creating and popularizing regenerative medical treatments based on cell sheet engineering. They then formed a center that undertook everything from basic to clinical research and trials, and worked closely on research and development. The center has achieved positive outcomes in the highly complex areas of establishing regenerative medicine and creating an industry, using a cutting-edge technology that involves regenerating tissue that has lost its "cell sheet" by placing a thin sheet of cells collected from the human body over the tissue in question.

In FY2013, MEXT launched the Center of Innovation (COI) Program, aiming to consider the needs that society would likely have ten years from that point and using the findings to set out three visions for the ideal shape of society and approaches to daily life. Based on these, the Japan Science and Technology Agency (JST) provides support for up to nine fiscal years for challenging, vision-led high-risk research and development projects. One of the key features of research and development in this program is that, rather than commercializing technological seeds, it employs a method called backcasting, which involves using the vision for an ideal society as the starting point for identifying research and development topics. Another is the "under one roof" approach, in which representatives of academia and industry get together under one roof to undertake discussions and work as a unified whole on research and development. In addition, there is a structuring team, which examines measures for cross-cutting issues affecting COI sites, such as regulatory reform.

For example, in the Center of Healthy Aging Innovation project (due to run from FY2013 to FY2021), in which Hirosaki University is the core institution, one of the activities involves the development of an algorithm to detect symptoms of dementia and lifestyle-related diseases based on the analysis of health and medical big data, including a cohort study[1] launched by Hirosaki City in 2005. Companies participating in the Hirosaki University COI are permitted to use health and medical big data analysis, so, in addition to the companies that have been involved since the beginning, a large number of companies have subsequently joined the project, enabling open innovation to be put into practice. The Aomori Prefecture and Hirosaki City Life Innovation Strategies[2] both mention strengthening collaboration with the COI, which is considered to be a local innovation initiative aimed at overturning Aomori Prefecture's reputation as the prefecture with the shortest life expectancy.

Center of Innovation Program
Source: MEXT

In FY2016, the Japan Science and Technology Agency launched the Program on Open Innovation Platform with Enterprises, Research Institute and Academia (OPERA), which aims to accelerate open innovation through joint research by industry and academia based on matching private sector funding, focusing on interdisciplinary research fields (pre-competitive stage) that are both academically ambitious and industrially innovative. OPERA's key features are the pursuit of large-scale joint research involving industry and academia at the pre-competitive stage and human resource development through this, along with the implementation of university system reforms.



Program on Open Innovation Platform with Enterprises, Research Institute and Academia
Source: MEXT

Thus, initiatives in which private sector companies, universities, and R&D agencies aim to generate innovation on equal terms have evolved from a system of centers involving a small handful of companies

1 Iwaki Health Promotion Project. Ongoing collection and analysis of 600 items of health information from a total of 11,000 people.
2 Aomori Prefecture, *Aomori Life Innovation Strategy Second Stage* (March 2016); Hirosaki City, *Hirosaki Life Innovation Strategy* (March 2017)

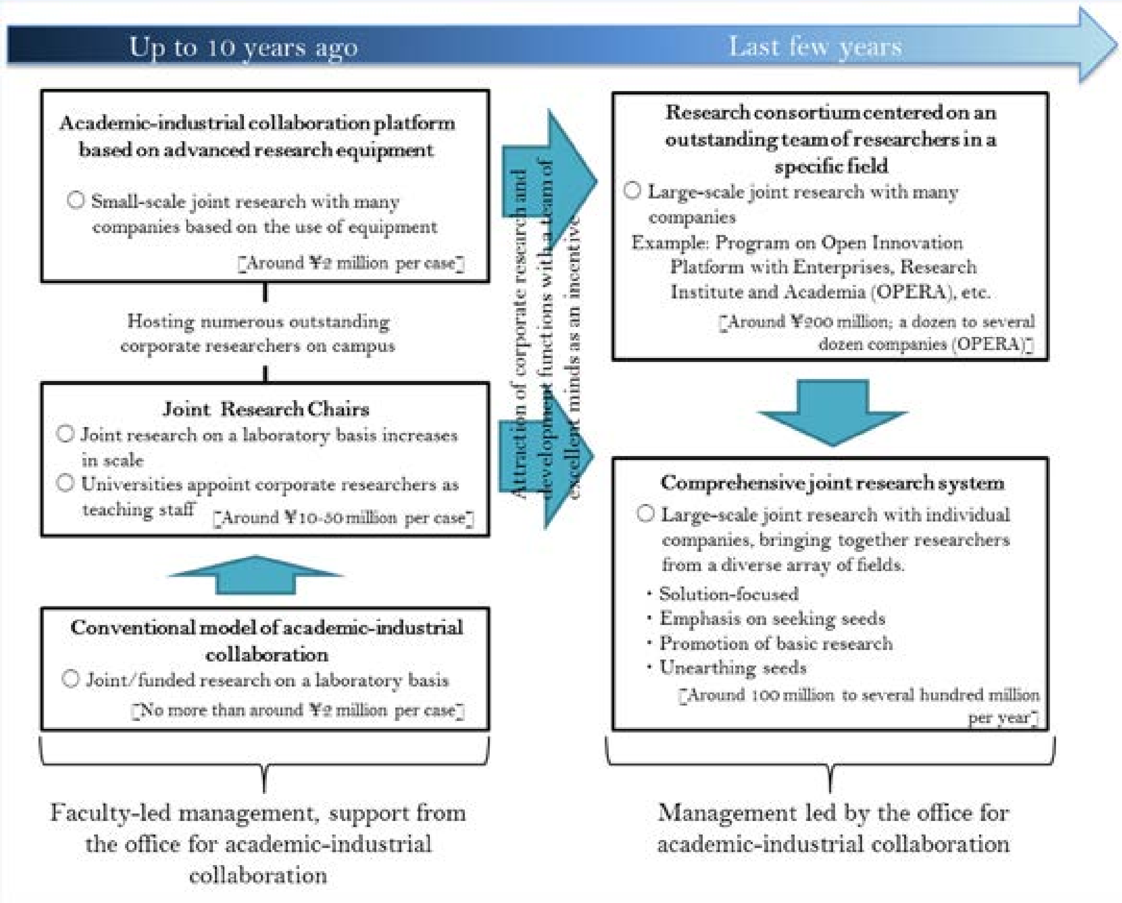
with a single university/R&D agency at their core to a system of consortia involving multiple universities and multiple universities/R&D agencies.

