Theoretical Studies on International Technology Agreements for Climate Change Mitigation

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論 文 内 容 の 要 旨

Technologies are expected to play an integral role in mitigating climate change. However, these technologies tend to require high costs in the phase of research and development (R&D). Moreover, one country's knowledge acquired through R&D spills over into others, which causes a free-rider problem. From the above reasons, each country may not conduct sufficient level of R&D individually and voluntarily (e.g. Carbon dioxide Capture and Storage (CCS)). To solve this problem, the mechanism, which promotes multilateral technology collaboration in the R&D phase, is considered necessary: hereafter, we call it an international technology agreement (ITA). An ITA is a joint-research project which is carried out by the group of countries who are voluntary participants. By sharing knowledge and collaborating, countries may be able to develop technologies more effectively and at lower costs.

In this thesis, we analyze the effectiveness of an ITA under various conditions by using coalition formation game in which players are countries and their strategies include technological R&D and adoption. This thesis is organized into five chapters.

Chapter 1 provides research background by conducting a literature review. Moreover, we present motivation, objectives, main results and contributions of this thesis. In addition, we also propose the structure of the thesis.

Chapter 2 analyzes the effectiveness of non-cooperation in technology adoption. We assume that R&D has the role of reducing the cost of technology adoption. We introduce the following three-stage coalition formation game. In the first stage, each country decides whether to join an ITA. In the second stage, the signatories collectively decide R&D investment costs. In the third stage, each country makes decision about technology adoption independently. By solving the above game, we get the following results. First, in the equilibrium state, the situation, in which all countries adopt technologies, is always achieved by introducing the ITA. Second, the social welfare with the ITA is the same or higher than without the ITA. We conclude that full adoption can be induced without the mechanism which promotes cooperation in technology adoption if there is the ITA which promotes R&D cooperation.

Chapter 3 investigates the impacts of R&D investment costs on an ITA. The role of R&D is the same with chapter 2. Here, we assume that R&D investment costs are determined exogenously. Therefore, the second stage of the game in chapter 2 is changed to the following:

the signatories decide whether to conduct R&D collectively. Our conclusions are summarized as follows. First, the number of signatories has a U-shaped relationship with R&D costs: when R&D costs are sufficiently either low or high, many countries rationally join an ITA. Second, there is a threshold regarding R&D costs that determines the effectiveness of the ITA: when R&D costs are smaller than the threshold, the ITA is functional, otherwise not. Third, the effectiveness of the ITA has a positive relationship with the number of countries that share the resource. Fourth, when the ITA functions, it can always induce technology adoption into all countries and improve all non-cooperative equilibria except the case in which the first-best is achieved in non-cooperative equilibrium. We conclude that, when R&D investment costs are relatively high, the ITA may be formed by many participants and hence function effectively.

Chapter 4 investigates the impacts of learning on an ITA. We assume that the role of R&D is creation of a new technology. It is also assumed that, if R&D succeeds, the benefit of adopting the new technology is high; otherwise it is low. The benefit of adoption may be uncertain, especially when evaluation of the R&D outcome takes a long time. Hence, we focus on the timing of learning relating to the benefit of adoption using two different models. When countries decide whether to adopt technologies, they either know the precise benefits of adoption (a model with learning), or they do not know the benefits of adoption (a model with no learning). Our conclusions are summarized as follows. First, in a state of equilibrium, the total number of signatories, total number of countries conducting R&D, and social welfare are always greater in the no learning case than the learning case. Second, all countries always choose to adopt technologies regardless of whether R&D succeeds or fails in the no learning case. Conversely, in the learning case, all countries adopt technologies only when R&D succeeds. Third, regardless of the existence of learning, the expected social welfare with an ITA becomes higher than without an ITA except the case in which non-agreements state achieves the first-best. We conclude that learning brings negative impact on the effectiveness of the ITA.

Chapter 5 concludes the thesis. We summarize the main findings in chapter 2-5 and give policy implication. Further, we present the focus of future research.