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Innovation and Incentives in Japan
Focus on pre-Meiji

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This manuscript is based on a chapter to be included in "Intellectual Property – Innovation and Incentives" by Suzanne Scotchmer[1], translated by Munetomo Ando, forthcoming from Nihon Hyoronsha. The purpose of the chapter is to shed light on Japanese historical and institutional aspects that corresponds to US aspects in the original book. We particularly focus on innovation and incentives before Meiji period. There was no intellectual property but there were significant innovations. We seek to answer the questions, what is the environment that produced them and how did innovators make a living? We see that there were organizations such as "za" that functioned like guilds in the west while "senbai" system probably induced a procurement system, much like government of today. This manuscript is not an English translation of the final version (in Japanese) in the book.

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[1] Original book is Scotchmer, Suzanne, "Innovation and Incentives", MIT Press, 2004.

Chapter 12; Case of Japan

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In this chapter we look at history and current state of Japanese incentives. There are many books on the current Japanese patents and other intellectual property systems. Thus this book's examination of the current system will be limited to the economic analysis of two aspects of the current system: service inventions and research exemption. Instead we focus on innovation and incentive before the patent system was established. The patent system was established only in the Meiji period. But many innovations took place before that. We all know Hiraga Gen-nai, the great innovator and entrepreneur. What motivated the innovators such as him? How did they make a living or was innovation limited to the independent wealthy? We also briefly discuss Takamine Jokichi, a more modern inventor-entrepreneur and Riken Research Institute. The institute was a prime example of university-private partnership, funding research all from commercialization of its research and patents.

1 Weapon production in ancient and middle ages

Sword making was concentrated in areas close to source of raw materials, such as Yahata or close to consumers such as Awataguchi. Blacksmiths and weapon makers were given special treatment such as exemption from chou-yo (type of tax). Carpenters and craftsman were also protected. Dye makers were organized into groups and the central government called them (much like military service) to help with construction of temples and Buddha statues. The country depended on technology from abroad. For instance, there is a record of craftsman from China assisting with casting of bells for Goda-ji (temple) and Todai-ji (temple) in 1183.

Particularly after the feudal system deteriorated, local lords began to build and support

individual armouries. As fighting between the local lords become more serious and wide spread, demand for weapons increased and the status of craftsmen improved. Production changed from methods that required highly skilled workers to methods that made mass production with low skilled labor possible. Manufacturers soon organized themselves into “za” (guilds). The sword-za obtained the exclusive right to produce and market swords from the Muromatchi Shogunate in return for dedicating him swords. These were very similar to the European guilds mentioned in Chapter 1. However it should be noted that za got monopoly in return for a payment to the Shogun. It was not a reward for innovation and was not designed as an incentive scheme. In order to sustain monopoly, it would have been necessary to have some advantage (cost, access to raw materials, knowledge). Secrecy was used to maintain this advantage. For instance, outsiders were not allowed to be present when iron was heated to make swords.

The first firearms arrived in Japan as part of a shipwreck on Tanegashima Island in 1543. When the sailors returned two years later, they were surprised that the Japanese were already producing firearms. The validity of this statement aside, the fact that Takeda army used 3000 riflemen in the Battle of Nagashino in 1574 suggests that some level of mass production of firearms had been achieved.

Firearms, the weapon of mass destruction at the time was in high demand among the feuding daimyos (domain lords). What was the environment that allowed such quick development of firearm production? Tanegashima Toshiaki, the leader of Tanegashima Island promoted the process of learning to manufacture the firearms. He obtained two rifles and ordered Shinogawa Kojiro, one of his samurais to learn production of gunpowder and had a blacksmith named Yasak Kinbei learn to make firearms. A firearm was produced in 1544 for the first time in Japan. There seems to have been no attempts to monopolize the knowledge although Tanegashima continued to produce firearms during the Edo period.. Record shows that he gave two firearms to Tachibanaya Matasaburo, a merchant from Sakai (now Osaka) who took them back to Sakai. Backed by the Sakai’s wealth and proximity to major battlegrounds, he eventually ran a very profitable firearms manufacturing business.

Another area known for firearms production, Kunitomo-mura, also got it starts at the end of Sengoku (fighting nations) era. “Kinitomo Teppo Ki” (Kunitomo Fiarearms Record) states that Shogun Yoshiaki ordered local lord Hosokawa Harumoto firearm

production. Hosokawa focused on the Kunitomo-mura center of sword making at the time. He ordered the four master blacksmiths to manufacturer firearms. The truth of story is questionable taking into account the fact that Ashikaga Shogunate was losing power and Kunitomo-mura was controlled by Imagawa at the time. However it is probably true that firearms production was organized and promoted by a local official. The record also states that because the blacksmiths had never seen a firearm, the Shogun provided them with one. Later Tokugawa Ieyasu appointed the four blacksmiths "teppo daikan" (firearms official) but also forbid them from leaving Kunitomo. This restriction could have been motivated by military needs but it also prevented the technology (and production) from being copied by other regions. Tokugawa Shogunate[2] maintained control over firearms production.

