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Research and Development in Japan and its Implication

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I. Introduction

When talking about scientific research, people generally think of a group of scientists in their goggles and gloves in a lab working with microscope and test tubes. Surprisingly, a large number of companies and corporations also conduct countless scientific research. Scientific discoveries are typically available to the public; therefore, firms can choose to free-ride on the research efforts. However, companies still invest in a significant amount of money in scientific research to produce more scientific knowledge. In 2013, the business sector in the United States alone contributed to about 24% of all scientific research (Arora et al., p. 1). The reason that firms spend resources on doing scientific research is that they can take advantage of the findings of the research to develop new products or services. Despite the economic downturn, global spending on R&D by the world's top 1400 R&D investors increased by 9.5% in 2008 (Walter, p. 7). Innovation-based industries such as pharmaceuticals and biotechnology also experienced a growth of 7% (Walter, p. 7). Businesses and companies are willing to invest in innovation during a recession because the costs of doing so are likely to be lower. Japan and the US, unsurprisingly, are two countries that contributed to 80% of the world's R&D (Walter, p. 7). One character of R&D investment is that it requires a relatively large amount of money up front, but the return of investment is usually not seen imme-

diately; it takes time for a specific scientific achievement to transfer to specific products or services. Also, there are risks involved in R&D investments, such as decreased internal cash flow and risks associated with knowledge spillovers. So, what makes firms want to make investments in R&D?

Investments that corporations made to research account for a significant share of its overall investment and understanding why firms invest in research is useful not just for informing policy formulation but also for insights into how the economy itself is changing (Arora et al., p. 3). Corporate production of scientific knowledge is closely related to its use of the internal invention (Arora et al., p. 3). Firms that are able to build on their research in their inventive activity produce more knowledge than those that are less successful in using their research internally (p. 3). Research that is internally used is valued more by investors and the internal use of research results is associated with higher R&D productivity (Arora et al., p. 3). In a study conducted by Griliches, he found that the return to basic research to be prominent; companies that spent a larger percentage of their total R&D on basic research has shown a higher productivity (Arora et al., p. 5). The purpose of this paper is to examine some of the leading factors that drive businesses to invest in R&D, even when doing so involves risks that can affect firms' profitability. I look at companies in Japan in particular in making my arguments in favor of business collaborations and present some of the benefits that Japanese firms have obtained by doing R&D collaborations with universities. Based on my findings, I offer some implications in terms of public finance and policy making to facilitate the activities in R&D. The rest of the paper is organized as follows: the next section presents some of the main arguments made by Aurora et al. regarding the incentives of investing in R&D and the sharing of re-

search results; then, I present my own argument about firms investing in scientific research, especially firms in Japan, and assert that firms benefit from doing scientific research when collaborating with universities. In the third section, I compare firms in Japan with firms in the US and explain the different approaches taken by the two countries in doing scientific research. Lastly, I present some implication to public finance and policy makers regarding the facilitation of R&D.

II. 1. Incentives for Investment in R&D and Information Sharing

As mentioned before, since the results of basic research conducted are usually shared and published, how do companies actually benefit from their own investment in research is intriguing. A couple of literature attempted to provide insights into this question. The first opinion is the notion of absorptive capacity. Absorptive capacity refers to firms' ability to access external knowledge (Arora et al., p. 6). In other words, absorptive capacity is a limit to the quantity of scientific knowledge that a firm can absorb. As a result, firms need to engage in internal R&D to expand its research capacities. For example, Cockburn and Henderson found that pharmaceutical firms must invest in internal basic research to take better advantage of publicly available scientific knowledge (Arora et al., p. 6).

So why do companies choose to publish the results of their scientific research in the first place? Many studies show that conducting corporate research and publishing the results is an effective way to attract talented scientists and inventors (Arora et al., p. 6). The corporate publication provides a reward system for scientists who want some autonomy to spend some time on their own research. Moreover, publication of re-

search results sends a positive message to regulators, customers, and investors about firms' product quality and potential, which in turn builds firms' reputation (Arora et al., p. 7).