R&D agencies in particular are expected to fulfill intermediary functions. For example, the New Energy and Industrial Technology Development Organization (NEDO) has been undertaking the Bridging R&D and Business Promotion for Small and Medium-Sized Enterprises Project since FY2015, while MEXT began implementing a program to support the formation of innovation hubs at R&D agencies the same year.

As Japan's largest R&D agency focused on industrial technology, the National Institute of Advanced Industrial Science and Technology (AIST) aims to ensure that it serves as a bridge to world-class research and the results thereof during the fourth mid-term objective period, which began in FY2015. As such, one of its basic policies is to actively bring diverse and outstanding technological seeds and personnel into the institute from Japanese and overseas universities, public institutions, and companies, aiming to enhance its research potential and become an innovation system hub for Japan, thereby driving open innovation that mobilizes intellects within Japan and abroad. To this end, it is undertaking various initiatives, including human resource development, regional cooperation, and support for startup companies.

The forms of cooperation between universities and R&D agencies on the one hand and companies on the other are changing (Figure 1-1-34), with R&D agencies playing a major role as an intermediary facilitating the commercialization of university research results by companies. As such, these organizations need to adopt a different style of management from that employed until now, in order to meet companies' expectations.

■ Figure 1-1-34 / Trends in Full-scale Joint Research by Industry and Academia



Source: Compiled by MEXT

④ Feeding back results to society by founding startup companies

The government has introduced various startup support measures to date, aimed at creating new industries and encouraging the founding and growth of startup companies. These measures include the 1995 introduction of a stock options system[1] (amendment to the New Businesses Act[2]) to facilitate the hiring of personnel by startup companies; the 1997 creation of an angel tax system[3] to encourage retail investors to supply funding to startup companies; the 2005 easing of capital requirements for starting a company with the abolition[4] of minimum capital regulations (enactment of the new Companies Act[5]); and investment in startup companies by the Innovation Network Corporation of Japan, which was founded in 2009 (established by means of an amendment to the Industrial Revitalization Special Measures Act).

In its 2001 Plan for the Creation of New Markets and New Jobs (Hiranuma Plan), METI mapped out a

1 A type of remuneration system in which a company grants its directors and employees the right (option) to acquire shares (stock) in that company at a price determined in advance (strike price/exercise price), enabling the directors and employees to exercise their right to acquire their company's stock in the future when the price has risen and then sell it, so that they can receive the amount by which the value of the stock has risen as remuneration. Preferential tax treatment applied from FY1996.

2 Act on Temporary Measures to Facilitate Specific New Businesses (Act No. 59 of 1989)

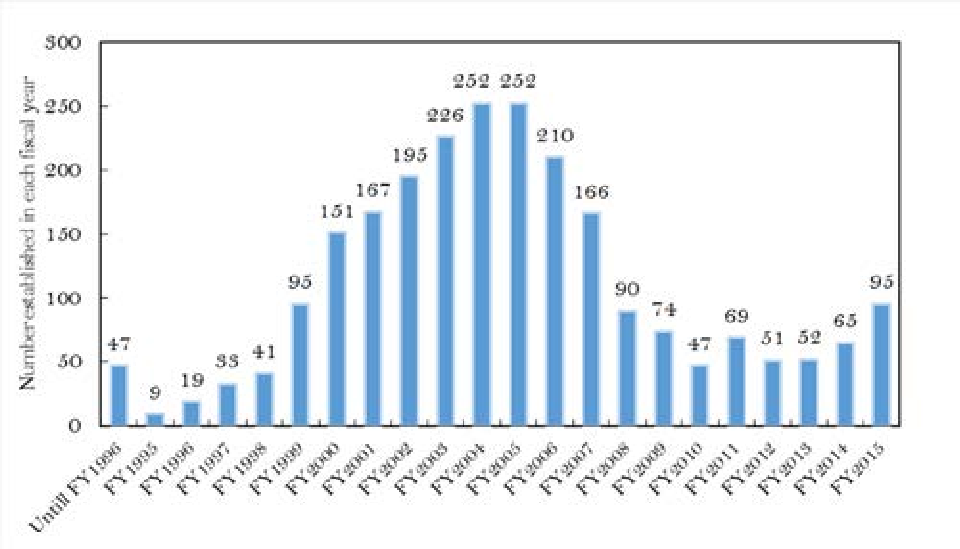
3 A system offering tax incentives to retail investors who have invested in a startup company, both at the time of the investment and at the time of sale. In FY2014, a tax system was established to promote investment in startup companies, which enabled companies investing via certified venture capital funds to include their reserve for investment losses in deductible expenses.

4 The minimum capital regulation (¥10 million, in the case of a joint-stock corporation) introduced in 1990 was relaxed in 2003 as a special scheme, reducing it to a minimum of ¥1 on condition that the capital was increased within five years of the company's establishment. The new Companies Act abolished the rule completely, enabling companies to be established with stated capital of anything down to ¥1 to be established from May 1, 2006.