There are other known examples of secrecy. We already mentioned how sword making trade secret was preserved. Trade secrets of the metal craftsmen were preserved in "Hidensho" (Secret Book). Iyo navy's "Ippinryouu Tenki Hidensho" (Secret Book of Ippin Method Weather) described weather forecasting methods based on experience. Weather forecasting was essential to sailors when maritime technology was not well developed. At the end of the book, it states that "This is the secret method of weather forecasting passed down the generations. Descendents should not take the information out of the family".

2. Industrial technology of Edo period and Yoshimune's "Shinki Gohatto"

Yoshimune's "Shinki Gohatto" (Prohibition of Renewals) prohibited people from improving or inventing things. The decree was aimed to control excessive consumption but it had the effect of discouraging innovations. Decrees preventing horse drawn vehicles and bridges were designed to prevent importation and transportation of large quantities of goods which should discourage revolts. When there was no printing technology, reverse engineering would have been a very valuable way of learning new technologies. Restriction of movement of goods would have been very effective in preventing dissemination of new knowledge.

[2] Tokuwawa Shogunate = Edo Shogunate = Edo Government. Years 1603-1868 is called the Edo Period. Tokugawa Ieyasu unified Japan, was appointed the Shogun in 1603. He moved the capital from Kyoto to Edo (no Tokyo). The Tokugawa family continued to occupy the Shogun position until Tokugawa Yoshinobu resigned in 1868. This was the beginning of rule of Meiji Emperor and the Meiji period (1868 – 1912).

However we should not conclude that Yoshimune was against progress. First of all, absence or slow spillover could encourage innovation. In addition, he lifted sanctions on importation of books from the west and promoted certain technologies. Japan's three top imports at the time were silk, sugar and ginseng. There was no domestic production resulting in a large trade deficit. Yoshimune started the Edo government policy of import substitution by funding researcher, scholars and craftsmen. This form of directly funding research was the most common form of technology policy undertaken by both the Edo Shogunate (central government) and han (local domains). Accumulated knowledge, mostly in agriculture were compiled into books and distributed.

Merchants and craftsmen were organized in groups such as "za" and "kabu nakama". "Za" were organized directly by the Edo Shgogunate: Gin-za (silver za) was the government mint. "Nakama" were trade association and "Kabu nakama" obtained certain privileges by paying a tax to the Shogunate. Shogunate used these organizations to detect any attempts to innvoate. However there is no doubt that these associations also bestowed market power and functioned in many ways similar to the Western guilds.

In 1823, a man named Sayei, who lived near Nyorai Temple in Shiba (in Tokyo) invented a water pump that did in 2 hours worked that previously required 50 men. Machi bugyou (City office) awarded him the exclusive right to market this pump. The system of granting exclusive rights was not for the purpose of promoting innovation. Probably the man was able to pay enough tax (or borrow enough money to pay the tax based on the potential profit generate from an exclusive right) to buy this right. However such a prospect would have functioned as an incentive to innovate.

From middle of the Edo period, it became necessary for han (local domains) to generate income in order to meet the never ending demands by the Edo Shogunate such as digging canals and fixing the Edo castle, not to mention financing Sankin Kotai (bi-annual trip to or from Edo). From around 1870, many han started the "sen bai" (exclusive sale or monopoly) and "sanbutsu kaisho" (produce exhibits). The system of "sen bai" is often considered to be the forerunner of the Japanese patent system. Most of the local specialities of today, such as Choshu's paper, Gunjo's silk, Himeji's cotton, and Akita's rice were all part of respective han's sen-bai system. Sen-bai meant the han was the exclusive exporter (seller outside the han). All producers within the han

must sell to the han, making han a monopsonist. Han had "sanbutsu kaisho" in Osaka or Edo (Tokyo) as showrooms to sell their local produce. Han was able to extract rent by exercising monopsony power, buying below market price.