Despite the popularity of the above arguments, they raise additional questions. It is still not answered as to why do firms want to attract researchers. Also, it is not entirely clear as to whether the research conducted by firms generate real private value. The study of Arora et al. finds that firms indeed have incentives to invest in research, even though the results are shared (p. 8). Scientific knowledge generated from the firm will help the firm's inventive activities. Also, firms that produced the scientific knowledge have the best understanding of the findings, and firms may leave some details of the research findings to themselves, which put them in an advantageous position to their competitors. As a result, firms with greater use of internal research are likely to exhibit a higher R&D productivity (Arora et al., p. 8). On the contrary, if the firm's research results were being cited by its rivals, then logically this would lower the firm's private return on internal research and hence its willingness to invest. Specifically, a firm whose research is used in its own inventive activity is likely to continue investing in research. Logically, a firm whose research results spill over to its rivals is likely to reduce its investment. That begs the question, will firms be better off sharing knowledge or keeping their research results a secret? We can get some insights by looking at how firms conducting R&D in Japan.

II. 2. University-Industry Collaboration in Japan

Perhaps a much more obvious place where research is being frequently conducted is in universities. In Arora et al.'s study, they compared

research done by corporations with research done by universities and found that corporation publications are about three times more likely to be cited by a patent than university publications (p. 12). Contrary to the results found in Arora et al.'s study, Japanese firms often collaborate with universities in conducting university-industry research, and that university knowledge can spill over into firms leads to a positive effect on firms' R&D productivity. Fukugawa argued that while basic research conducted in universities do not directly associate with industrial use, it can often be applied to achieve technological advances and solve firms' problems in R&D (p. 415). Companies in Japan often benefit from knowledge spillovers from major national universities to foster industrial innovations (p. 416). The study of Arora etal. seems to present the argument that companies should not rely on basic research conducted by universities because the results are not always valuable to industrial use and that the publications of university research get cited less often. However, based on the study of Fukugawa, the situation is Japan is different. Larger firms had a long history of sharing talents and results with major universities, either by hiring graduates or by the voluntary transfer of university inventions (p. 416). There are some apparent benefits of R&D collaborations. One of the most important aspects of the R&D collaboration is the possibility of information sharing and skill sharing. R&D collaboration allows participating firms to have free access to knowledge of others, which can encourage firms to increase their investment in R&D (Fukugawa, p. 417). For example, even though the interaction between universities and companies do not necessarily guarantee the success of product development, firms can still take advantage of the knowledge and skills of university-based scientists to help improve the productivity and skills of their R&D personnel which can be valuable to firms' future R&D projects (Fukugawa, p. 419). Therefore,

collaborations with universities can improve R&D productivity of participating firms.

Traditionally, larger firms are reluctant to R&D collaborations in general because they have sufficient resources to support them do internal research (Motohashi, p. 340). However, as globalization continues to bring more players to the table, innovation competition is intensified. Large corporations in Japan find it harder and harder to conduct all R&D internally to compete with other fast-developing countries such as South Korea and Taiwan (Motohashi, p. 340). As a result, more large corporations in Japan start to actively seek opportunities to collaborate with universities. Compared to smaller firms, large corporations can take more out of the R&D collaboration with universities because they have more resources and assets such as distribution channels, service networks, and reputation, to utilize the results of R&D into product development (Fukugawa, p. 418). After the reform of national innovation systems in Japan, smaller firms also have access to exploit university knowledge for innovation. But instead of embodying the outcome of R&D in products, smaller firms rely on the licensing of patents to commercialize technology (Fukugawa, p. 419). Therefore, the measurement of the effect of research collaborations with universities on the productivity of R&D of smaller firms is by the number of patents issued by their R&D personnel. The study done by Fukugawa found that smaller technology firms who have less complementary assets, such as reputation and distribution channels, tend to apply for patents more positively than their larger counterparts (p. 425). By issuing more patents, smaller technological firms will have appropriate means to commercialize the technology, as they can profit from citations of their patents from other firms.