5 Companies Act (Act No. 86 of 2005)

plan for increasing the number of university startups to 1,000 over the three years from FY2002 to FY2004. While the budget allocation for the plan was not great, it sent out a powerful message. In FY2002, university startups began to be granted access to use facilities at their originating universities for a fee, while in FY2003, special measures were put in place allowing companies to be founded with stated capital of just ¥1, under certain conditions. Such institutional backing, coupled with the message sent by METI's plan, resulted in the target being achieved in FY2004. However, having peaked around this time, the number of university startups founded has since dwindled and currently remains flat, at around 50-60 companies per year (Figure 1-1-35). Although university startups with an aggregate market value in excess of tens of billions of yen are starting to appear (Table 1-1-36), the rate of establishment of new firms in general is lower in Japan than overseas (Figure 1-1-37), and Japan languishes near the bottom in rankings of developed countries by the percentage of entrepreneurs and individuals planning to start a company (Figure 1-1-38).

■ Figure 1-1-35 / Number of University Startups[1] Established



Source: MEXT, *FY2015 Survey of University-Industry Collaboration* (January 13, 2017)

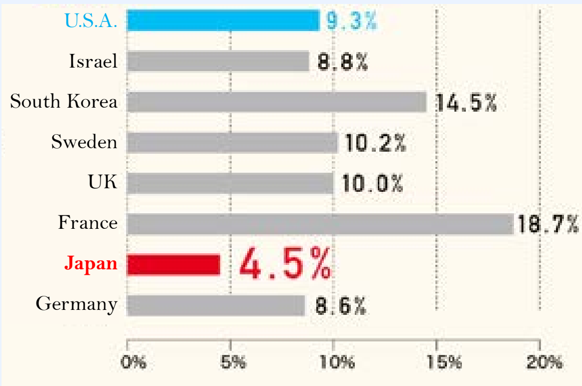
1 The definition used in surveys of academic-industrial collaboration is as follows.
"A company newly established on the basis of technologies or business techniques based on education and research at a university, etc." It includes only those established within Japan and excludes incorporated non-profit organizations. More specifically, it covers those to which at least one of the following five classifications applies.
(1) A company founded on the basis of a patent for an invention by a member of a university, etc., specifically a member of its academic/administrative staff, a research fellow, or postdoctoral fellow (member of academic/administrative staff, etc.) or an undergraduate or postgraduate student (student) (technology licensed by means of a patent)
(2) A company founded on the basis of research results achieved or skills acquired at a university, etc. other than that in (1) (technology licensed by means other than a patent (or use of research results))
(3) A company founded as a startup by a member of academic/administrative staff, etc. or student of a university, etc. or in whose founding such individuals were closely involved (personnel transfer)
(4) A company founded as a startup with investment from a university, etc., TLO, or related venture capital fund (investment)
(5) A company other than those described in (1)-(4) above, which is organizationally related to a university, etc. (otherwise related)

■ Table 1-1-36 / Aggregate Market Value of Listed University Startups (as of the end of April 2016)

University Startup Name	Founded	Listed	Listing Market	Originating University	Aggregate Market Value (¥1 million)
PeptiDream Inc.	July, 2006	June, 2013	TSE First Section	The University of Tokyo	357,099
CYBERDYNE, INC.	June, 2004	Mar., 2014	TSE Mothers	Tsukuba University	295,480
euglena Co.,Ltd.	Aug., 2005	Dec., 2012	TSE First Section	The University of Tokyo	128,494
SanBio Company Limited	Feb., 2001	Apr., 2015	TSE Mothers	Keio University	70,061
HEALIOS K.K.	Feb., 2011	June, 2015	TSE Mothers	RIKEN	67,310
Total for 37 listed startups	—	—	—	—	1,539,477

Source: Prepared by MEXT and the Japan Science and Technology Agency from published documents

■ Figure 1-1-37 / New Firm Establishment Rate in Major Countries (number of new companies established / total number of companies)



(Source) 2010 comparisons (2012, in the case of Sweden)

Japan: Ministry of Health, Labour and Welfare, "Annual Report on Employment Insurance Services"

U.S.A.: U.S. Small Business Administration, "The Small Business Economy"

UK: Office for National Statistics, "Business Demography"

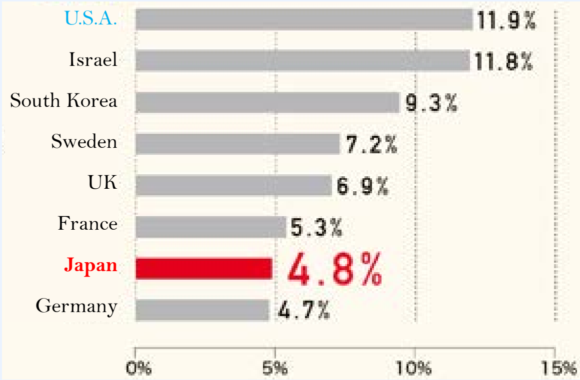
Germany: Statistisches Bundesamt, "Unternehmensgründungen, -schließungen: Deutschland, Jahre, Rechtsform, Wirtschaftszweige"

France: INSEE, "Taux de création d'entreprises en 2012"

Israel, South Korea: OECD, "Entrepreneurship at a Glance"

Data: Headquarters for Japan's Economic Revitalization, *Venture Challenge 2020* (April 2016)

■ Figure 1-1-38 / Major Countries by Percentage of Entrepreneurs and Individuals Planning to Start a Company (total entrepreneurial activity[1] index)



Source: *Survey of Entrepreneurial Spirit* (METI, 2015) (figure for France is from 2014)
Data: Headquarters for Japan's Economic Revitalization, *Venture Challenge 2020* (April 2016)

In general, a university/R&D agency startup company based on research and development requires a lump sum for startup costs and to assist with growth. One financial support measure introduced permitted national university corporations to invest in venture capital (VC) funds under the 2013 Industry Competitiveness Enhancement Act (Act No. 98 of 2013). MEXT allocated ¥100 billion in startup investment funding to four national universities,[2] which established VC funds. These moves served as a pump-priming measure and other universities are also making progress in establishing similar funds,[3] so the momentum for the establishment of startup companies is expected to start growing once more. Currently, the percentage of university startups that have begun to make a profit is growing[4] and listed university startups with an aggregate market value of ¥110 billion or more — equivalent to what are called unicorn companies[5] — are starting to emerge, albeit just a few (Table 1-1-36).