A han always wants to buy at the lowest price possible and sell at the highest price possible. Lower price can be achieved by reducing production cost and higher selling price can be achieved by improving the quality of the product. Either way, han had an incentive to promote product and process innovation.[3] Han hired specialists and financed research into new products and manufacturing methods. In case of Tanegashima, the local lord promoted production of firearms for military superiority. In case of most hans, the goal was commercial superiority. Nan-bu han invited sake experts from the outside in order to learn to produce sake. So did Matsue han in order to learn how to produce paper. Interestingly, in many cases craftsmen were allowed to move to other han with their skills. There was explicit restriction on samurai to change employment but no such blanket restrictions on merchants and craftsmen. And many han were able to start a new industry by inviting specialists from other regions.

However there is evidence that trade secrecy was fiercely protected. According to Okumura (1973), Honda Toshiaki (1744-1821) describes in "Kei sei hi wa" (Secrets of Life) of coming upon a beheaded head on display in front of a town in Ohwa. The man had brought in outsiders into the mines. In addition to Honda's explanation that hans kept their production a secret from Edo in order to avoid taxation, Okumura points out that hans guarded technology just as fiercely. Okumura also mentions a story of Shuboh-han's attempt to learn about cotton production from Kawauchi-han. They dispatched someone disguised as a drifter but it took him five years to be allowed near front line of production. When it came time to leave, he disguised himself as a travelling monk and hid the seeds in his walking stick.

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[3] There was a very similar system in New Zealand until very recently. Until deregulation in 1980s, government organizations such as the Apple and Pear Board and the Dairy Board were the sole exporters of respective produce. Farmers were only able to sell to the Board. On the other hand, government funded Crown Institutes conducted intensive R&D. Apple and Pear Board has been privatized and now known as ENZA, the Dairy Board is now part of a cooperative called Fonterra, one of the top ten dairy companies in the world. Crown Institute continues as Horticulture and Food Research Institute of New Zealand Limited (HortResearch). One of their successful innovations is the golden kiwi fruit, less tart kiwi fruit with yellow meat.

3. Agricultural technology of Edo period

One of the items in "Ankei no Ofuregaki" (Ankei Notices), promotes use of toilets. In addition to promoting hygiene in growing cities such as Tokyo, this was part of agricultural policy. Efficient collection and use of manure increased agricultural production. Edo Shogunate supported agricultural research as part of the import substitution policy.

Much of accumulation of agricultural knowledge is due to the three great horticulturist of Edo (period): Miyazaki Yasusada(1623-1697), Sato Nobufusa(1769-1850) and Okura Tsunekura (1768-1860). They were all independently wealthy and made it their life work to improve agricultural production. They travelled and compiled know-how from various regions into books, which were then distributed widely. Miyazaki, who wrote "Encyclopaedia of Agriculture" was born to a samurai family in Hiroshima-han. He retired in his 30s and started to practice agriculture. Okura was born as a son of a candle craftsman. He was originally an apprentice where his father worked but after witnessing frequent famines, he also started farming. He eventually went into the gardening business and held an official post of agriculture instructor in Tawara-han (in Mikawa). Sato as born to a family of scholars of mining and agriculture. He was trained as a doctor and had a practice. He travelled widely and wrote many books on agriculture.

The yo-to-ke, a thermometer to measure temperature of silk worms was "invented" by Baba Shigehisa He was also an independently wealthy part-time doctor who lived in Somegawa in Date, one of the centers of silk worm production. He made the yo-to-ke after seeing a thermometer from the west during a trip to Nagasaki. Among his numerous contributions to the industry was the "Yotokei Hiketsu" (Essentials of Yo-to-kei) explaining how the tool should be applied.

Edo and han governments supported research and were keen to promote anyone who had talent, independent of class[4]. Aoki Konyo, who was a son of a fish monger in Edo, is an example of a talent the Edo government promoted to an official position to conduct research. Although he is known for his research on Satsuma potatoes, he initially did

[4] There were four classes, royalty, samurai, farmers, merchants and trademen. This was also the order of hierarchy, from top to bottom.

research on sugar beets. Sugar beets could substitute for imported sugar. Kuse Yoshihiro was born to a farmer in Ogaki-han. Han noted his talent and sent him to Kyoto to study ran-gaku (western knowledge). He made contributions to the minting technology in the Meiji government.

4. Hiraga Gen-nai

Here we examine the life of Hiraga Gen-nai (1728-1779), the inventor and entrepreneur, a Japanese Benjamin Franklin or Thomas Edison. Everyone knows him as a famous inventor but one wonders how he made a living when there was no intellectual property to protect his inventions. He was born to a family of ashigaru (lowest ranked samurai) in Takamtasu-han. The Lord of Takamatsu-han was impressed with Gen-nai's talents and he was recruited to study ginseng production. As mentioned before, all ginseng was imported at the time. He was also allowed to study in Nagasaki (equivalent of studying abroad at the time). This prompted him to pursue his studies further and he passed on his family position (which came with a stipend of rice) to his brother in law. He moved to Edo in 1756 but continued to get financial assistance from Takamatsu-han.