II. 3. Sharing is Not Necessarily a Problem

One of the arguments made in Arora et al.'s study is that even though published knowledge is available to everyone, companies still have the incentive to conduct research and publish the results because the firm that produced the knowledge in the first place has the best place to use the knowledge (p. 8). Fukugawa made a similar argument about the collaboration between universities and small firms in Japan. Intuitively, the spillover of knowledge should not be localized because everyone has access to it. However, the reality is that firms that have local ties receive more knowledge spillovers from the collaboration with universities in research (p. 419). In other words, firms that are far away from the university that produced the scientific knowledge will likely to receive fewer benefits from the knowledge. This is because, as Fukugawa argues, technological knowledge developed in universities are usually not in its mature state, and in order to effectively understand the practical application of the new knowledge or technology, firms need to communicate and work closely with the inventor of the university (p. 419). The similarity between the two views is that the application of new knowledge is usually not easily understood. Therefore, those with a more proximate relationship with the inventor of the knowledge will have better chances communicating with the inventor of the knowledge or technology and thus will be in an advantageous position compared to those who are remote from the inventor.

Under the Japanese context, knowledge spillovers may be especially valuable to R&D of small technology firms. As argued by Fukugawa, cooperative research has been used by large corporations as means to preempt outcomes of publicly funded research, and that the Japanese Patent Law prohibits one single co-owner of patents to transfer patents to other

firms without the permission of all the co-owners (p. 425). This puts smaller firms at a disadvantage since they often lack the social capital and resources required to perform research collaboration with universities. Therefore, small firms have incentives to patent their inventions to build their business reputation. Given such situation, policy makers should have initiatives that facilitate the cooperative research between smaller firms and universities to improve the knowledge of smaller firms. For example, policy makers may consider implementing projects that strengthen the relationship between the two, such as setting up regional cooperative R&D center or local public technology centers (p. 426).

In general, technology-based firms rely on doing extensive research to make breakthrough discoveries which then can be translated into a sustained competitive advantage. The role university-industry collaborations play in shaping the innovative performances of universities and firms have been a key issue in the discussion of innovation. Among sectors that rely heavily on scientific breakthroughs, the contribution of basic science is considered to be high in the pharmaceuticals and chemicals industry (Baba et al., p. 756). Collaborations between universities and firms lead to the transfer of knowledge and bilateral interaction which help to carry out R&D activities more effectively. As argued before, scientists from universities are important in helping smaller technology firms to improve their R&D productivity. Characterized as one of the innovation-driven industries, firms from the pharmaceutical industry often have a high level of R&D expenditure. High level of R&D investment is usually associated with higher firm value and operating performance (Nivoix & Nguyen, p. 225). In Nivoix and Nguyen's study, although the linkage between R&D expenditure and sales growth seems to be weak, they explain that it could be due to the fact that the benefits of R&D investment will

take some time to show. Otherwise, it would be hard to explain why firms would be willing to bear the risks, such as lower internal cash flow, of conducting R&D without anticipating any benefits (p. 237). Nevertheless, they did show a significant increase in sales following the R&D in a large control sample of firms with active R&D projects (p. 238).

Another interesting case specifically about the biotechnology sector of Japan offers different insights on the role top scientists play in the success of biotechnology industry of Japan. The case of the Japanese biotechnology industry is important because Japanese bio-scientists are second only to the US in their genetic sequence discoveries, which is the critical driving force behind the latest major wave of technology transfer from basic science (Zucker et al., p. 38). Also, the knowledge and discoveries produced by biotechnology scientists are often of high value, meaning that it has a high degree of privatization compared to knowledge produced via basic science (p. 38). One of the characteristics of knowledge produced by the biotechnology sector is the high tacitness of the knowledge, which limits the ability of other scientists to learn the knowledge (p.39). Therefore, when dealing with knowledge with high tacitness, a certain level of collaboration is often a requirement. In the study of Zucker et al., they found that firms with linkages to top scientists from universities exhibit higher scientific productivity and produce a higher number of biotech patents compared to those with no linkage (p. 52).