To further strengthen the founding and growth of university startups, the government is implementing a variety of measures to support startups based on research and development. These include the Japan Science and Technology Agency's Program for Creating STart-ups from Advanced Research and Technology (START), which links business promoters with know-how in the field of commercialization to university researchers; and the Startup Development Strategy Task Force system at the Institute of Advanced Industrial Science and Technology, which guides the creation of new companies expected to have high growth potential (hi-tech startups).

Founded in September 2014, with the aim of bringing to fruition the Venture Declaration[6] formulated by METI's Expert Meeting on Venture Business in April that year, the Venture Business Creation Council[7]

1 Total entrepreneurial activity (TEA) index: Percentage of entrepreneurs (those who are preparing to start a new business or are already the proprietor of a company and have been receiving remuneration from the business in question for less than 3.5 years) among the adult population
2 Tohoku University, University of Tokyo, Kyoto University, Osaka University
3 Venture Enterprise Center, *VEC Yearbook 2016* (November 2016)
4 METI, *FY2015 Survey of University-Oriented Venture Businesses*
5 Unlisted startup companies valued at $1 billion (approximately ¥110 billion) or more. These have begun to be called "unicorns" in the U.S.A., taking their name from the legendary creatures because of how rarely such companies are seen. In Japan, as shown in Table 1-1-36, there are already three listed companies with an aggregate market value of ¥110 billion or above, which this paper describes as being equivalent to unicorn companies.
6 "Venture" refers not only to the process of starting up a company, but also efforts by companies to take on the challenge of new initiatives, including the reform of existing large corporations. The declaration advocates bringing to fruition a virtuous circle of venture creation in order to form business clusters to lead the next generation and regenerate the economy through an injection of fresh vitality.
7 A council aimed at encouraging independent activities by members and exchange between them, in order to bring the Venture Declaration to fruition. Its administration bureau was located within METI.

merged in March 2017 with the Japan Open Innovation Council (JOIC),[1] which had been founded in February 2015. The name of the latter, as parent organization, was retained in English, although the Japanese name was changed. The reorganized JOIC is a platform for gradual collaboration, which encourages independent activities and exchange on the part of its 800 or so members. As well as promoting open innovation initiatives by private sector business operators, it continues to undertake activities that contribute to generating innovation and increasing the competitiveness of Japanese industry by pursuing efforts to bring the Venture Declaration to fruition.

Recognizing that the Fourth Industrial Revolution will be the age of startups, the Japan Revitalization Strategy 2016 set a new target of doubling the value of VC investment in startup companies as a proportion of nominal GDP by 2022. As stated in Venture Challenge 2020, which was approved by the Headquarters for Japan's Economic Revitalization in April 2016, the government is adopting an aggressive approach in its efforts to build the startup ecosystem[2] that Japan still lacks, with the aim of creating startups that differ by an order of magnitude from those founded until now.

⑤ Securing and cultivating highly skilled specialist professionals to lead open innovation

Regarding research personnel who create the seeds of open innovation, the 1st Basic Plan stated that the government would implement a program to support 10,000 postdoctoral fellows, aimed at augmenting the number of young researchers and nurturing them. This goal was achieved in FY1999. Postdoctoral fellows make a significant contribution to the active development of research activities in Japan, but the uncertainty of their career path has been pointed out.[3] In light of the increase in the number of postdoctoral fellows, human resource development has broadened its horizons to include a diverse array of career paths.

In terms of support for researchers engaged in industry-academia-government collaboration, in FY2012, NEDO launched the Industrial Technology Research Grant Program, a competitive research fund aimed at unearthing industrial technology seeds capable of meeting the needs of industry and society, and also cultivating industrial technology research personnel. NEDO also launched the Industrial Technology Fellowship Program to nurture outstanding personnel involved in academic-industrial collaboration, including engineers. As stated in 1. (2) ③ of this section, AIST started up its Innovation School in FY2008 and the initiative is still going strong today. In addition, METI and MEXT provide support in building career paths and implement people-to-people exchange programs that incorporate medium- to long-term internships.

Furthermore, the 5th Basic Plan states, "we are continuously developing and securing diverse and talented pool of professionals, and creating a society in which through their activities, STI professionals can play an active role as knowledge professionals in a variety of sectors, both in academia and in industry." Since FY2016, MEXT has been implementing the Leading Initiative for Excellent Young Researchers, which offers outstanding young researchers career paths that enable them to achieve success at nationwide

1 A council founded at the initiative of private sector business operators to share examples of the promotion of open innovation, undertake public awareness campaigns, and make policy recommendations. Its administration bureau has been located within the New Energy and Industrial Technology Development Organization (NEDO) since its founding.

2 A mechanism in which the component bodies — including entrepreneurs, existing companies, universities, research institutes, financial institutions, and public institutions — can co-exist and enjoy mutual prosperity, as participants in the cyclical process of company founding, growth, maturity, and regeneration.