His most famous "invention", "erekiteru" (electric, the electric generator), was based on a broken western made generator he brought back from Nagasaki. It should be noted that high Japanese humidity requires special care and it was not trivial generate electricity even if one had a western version.[5] This electric generator was a source of the first known Japanese intellectual property dispute. Gen-nai had a craftsman build his generators according to his plans. This craftsman made his own versions of the machines and tried selling them. Gen-nai complained to the city judge (sort of a legal system). Unfortunately both parties died before any ruling was made. It should be noted that the craftsman had not actually stolen the machine itself, Gen-nai was complaining that the craftwman had taken his idea. Gen-nai was ahead of his time in this respect also.
He made 15 generators but they were not profitable, probably because the practical use was not very clear. He shifted his time to production and sale of useful things, such as "manpo kei" (pedometer) and "ondokei" (thermometer).

[5] Okumura mentions how engineers at a major Japanese electronics company failed to generate electricity using a replica of a Gen-nai machine at a ceremony commemorating Gen-nai. Unfortunately the engineers had failed to appreciate Gen-nai's skill and did not take the time to prepare.

Gen-nai today would be called a "consultant". He realized that the financial support from Takamatsu-han was not benevolence. He was called upon to consult and to assist on various technical matters, such as surveying and recording types of fish in of Kishu and Sagami Bays. Although he was eventually allowed to leave Takamatsu-han, he was prevented from begin employed by another han. This is clearly stated in the letter from han to Gen-nai but it was a practice decreed by Shogun Hidetada in 1615 as part of "shikan okamai" (rules of samurai employmen). It was primarily to maintain the power of han and the hierarchical structure of the samurai class. But perhaps Takamatsu-han wanted to stress the fact that Gen-nai could not work elsewhere by mentioning it in the letter, like a non-competition clause. Hans were keen to have an advantage over other han in order to meet various demands of the Edo shogunate (and get favourable treatment). Gen-nai was a ronin[6] for the rest of his life. However one does suspect that given his talent, other han found ways to get his expertise in return for compensation. He submitted to Akita-han for "Kozan kaihatsu negai" (Petition to Develop Mining) and did survey and experimental mining. Unfortunately Gen-nai did not succeed (see Okumura (1976) for explanation of technical obstacles at the time).

Gen-nai was also an entrepreneur. His claim to fame when he first went to Edo was organising a series of five "Toto[7] yakuhin kai" (Toto Pharmaceuticals Exhibition). This was equivalent of expositions held in Europe in 19th century. Sohon-gaku (study of plants) was not only biology but included what pharmacology and horticulture. For the first exhibition he asked a reknowed sohon-gaku scholar Matsudaira Motoo to be the convener. He organized financing and sponsorship. Sponsorship included a major mail and package company. This allowed exhibitors to send their products to Edo without prior payment. Gen-nai paid the freight after he had collected participation fees. There were 180 products on show at the first exposition in 1757 but it grew to 1800 items in the fifth and last exhibit in 1762. Gen-nai published a catalogue of 400 selected products from the fourth exhibition.[8] He wrote the descriptions very much like the patent applications are today, using diagrams. According to Okumura (2003), his patent application would have been commended by the patent examiners.

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[6] One without master.
[7] Toto means Easter Capital. While Kyoto was the original capital, Edo to the east was the current center of government.
[8] Recall that although Edo government did not allow any exchange with overseas, western books were allowed to be imported. Gen-nai, as were many horticulturists must have been influenced by the enlightenment movement of Europe.

5. Current Patent System

In 1860, the delegation that went to the US to sign the Japan-US Commerce Treaty visited the US Patent Office and met the commissioner. They returned with official patent office publications. Fukuzawa Yukichi (who later founded Keio University) followed the delegation as an assistant to the captain of the ship that took the delegation. He has written in detail this event and the patent system in "Seiyo Jijyo" (Goings on in the West). He notes that "they make people's heart beat faster by providing exclusive rights and great profit to inventors". Kando Takahiro noted the importance of a patent system in his book "Seiyo Zasshi" (Writings about the West). He thought that it was necessary to provide rewards for new inventions and that it should be administered by the government. He listed the people worthy of rewards: "someone who thought of something new in Japan", "someone who brings to Japan something invented abroad", and "someone who has improved something that already existed". He said the government should be the stock owner and people are not allowed to use inventions without the approval of the stock owner. With such protection for inventors, people will strive to produce new inventions and this will lead to a strong and wealthy nation. Meiji government abolished "kabunakama" (1868) when the new commercial law was passed (1868) and abolition of han also meant the end of "sen-bai" (1871). In 1871, it established "Senbai ryakuki" (Rules of Monopoly) but it did not function and was repealed the following year. It is not clear why it failed but there was an over all bad impression of the monopoly (actually monopsony) carried over from the old "sen-bai" system.

