論文の内容の要旨

論文題目　Study on the effects of university-industry collaboration at the different stages of the solar cell technology lifecycle
（太陽電池技術ライフサイクルの異なる段階における産学連携の効果に関する研究）

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University is important for the national innovation system and companies' R&D. There are many studies to deal with the importance of science, university and UIC in the innovation system. The contribution to technological innovations in industry and economic growth by scientific research (university research) activities itself has been identified. Countries, where researchers successfully generate important technological knowledge by science, have greater potential for economic growth by diffusing the technological knowledge to their local firms through a variety of channels to link to science like published papers and reports, public conferences and meetings, informal information exchange, and consulting.

In addition, research collaboration like university-industry collaboration is a good approach to enhance research quality and a growing phenomenon. Technology development is by itself typically the result of a complex set of relationships like research collaboration among actors, which includes enterprises, universities and government research institutes. This impact on innovation processes have been a longstanding object of analysis in various area like management studies, the economics of innovation, industrial organization, the sociology of science and science studies, and science and technology policy. UIC is one type of research collaboration, and one important topic of innovation system. Companies find various meaning in UIC like developing new product and technology, upgrading R&D potential, licensing of patents and know-hows, discovering of future R&D theme, R&D HR development, publication of papers, and advancing project management skill. "Open innovation" concept further includes more varieties of options like licensing, joint ventures or spin-offs, and the research collaboration. As a whole, companies increase applied research productivity in terms of both timing and quality by engaging in science, and getting the absorptive capacity for a better identification, absorption and integration of external public knowledge.

Role of university for innovation in industrial research and the balance of dividing R&D roles between universities and companies should change through technology lifecycles. (University research is almost the basic research in the sense that its aim is to understand

phenomenon at a relatively fundamental level, while university research is influenced by the technological problems and objectives. On the other hand, industry R&D is basically toward and good at a shorter term problem-solving activities, like an applied research and experimental development.) This is because specific weight of activities in each R&D phase would change with the technological change of general products, processes and services. Specific weight of basic research activities, which university mainly carries out, should be large in the technology introduction stage, and specific weight of applied research and experimental development activities becomes big in the technology growth and mature stages. The change of university role becomes clear recently, because this division of labor has been promoted recently. Companies have downsized the industrial laboratories from 1970s in USA and from 1990s in Japan, and depended more on universities about basic and applied research. In USA, industrial laboratories like AT&T's Bell Labs and the Xerox Palo Alto Research Center were wellsprings of powerful new technologies. But, in the competitive environment of the 1980s and the 1990s, research activities have been downsized, redirected, and restructured within most of the firms that once were major sponsors of industrial research. In Japan, firms had continued to do more in-house R&D compared to firms in USA, but followed the USA trend twenty years later. Japanese governments promoted this, as demonstrated by a series of legislative actions such as the 1998 Technology Licensing Organization Promotion Law and the 2000 Law to Strengthen Industrial Technological Capabilities.

In this study, we analyze the effect of university-industry collaboration on the quality of scientific publications and patents, and the effects of university-industry collaboration experience of industrial researchers on the patent quality, at the different stages of solar cell technology lifecycle.

First, we categorized the solar cell areas by the citation network analysis using solar cell scientific publications, identified four main component areas (silicon, compounds, organic thin-film, and dye-sensitized) in the solar cell research, and analyzed the characteristics of technology lifecycles of each solar cell area. Further, we identified the difference of degree of science-based in innovation between at the early and late stages of technology lifecycles especially in the silicon solar cell area. The relationship between scientific publications and patent applications is strong at the early stage of silicon solar cell technology lifecycles, and weak at the late stages of silicon solar cell technology lifecycles. In order to consider the structural change by the UIC promotion policy, we compared between the characteristics of silicon and dye-sensitized solar cell after 1998. These areas have the most tenuous relationship. We found that the involvement of university to the patent applications is strong at the early stage of solar cell technology lifecycles, and weak at the late stages of

solar cell technology lifecycles. The intensity of science-linkage is also strong at the early stage of solar cell technology lifecycles, and weak at the late stages of solar cell technology lifecycles.

Further, by using these patent and scientific publications data, we analyzed the relationship of these quality indexes, like forward citations, and science-linkage, with the interested variables like the dummy variable of university-industry collaboration and this cross-term with the citation count of non-patent literatures, at the early and late stages of solar cell lifecycles.

The result shows the clear difference of characteristics between early and late technology lifecycle stages. At the early stage of solar cell technology lifecycle, University-industry collaboration enhances scientific aspects of outputs, but does not enhance the technological value. Further at the early stage, university-industry collaboration experience also enhances scientific aspects of outputs, but does not enhance the technological value. On the other hand, at the late stage of solar cell technology lifecycle, university-industry collaboration does not enhance both scientific aspects and technological value of outputs. However, at the late stage, university-industry collaboration enhances technological value of patents, not scientific aspects.

In the conclusion, the role of UIC changes by the characteristics change of technological regimes through the technology lifecycles. UIC is directly effective at the scientific aspect for industry only at the early stage, at which technological regime is science-based, by the strong collaborative relationship between industry and university to create scientific knowledge and science-based technology. Industrial researcher tries hard to do scientific research and learn scientific knowledge from university researcher. On the other hand, UIC is not directly effective, but this experience is effective for the enhancement of technological value of inventions at the late stage. At this stage, the importance of scientific knowledge to industry is still high. The reason, that UIC is not directly effective at the late stage, is probably because companies hesitate to get the common patent rights of the technologically important inventions with universities, and so they get the hints of such inventions at UIC, complete them at their own companies, and get the rights exclusively. Therefore, we cannot grasp the real effect of UIC promotion policy by monitoring the outputs which are directly created by UIC.

We think especially that it is valuable to pay attentions that UIC have potential to contribute to the creation of commercially important invention at the late stage in the technology lifecycles. The ratio of industrial researchers who has experienced the university-industry collaboration from 1992 to 2007 is much smaller at the late stage than at the early stage. There might be room to promote industrial researchers to collaborate

with scientific researchers and enhance the assimilation capability as well as the acquisition capability of scientific knowledge in order to urge the industrial researchers to exploit more scientific knowledge for the creation of technologically important innovation especially at the late stage.

In addition, we think that we should evaluate the UIC not only by judging the value of outputs created through UIC, but also by recognizing the effect on the capability building of companies. Both at the early and late stage, UIC seem to have the positive impacts on the capability of companies. Therefore, it might be effective for policy makers to promote UIC further as the capability building opportunity as well as the output enhancement opportunity in order to promote solar cell innovations and other innovation. For the companies, it is also valuable to utilize UIC strategically as the capability building opportunity as well as the output enhancement opportunity, and there might be the chance to apply UIC to build the competitive advantage especially at the late stage of technology lifecycles.