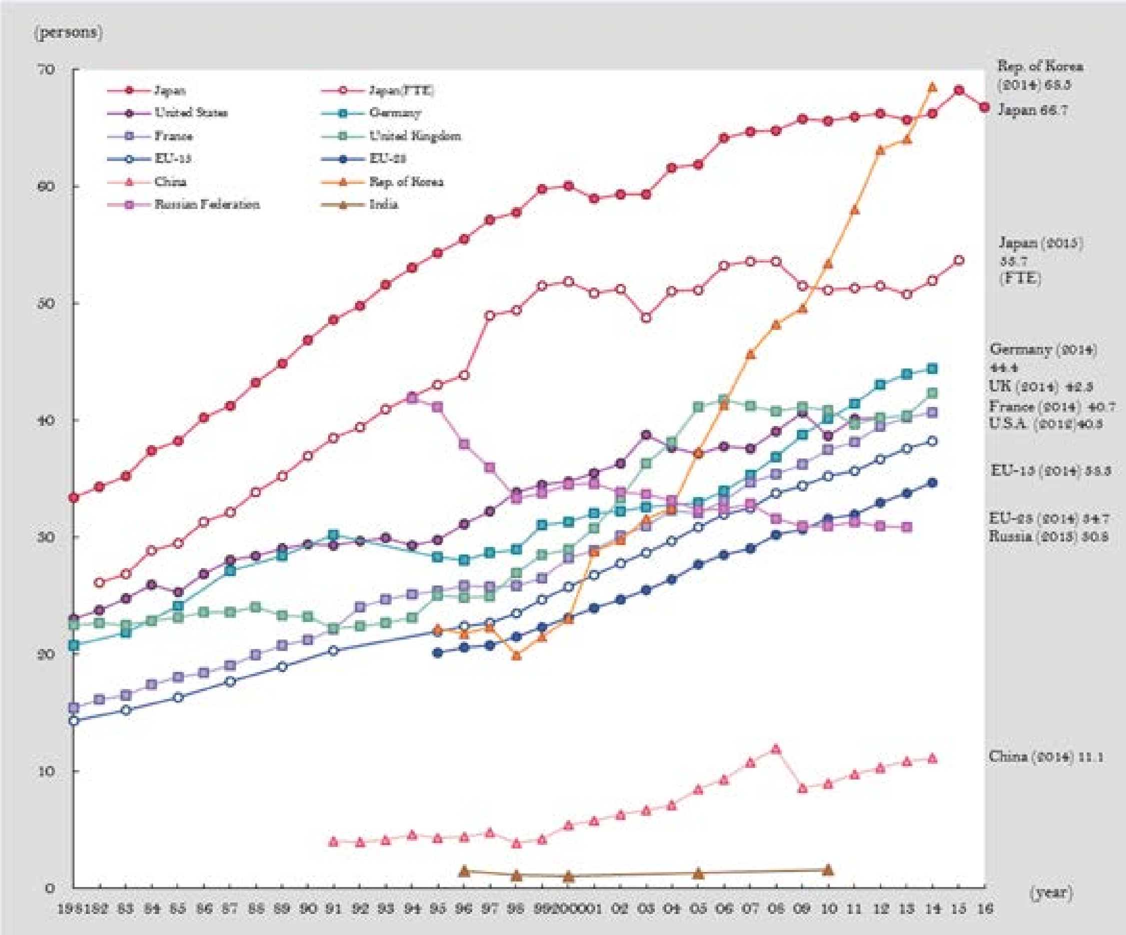
3 3rd Science and Technology Basic Plan (approved by the Cabinet on March 28, 2006)

industrial, academic, and government research institutes.

These are some of the programs that have been undertaken with the aim of cultivating highly skilled specialist professionals able to play an active role in industry, academia, and government. However, while Japan has the highest number of researchers per capita of any major nation, despite having been overtaken by South Korea in 2010 (Figure 1-1-39), the number of people obtaining doctorate degrees per capita is low compared with other major countries (Figure 1-1-40). Holders of doctorates, including thesis-only doctorates, are increasingly attaching importance to universities that undertake academic and basic research, and to papers and other science and technology literature, using them more and more as the source of knowledge for inventions (Figure 1-1-41). As such, highly skilled specialist professionals of this nature are crucial to open innovation. Some have pointed out[1] that Japan's lack of a deep pool of these highly skilled specialist professionals is a serious issue that could reduce our nation's intellectual creation capabilities in the future and cause our international competitiveness to decline, including in the area of science, technology and innovation.

1 Council for Science and Technology 8th Committee on Human Resources, *Encouraging Doctorate Holders to Play an Active Role in a Variety of Sectors* (January 1, 2017)

Figure 1-1-39 / Number of Researchers Per 10,000 Population in Major Countries



Notes: 1. Figures for each country include researchers in the humanities and social sciences. However, researchers in the humanities and social sciences are not included in the figures for South Korea until 2006.

2. The number of researchers per 10,000 population is calculated by MEXT from figures for the population and the number of researchers.

3. Figures for the number of researchers in Japan indicate the number as of April 1 up to 2001 and as of March 31 from 2002 onwards.

4. Full-time equivalent figures for Japan were estimated by the OECD until 1995.

5. Figures for the number of researchers in the U.S.A. from FY2000 onwards are OECD estimates.

6. Figures for the number of researchers in the EU are OECD estimates.

7. Figures for Germany in the fiscal years 1996, 1998, 2000, 2002, 2008, 2010, 2013, and 2014 are estimates; figures for FY2013 and FY2014 are provisional.

8. Figures for the number of researchers in the UK until FY1983 are the total number of employees in industry (scientists and engineers) and at national research institutions (degree-holders and above), and do not include researchers at universities and privately run research institutions. Figures for FY1999-2004 are OECD estimates, while those for FY2005-2010 and FY2012-2014 are British estimates; figures for FY2013 and FY2014 are provisional.