Japan participated in the Vienna Exposition in 1873. It was very clear that Japanese technology lagged significantly behind those of the west. Need for innovation was debated widely. It should be noted that the concept of providing incentive by rewarding desirable innovations was a new idea in Japan. Finally "Shojhyo jorei" (trade mark law) was passed in 1884 and "Tokkio Senbai Jorei" (patent monopoly act) was passed the following year. The first patent was issued in July that year to "Hotta method of rust prevention paint and its application". The system was basically the US system with "first to invent" rule and liability rule. However as system of private laws shifted from the French to the Prussian system, the patent system was also changed, including the move to the property rule in 1909. Initially trade marks were also "first to use" but both trade marks and patents were changed to first to file rule in 1921.

Pharmaceuticals were not patentable for the reason of public interest. Length of protection was restricted to 20 years from date of application in 1969; publication of applications and examination request system was instated in 1970; product patents were introduced in 1975. This also made pharmaceutical products patentable.

Trade Negotiations and IP

We discussed the IP in the context of international trade in Chapter 11. We mention here evidence that there was already an example of political economy of IP and international trade in the 19th century. In the patent law of 1885, acquisition of patents by foreigners was restricted to those that either resided or had commerce in Japan. It was believed that all important technologies would be monopolized by foreigners otherwise (Kiyohara 1929). At the time, Japan had concessions to countries as result of Ansei treaties with US, England, France, Russia and the Netherlands (1858). The concessions were abolished in 1894 when at the same time Japan extended patent ownership to all foreigners. Countries took a strategy very much like the TRIPs agreements of 1990s: IP negotiation coupled with other international treaties.

Takamine Jokichi and Riken Institute

Riken Institute became an independent agency under Ministry of Education, Science and Technlogy in 2003. It originally was a private research institute that worked closely with university academics while financing itself through patent licensing and commercialization of patents.

Takamine Jokichi is known for isolating the grandular hormone epinephrine and for Takadiastase[9]. Takadiastase is an enzyme made from rice that functions much like the digestive enzyme diastase and is a trade marked name. Takamine did his work on diastase in the United States and made a fortune from the product. (He paid financed the cherry blossoms on the banks of the Potomac River, a gift from mayor of Tokyo in 1912.) He felt that Japan needed a national science research institute. He campaigned along with other prominent businessmen and politicians, such as Shibusawa Eiischi and Sakurai Joji. The Rikagaku Research Institute was established in 1917 funded by contributions from the government, private donors and the Imperial

[9] Finley Ellingwood, 1919. “Diastase – Takadiastase”, The American Materia Medica, Therapeutics and Pharmacognosy.

family.

Reflecting Takamine, who was a scientist and an entrepreneur, the institute was interested in both basic research and commercialization from the beginning. In 1922 it established the system of principal researchers who could conduct independent research on topics of their choosing. Principal researchers were often also members of faculty at Imperial Universities and included Nagaoka Hantaro a, Suzuki Umetaro and Honda Koutaro. Suzuki Kotaro made scientific contributions in vitamin research but also contributed to the institute through his research on industrial sake production. The institute first successful commercialization of research was Adozol (a cooling and drying agent). Sale of the product started in 1921.

In 1922, Takahashi Katsumi succeeded in isolating vitamin A from liver oil after returning from his studies at University of Wisconsin. Vitamin A itself had been discovered in 1913 by Elmer V. McCollum at Wisconsin. Takahashi obtained patents for the production method in the US and other countries. The product was sold as "Riken Vitamin" and generated for Riken a revenue of 300,000 yen per year, a substantial contribution to the institute's budget. In return, Takahashi received from second half of 1922 to first half of 1930 invention bonuses totaling 480,000 yen (this is equal to 720 million yen today when adjusted for price of rice.)

Riken Kogyo (Riken Industries) Incorporated was established in 1927 to commercialize and manufacture products developed at Riken. Products included piston rings, light-sensitive paper and Arumaito (oxidized aluminum). At its height, the Riken Industrial group included 63 firms and 121 factories, some of which still exist today such as Ricoh. In 1939, the institute had revenue of 3,705,000 yen including revenue from its group firms (patent license royalties and dividends) of 3,033,000 yen. Research budget that year was 2,311,000 yen. Riken group was one of the 15 zaibatsu that was dismantled after World War II by the General Headquarters of the Allied Forces. In 1950 "Riken Research Institute" bill was passed and it became a government funded research institute for basic science.