Similarly, one of the hypotheses brought up by Baba et al. is that collaborations with "Pasteur scientists", who are crucial in the process of co-evolution of science and technology, are important in determining firms' R&D productivity in industries that require advanced knowledge (p. 760). They argue that in fields where advanced knowledge is demanded, such as biotechnology, pharmaceuticals, and advanced materials, universities

play important role in providing firms with appropriate consulting to help them solve problems (p. 760). Based on the results of their study, collaborating with "Pasteur scientists" made a positive and prominent impact on firms' innovative productivity. This confirms that it is important for firms to work selectively with the appropriate university partners to get valuable scientific and technological experience and advice (p. 762).

III. The Japan Way vs. The US Way

Another study done by Cohen et al. looks at the manufacturing sectors in the US and Japan and how the within-the-industry flows and spillovers of knowledge differ between Japan and the US. As argued before, companies, in general, need to have certain ways to appropriate the value created by innovations to keep investing in R&D. What Cohen et al. find in their study is that intra-industry spillovers of R&D knowledge in Japan are greater than in the US (p. 1350). As data shows, R&D spending in the US has been experiencing a slight decrease in recent years, and a large part of the reason is that firms in the US do not want knowledge to become accessible to their rivals. In Japan, however, R&D spending as a percent of total GDP is higher than the US (p. 1350). Such difference can suggest that the flow of information and knowledge within industry plays different roles in Japan and the US. In the US, only 13% of companies admit that information from their rivals helps them with their own project execution, whereas in Japan, the number is 51% (p. 1351).

Given the more rapid spillovers of knowledge amount Japanese firms, the appropriation of profits due to innovation in Japan should be less than in the US. Cohen et al. find that the time it takes for a Japanese firm to imitate an innovation of its competitor is much shorter than it is in the

US (p. 1353). This makes Japanese firms to have a smaller profit window for its inventions and innovations, thus a weaker ability to appropriate the returns to their innovations. In the US, using secrecy as a mechanism for protecting product innovation is seen as the most effective method across all industries, where as in Japan, secrecy is viewed as the least effective appropriability mechanism. Compared to secrecy, patents in Japan are viewed as more effective for protecting product innovations. This difference, as argued by Cohen et al., can be attributed to the different patent system in Japan and the US (p. 1355).

The Japanese patent system was first developed in the 19th century not only to encourage domestic inventions but to help the technology transfer from Japan. Therefore, the emphasis of the Japanese system was the disclosure function of patents (p. 1356). One of the key differences between the Japanese patent system and the one in the US is that the Japanese patent system requires disclosure of information at filling, whereas the US system only requires disclosure upon issuance (p. 1356). Additionally, there exists a "pregrant opposition" rule in the Japanese patent system where competitors can challenge the validity of a filed patent within three months after the examiner of the patent gave notice about the potential grant of the patent (p. 1356). As a result, Japanese firms filing for patents disclose the information to the general public sooner, which leads to the sooner filing of patents and also the incentive to monitor competitors' actions.

It is not uncommon nowadays for countries to learn from each other's technological advancement and assimilate some of the valuable findings into their own research to facilitate economic growth. Many developed countries also offer technical assistance to less-developed countries and freely share knowledge with them. In Japan's case, since the WWII,

the way Japan has been taken in improving its trade balance and technology advances and productivity growth was largely by learning from the West, particularly the United States. Most of Japan's R&D efforts can be characterized as adaptation, assimilation, and diffusion of foreign technologies (Spencer, p. 521). However, a large number of policy makers of the US have argued that Japan has benefited so much from the US scientific achievements, but has been reluctant to give back (Spencer, p. 522). Contrary to such belief, Spencer argued that firms in Japan share no less knowledge with the rest of the world than firms based in the US (p. 522). Spencer's study finds that Japanese firms published significantly more scientific papers in foreign countries than their US counterparts and that Japanese publications were cited more frequently by foreign firms than US publications (p. 527). The results of Spencer's study make sense because as Japan moves into a highly technologically developed country, it has fewer opportunities to appropriate more advanced technologies from other countries. Scientists from Japan may be more willing to disseminate knowledge to the globe to get recognition internationally.