9. Figures for the number of researchers in China until 2008 are not compliant with the OECD Frascati Manual.

10. The number of researchers in India is per 10,000 residents. The figure for FY2005 is an estimate.

Source: Prepared by MEXT based on the following

Japan: (Number of researchers) Ministry of Internal Affairs and Communications Statistics Bureau, "Survey of Research and Development"

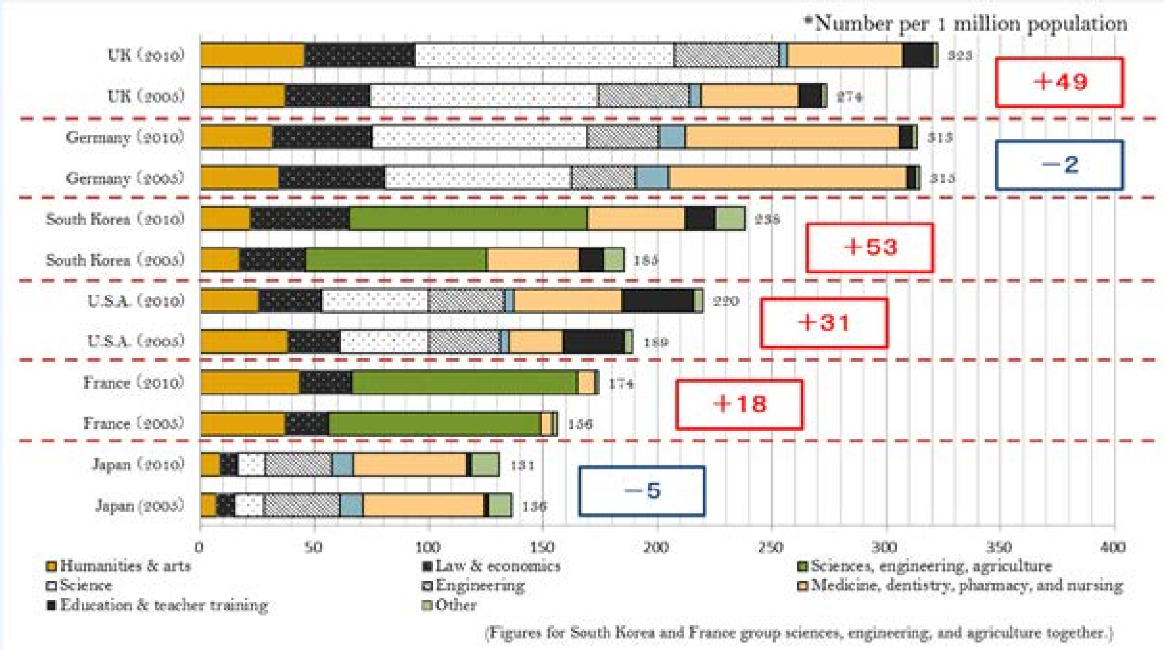
(Full-time equivalent figures) OECD, Main Science and Technology Indicators, Vol. 2015/2.

(Population) Ministry of Internal Affairs and Communications Statistics Bureau, "Population Estimates" (as of October 1 each year)

India: UNESCO Institute for Statistics S&T database

Other countries: OECD, Main Science and Technology Indicators, Vol. 2015/2.

Figure 1-1-40 / Individuals Earning Doctorates in Major Countries by Field of Specialism



Japan: Number earning doctorates between April in the year in question and March the following year.

U.S.A.: Number earning doctorates in the academic year starting in September of the year shown. Excludes first professional degrees.

UK: Number earning a higher degree at a university or other higher education institution in the year shown (calendar year).

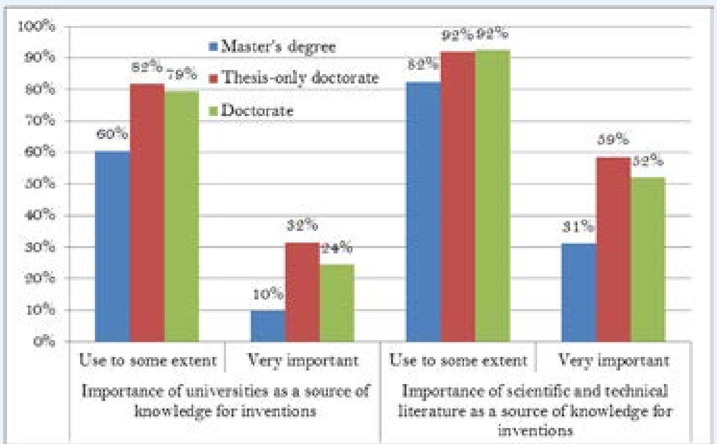
France: Number awarded by national universities in the year shown (calendar year). Figures for Metropolitan (mainland) France and overseas regions.

Germany: Number of people passing examinations in the winter semester of the year shown and the summer semester of the following year.

South Korea: Number earning doctorates between March in the year in question and February the following year.