Current Japanese IP System

Intellectual property in Japan has often been referred to as "industrial property". This includes patents, utility patents, design, trade marks and trade secrets. These are

overseen by Japanese Patent Office, under the auspice of Ministry of Economics, Trade and Industry. Another important intellectual property, copyright is overseen by Ministry of Education, Science and Technology. Copyright covers printed, visual and sound recordings for creative activity in the artistic sphere.

We can differentiate the three industrial properties: patents, utility and design in the following example (Japan Patent Office[10]). When Alexander Graham Bell invented the telephone, the methods of turning vibrations of air into electric currents, transmitting the current, and then turning them into vibrations of air, this was a patented technology. Initially a telephone had a microphone (mouthpiece) attached to the main body and a separate ear piece to be held. When the mouth and the ear pieces were put into one piece to be held in one hand, this innovation qualified as a utility patent. When the design of the body and hand pieces were changed from the clunky black ones to colorful Princess Line telephones, the new design was protected as industrial design. The name Princess Line was trade marked.

For the purpose of a patent, an invention is defined as "products or methods characterized by a high level of a creative technological idea" (Patent Law Article 2, Item 2) and also are "items characterized by a longer life cycle than a new utility model" (Japan Patent Office[11]). Article 29 explicitly states the three requirements for patentability 1) Usefulness 2) Novelty and 3) Innovativeness. In order to obtain a patent,[12] an inventor submits an application, the application will be examined when a request for examination is submitted. (The request must be made within three years or otherwise the application will be considered withdrawn.) Application is examined, checked if the technology satisfies the three requirements for patentability. If the a patent is refused, there is an appeal process. If a decision to grant a patent is made, the registered patent (registration fee is paid) is published in the Patent Gazette. Any one is able to file to invalidate the patent. A panel of three to five appeal examiners decide either to invalidate the patent or not. A registered patent is valid for 20 years from the date the application is filed as long as annual renewal fees are paid.

The Japanese patent system may be characterized with 1) first to file 2) request for examination (no automatic examination of applications) 3) there is an examination 4)

[10] http://www.jpo.go.jp/seido_e/s_gaiyou_e/222e.htm
[11] http://www.jpo.go.jp/seido_e/s_gaiyou_e/4houe.htm
[12] http://www.jpo.go.jp/tetuzuki_e/t_gaiyo_e/pa_right.htm

disclosure of applications and 5) service inventions. Patent applications, not registered patents, are published 18 months after the application was filed. European Patent Office has the same system but only applications filed abroad a published by the US Patent Office. Applications filed only in the U.S. will remain confidential. This means, in particular, that it will not become public information when the application is rejected.[13]

A6 Research Exemptions and Service Inventions

Research Exemptions: Since 1909, Japanese Patent Law has excluded from monopoly protection use of the technology for "experimental and research" purposes. University research therefore was protected from patent infringement claims. In 1959 the Patent Law was changed so that patents gave ability to excluded others from using the technology in their "trade". In Europe and United States, non-profit or non-commercial uses are exempt. However in Japan non-commercial research will not be exempt if it is done as part of one's trade. Therefore Duke University would not have qualified for research exemption in Japan (Duke vs Madey). In Japan, research exemption was used as a defense when Hamamatsu Medical School was sued by AntiCancer for infringing on the company's model mouse patent.[14] Unfortunately the court did not rule on research exemption because it decided that School's mouse did not infringe the AntiCancer's patented mouse to begin with.

Research exemption is useful for second movers (follow-ups) because it allows it to use the technology without ex-ante agreements. It becomes significant where there is a probability of inventing around the old technology so that the new technology that is eventually developed will not be blocked by the old patented technology[15]

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[13] See Aoki and Spiegel (2005) for economic analysis of publishing patent applications. The objective of publication of patent applications is to promote information dissemination. However since not all applications become patents, there is a positive probability that a technology becomes public information without patent protection. This probability is extra cost of filing for a patent. As result, firms choose not to file for a patent when they would have if the application remained confidential, reducing the amount of information disseminated in the end.

[14] AntiCancer owns a patent for mouse susceptible to certain types of cancer.

[15] Nagaoka and Aoki (2006) show that under such circumstance, research exemption

Service Inventions: Article 29 of Patent Law states that an invention (and therefore the patent) obtained by an employee as part of employment belongs to the employee. The employer (firm or government) has the right to practice the patent provided employee is given "reasonable compensation".