IV. R&D Funding and Policy Implication

As discussed earlier, one characteristic of Japan's national innovation system is the significant role that large corporations play. The total R&D expenditure of corporations exceeded 11.8 trillion yen in 2003 (Motohashi, p. 339). Despite the large amount that these corporations spent on R&D, they are reluctant to collaborate with universities and in general. Relying on their internal financial resources, large corporations are dominant in the R&D field, leaving little room for small companies to participate (Motohashi, p. 340). However, the situation starts to change as the

Japan's innovation system shifts from large-firm-centered to a network-based system focusing on external collaborations. Such reform gives small companies much more space to participate in the R&D playground because external collaboration is generally welcomed by small firms. Through the active collaboration with universities, new technology-based firms have managed to sustain high productivity in R&D (Motohashi, p. 358). As mentioned earlier in the discussion, smaller firms lack the absorptive capacity, as well as sufficient funds and human resources, necessary to make use of the research results produced by universities. This makes their collaboration with universities riskier.

To foster the development of new firms, the government should consider offering direct financial support, such as favorable tax policies and subsidies. The updated R&D tax credit policy of 1999 offers a tax incentive to firms whose R&D expenses in a given year exceed both "the base R&D expenditure" and "the comparative R&D expenditure" (Koga, p. 644). Then firms can deduct 15% of the difference between the base amount and the comparative amount of their corporate taxes (Koga, p. 644). The study of Koga examines the effectiveness of R&D tax incentives on 904 Japanese manufacturing firms and finds a tax price elasticity of −0.68 for all firms, and −1.03 for larger firms (Koga, p. 646). Such result suggests that the existing tax credit benefits favor larger companies more than smaller ones. One reason could be that smaller firms do not have the R&D expenditure that is high enough to actually take advantage of the difference between the baseline and the comparative amount. However, since smaller firms are more active in participating in a university-industry collaboration which is beneficial to the productivity of R&D investment, maybe the Japanese government can introduce a new tax incentive designed specifically for start-up companies whose funds are limited.

Another way to support the research productivity of participating firms is to establish government-sponsored research consortia (Branstetter & Sakakibara, p. 143). In Japan, the government provides subsidies for members of R&D consortia, which can lower the effective cost of R&D, and also encourages the sharing of research results among participating firms (Branstetter & Sakakibara, p. 145). In general, after joining the consortia, firms generate more patents, however, as Branstetter and Sakakibara argues, the design of a consortium matters much more than the level of resources spent on it. A truly effective consortium should facilitate technological spillover and give incentives for firms to cooperate (p. 156).

V. Conclusion

Despite the recent economic recession, companies all around the world continue to pour a significant amount of resources into R&D. Companies believe that conducting R&D can help them stay innovated among its peers, develop new products and services, builds their reputation, and gain a competitive edge. On the other hand, there are also firms who are concerned about the spillover effect of conducting R&D, since they do not want their research results to become openly available to the public. Others are skeptical about cooperating with universities because they question the effectiveness of research done by universities in product development, and they are worried that the information they share with universities will become accessible to others. Nevertheless, in this paper, we have discussed the benefits of collaborating with scientists and experts from universities, and how it has helped large firms to be competitive globally and helped smaller firms with a focus on technology to sustain higher productivity in R&D. In Japan, R&D collaboration with universities

gives firms free access to the knowledge and expertise of universities, which can improve the skill of firms' own R&D personnel. When comparing firms in Japan with their counterparts in the US, we see that Japanese firms rely on patents as a more effective way to protect product innovations, whereas firms in the US value secrecy the most. This is in part due to the difference in the patent system between the two. In Japan, the patent system was designed to encourage information disclosure. In key areas where the technological process is rapid, such as information technology, engineering, and biotechnology, industry collaborations are crucial because companies in these areas need the expert scientific knowledge from universities. Therefore, from a decision-maker's perspective, incentives such as tax benefits and subsidies, and publicly-funded consortium, should be carefully designed and executed to better facilitate innovative activities.

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