Source: Prepared by MEXT based on MEXT, *International Comparison of Education Statistical Indicators* (FY2009 & FY2013 editions); and MEXT, *Education Statistics from Other Countries* (2014 edition)

Figure 1-1-41 / Extent of Usage of Universities and Scientific and Technical Literature as a Source of Knowledge for Inventions (figures for master's degree holders, doctorate holders, and thesis-only doctorate holders)



(Source) Prepared from the Japan Inventor Survey

Data: Research Institute of Economy, Trade and Industry, RIETI Discussion Paper series 12-J-033 "Innovation Process in Japan in the Early 2000s as Seen from Inventors: Agenda for strengthening innovative capability" (September 2012)

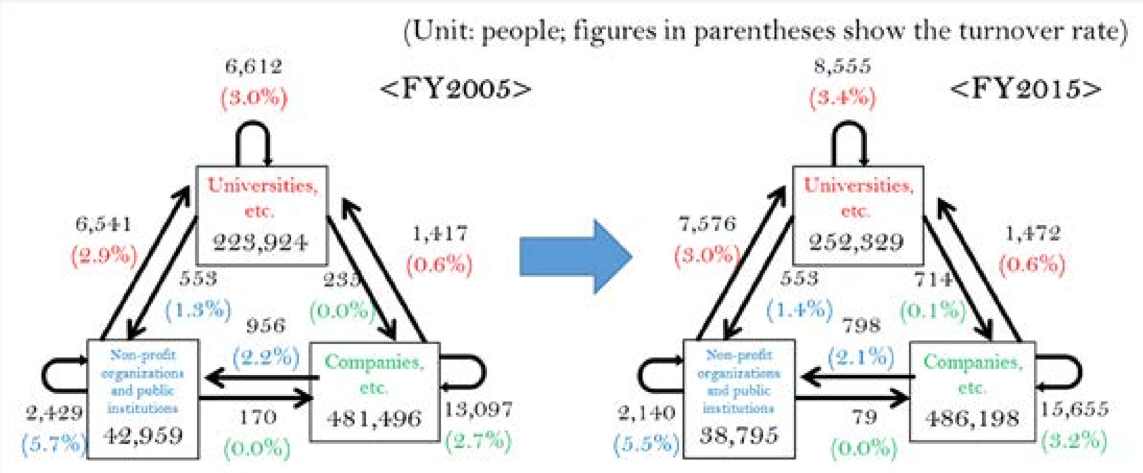
Along with the 1986 enactment of the Act for Facilitating Government Research Exchange (Act No. 57 of 1986),[1] the introduction and establishment of fixed-term appointments and public recruitment for university lecturers and government researchers were aimed at increasing the mobility of researchers.

The 2000 enactment of the Industrial Technology Enhancement Act (Act No. 44 of 2000) made it possible for university lecturers and others to concurrently hold positions as executives of private sector companies, enabling them to engage in subsidiary work when launching a university startup or undertaking joint research in close partnership with companies. Since then, the operation of this system has been relaxed and expanded under the Rules of the National Personnel Authority. Furthermore, the 2004 establishment of national university corporations meant that university staff were no longer civil servants, enabling each corporation to set its own rules on subsidiary work.

Salary-related measures are also required to encourage the mobility of human resources, including through the holding of concurrent posts. The Japan Revitalization Strategy set a goal of extending annual salary or mixed salary schemes to include a total of 10,000 people by FY2015. The government began implementing measures to encourage the introduction of annual salary schemes at national university corporations from FY2014 and the number of people included in annual salary schemes reached approximately 10,400 in October 2015, meeting the target. The 5th Basic Plan stated that the government would aim to increase the mobility of researchers between Japan's companies, universities, and public research institutes by 20% and double the level of mobility of researchers from universities to companies and public research institutes, because this has been particularly low.

However, personnel mobility continues to be low, especially from universities and public research institutes to companies (Figure 1-1-42).

■ Figure 1-1-42 / Movement Between Sectors



Notes: 1. Actual figures as of the end of each fiscal year.
2. The turnover rate is a percentage calculated by dividing the number of people entering each sector by the total percentage of researchers in the sector being entered.
3. Doctoral candidates have been deducted from the number of researchers at universities, etc.

Source: Prepared by MEXT based on Ministry of Internal Affairs and Communications Statistics Bureau, *Survey of Research and Development*

1 Abolished in 2008 with the enactment of the Research and Development Capacity Improvement Act.

Alongside researchers, the diverse array of personnel who support innovation systems (program managers (PMs), research administrators (URAs), intellectual property managers, technical support staff, etc.) have an increasingly important role to play in driving open innovation, which is a new innovation system.[1] The need to enhance the personnel and functions involved in the effective, efficient management of research management resources at universities and R&D agencies has been pointed out[2] and an adequate innovation management system has not yet been established. It has also been noted that Japan has few leading intermediaries (organizations) that bridge the gap between technology seeds and commercialization,[3] suggesting that there are not enough personnel fulfilling these bridging functions. Furthermore, from a startup creation perspective, there are few people launching companies.

Thus, there is a shortage of diverse personnel to lead open innovation.

⑥ Promoting open innovation through the research and development tax system

The research and development tax system, under which private sector companies undertaking research and development can credit a specific proportion of their R&D costs against their corporate income tax, has a long history. It began with the FY1967 creation of a tax credit based on the value of the increase in R&D costs (increase category). From the perspective of open innovation, the Special Tax Credit on special R&D costs was created in FY1993; this covered only relevant costs associated with joint research conducted in partnership with national R&D institutes, applying a credit rate[4] of 6% (combined with the credit for the increase category, this takes the maximum credit to 10% of the value of corporate income tax). The following year, in FY1994, certain types of joint research with R&D institutes overseas were added to the system, followed by certain types of joint research with universities, etc. in FY1995. FY1997 saw the addition of expenditure on certain types of joint research undertaken by companies in partnership with universities, etc. that was disbursed within the company itself. In FY2001, following the establishment of national R&D institutes as incorporated administrative agencies, joint research with specified incorporated administrative agencies was added to the program.

In FY2003, the system underwent a fundamental revision, aimed at consolidating and prioritizing research and development tax breaks to enhance the competitiveness of Japanese industry. As well as the establishment of a new tax credit calculated on the basis of R&D costs as a proportion of the total amount (total sum category), joint and funded research involving industry-academia-government collaboration was accommodated in the Special Tax Credit on special R&D costs with the application of a credit rate of 12% to joint and funded research undertaken with universities and public research institutions, up to a maximum limit of 20% when combined with the total sum category credit.