Nakamura Shuji succeeded in developing the blue light emitting diode (LED) as employee of Nichia Kagaku Kogyo. Red and yellow LEDs had already been developed but development of blue was considered to be a decade away. LEDs low energy property had numerous applications. Nakamura was paid 20,000 yen for the invention in line with the company regulation on employee inventions. Nakamura sued for "reasonable compensation" claiming that half of the firm's net revenue of 120 billion yen can be attributed to the blue LED. The court ordered the firm to pay Nakamura 20 billion yen. The firm appealed but eventually Nakamura received 6 00 million yen in an out of court settlement. This set off a series service inventions, and firms such as Hitachi and Ajinomoto were sued.

The court rulings demonstrated that firm internal rules for rewarding inventions, patent applications and patent registrations did not suffice as "reasonable compensation". In case of Olympus, firm regulation states that the firm pays the employee 3000yen at the time of patent application, 8000 yen when patent was registered and 200,000 yen when the patent generated revenue. Olympus was sued by Tanaka Shumpei (inventor of optical pick-up device) for "reasonable compensation". In the final ruling, the Supreme Court ordered Olympus to pay Tanaka 2.5 million yen, based on revenue of about 9 million yen. The final Supreme Court ruling in 2005 also determined that revenues from abroad (based on foreign patents) should be included in calculating "reasonable compensation".

Research Funding

In 2006 total research expenditure in Japan was almost 18 million yen. Private sector accounted for 80.7% of the total while government's share was 19% percent. Of the total government (central and local) funding of 3.4 million yen, 51.2% went to universities, 40.4% to public research institutions (publicly funded facilities for experiments and surveys). Only 4.3 % sent to private research. Looking the other

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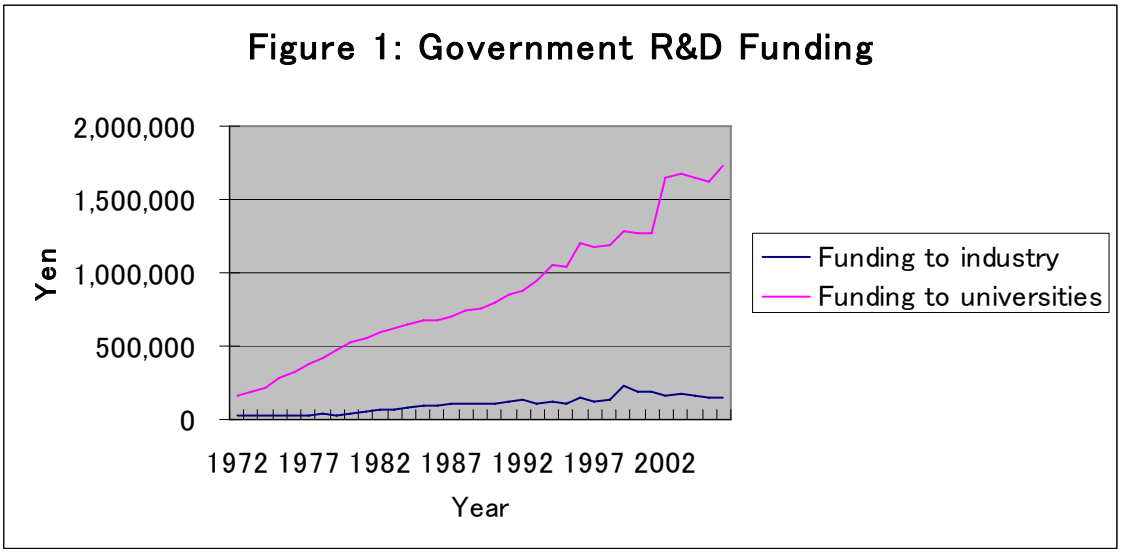
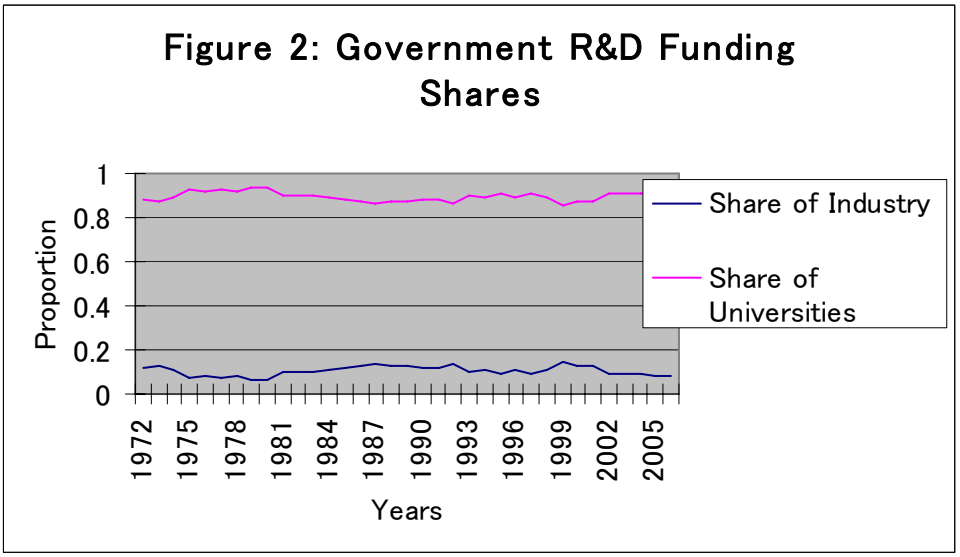
may increase probability of follow up (second generation) innovations taking place, but it may reduce over all welfare by discouraging ex-ante licensing.