In FY2013, when tax reform aimed at triggering private sector investment to generate a virtuous circle of growth and wealth creation was implemented, joint research carried out between companies was added

1 Council for Science and Technology Industry Collaboration and Regional Support Subcommittee Investigative Committee on the Management of University Intellectual Property Aimed at Enhancing Competitiveness, *Primary Recommendations on Approaches to the Management of University Intellectual Property for Innovation: Toward the Establishment of Forward-looking Research Management Systems at Universities* (August 7, 2015)

2 Japan Business Federation (Keidanren), *Toward the Enhancement of Joint Research Activities under the Framework of Industry-Academia-Government Collaboration* (February 16, 2016)

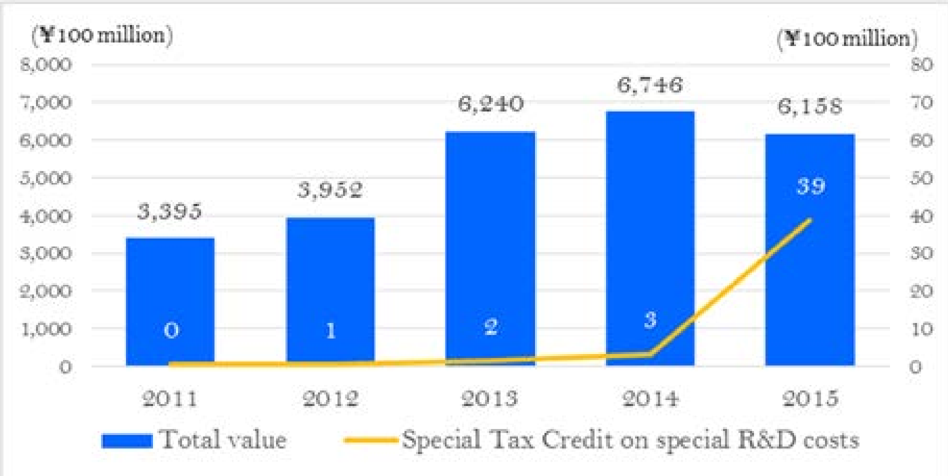
3 Industrial Structure Council Committee on Industrial Science and Technology Policy and Environment, *Interim Summary by the R&D and Evaluation Subcommittee* (June 2014)

4 A sum calculated by applying the tax credit rate to special R&D costs can be credited against the corporate income tax paid by the private sector company in question. If the special R&D costs amount to ¥10 million and the tax credit rate is 6%, the company can credit ¥600,000 against its corporate income tax. However, if the upper limit on credits is 10%, the company can only credit a maximum of 10% of the value of its total corporate income tax for the business year in question.

to the forms of research eligible for the special R&D costs credit and the requirements for the application of the credit to joint research with universities, etc. were relaxed significantly. In FY2015, the credit rate was increased substantially from the existing rate of 12%, in order to encourage open innovation by companies. The rate rose to 30% in cases where the research partner was a Japanese research institute or university and to 20% where the partner was another company. In addition, the separation of the upper credit limit from the total sum basis category was radically enhanced. Figures for FY2015 show that although the total value of tax breaks applied under the Special Tax Credit on special R&D costs (open innovation category) is small compared with the overall sum, it grew more than tenfold from the previous fiscal year (Figure 1-1-43).

Furthermore, the FY2017 tax reform introduced reforms that took into account the importance of open innovation, including operational improvements to the open innovation category, such as the expansion of eligible costs and the streamlining of procedures.

■ Figure 1-1-43 / Changes in the Value of Tax Breaks Under the Research and Development Tax System (¥100 million)



Source: Prepared by MEXT based on Ministry of Finance, *Report on the Result of the Application Survey of the Special Taxation Measures*

Thus, various measures relating to open innovation have been introduced and have yielded some positive effects, while legislative constraints on industry-academia-government collaboration have been eased. On the other hand, open innovation in which industry partners with universities and R&D agencies has not yet taken off in earnest, because, compared with Europe and the U.S.A., progress is still not adequate. As economic and social changes gather pace and globalization progresses, it is likely that a wide range of obstacles will come into play in practice and interact in a complex manner, from issues that have already been pointed out to problems that become apparent for the first time. As such, we are confronted by the thorny question of how to overcome these large and complex barriers.

3 Problems Concerning Open Innovation in Japan

The roles and expectations of universities and R&D agencies have gradually been changing in response not only to companies, which are the drivers of open innovation, but also to society as a whole. Various policies and measures — sometimes even major systemic reforms — have been implemented in an ongoing process, to enable universities and R&D agencies to fulfill the responsibilities with which they have been entrusted by the economy and society.

However, Japan is only halfway through its journey toward open innovation. Examining the current situation facing universities and R&D agencies reveals the following three problems.

○ Open innovation takes various forms, depending on the type and number of sectors involved in collaboration and the method employed for this. The way that universities and R&D agencies engage with this process needs to address the increasingly diverse requirements of industry. This means that they must demonstrate management functions as organizations in addressing these requirements, but joint research involving industry, academia, and government is still small in scale and conducted on an individual basis, so fully fledged organization-to-organization industry-academia-government collaboration has not yet got underway in earnest.

○ Moreover, startups, which ought to be a very important sector when building an innovation ecosystem, have not been properly incorporated into the ecosystem in Japan. Few university startups are founded and growth driven by financing is difficult, making it hard to draw up a model for success.

○ Furthermore, in terms of the human resources required for open innovation, each and every sector needs diverse personnel with advanced professional skills, but they are lacking everywhere, because of inadequate efforts to secure and nurture such personnel.

It is necessary to analyze the various background issues behind the problems that have surfaced in the state of affairs described above, and to work towards finding solutions to each of them.