way around, 50.9% of university research is funded by the government and only 1.2% of private sector research comes from the government.

Share of government funds in total research expenditure was around 30% in the 1960s but had dropped to around 20% by 1980. While government expenditure grew at rate of around 20% in the 1960s and private growth remained around 15%, private expenditure growth remained above 10% in the 1980s while the government growth remained below 10%. There was almost no research funding growth in the 1990s, government expenditure growth remains close to 0 but private research funding has been growing at around 1% since the beginning of the decade. (Figures 1 and 2)





Breakdown of 2006 university research expenditure[16] by field was life sciences 23.2%, information and communication 4.2%, material sciences 2.7%, environment 2.5%, nanotechnology 1.2%, energy 1.5 % , marine development 0.42% and space development 0.22%. Breakdown for non-profit sector research was life sciences 19.1%, energy 17.7 %, space development 12.4%, environment 7.3%, information and communication 5.7%, material sciences 4.6%, nanotechnology 0.99%, and marine development 0.42%. Private sector research was information and communication 21.02%, life sciences 10.1%, environment 5.6%, energy 4.3 %, material sciences 3.3%, nanotechnology 0.99%, space development 0.20%, and marine development 0.04%.

University Innovation

Japanese national universities became independent agencies in April 2005. The funding system is undergoing a change. Universities are turning to intellectual property licensing as source of funding. (Table 1). Patent applications are on the rise for all universities. In 2003 there were 32 national universities that had any revenue from patents. The number increased to 83 in 2005. Total revenue increase from 543 million yen in 2003 to 638 million yen in 2005. Nagoya University had the largest patent revenue with 409 million yen in 2003 but the blue LED related patents are beginning to expire and the university's patent revenue dropped to 199 million yen in 2005. The increase in over all revenue means other universities are increasing their patent revenue significantly. The distribution of university owned patents seem to exhibit the same skewedness mentioned in Chapter 8.

[16] 2006 Science and Technology Survey.

Table 1: Number of Inventions

	National Universities		Private Universities		Public Universities		Total	
	Ratio to Previous Year	Number Of Inventions	Ratio to Previous Year	Number Of Inventions	Ratio to Previous Year	Number Of Inventions	Ratio to Previous Year	Number Of Inventions
FY 2000	2,391		–		–		–	
FY 2001	3,040	1.27	–		–		–	
FY 2002	3,832	1.26	–		–		–	
FY 2003	6,787	1.77	1,094		197		8,078	
FY 2004	6,968	1.03	1,590	1.45	275	1.40	8,833	1.09

※「–」not surveyed

Table 2: Patent Applications

	National Universities				Private Universities				Public Universities				Total			
				Ratio to				Ratio to				Ratio to				Ratio to

Table 3: Patent Application by National Universities

	Life Sciences		Information and Communication		Environment		Nanotechnology Material Sciences		Other		Total
FY 2004	1,226	29.5%	670	16.1%	296	7.1%	960	23.1%	1,000	24.1%	4,152

Table 4: Practiced Patents and Royalty Payments FY 2005 (FY 2004)

	Number of Practiced Patents		Royalty Revenue (1000 yen)	
Total	(185) 477	Ratio to Previous Year 2.58	(543,224) 542,509	Ratio to Previous Year 1.00
National Universities	(79) 223	2.82	(427,655) 415,997	0.97
Private Universities	(106) 247	2.33	(115,569) 124,893	1.08
Public Universities	(0) 7	–	(0) 1,619	–

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