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The economic benefits of big science R&D: With a focus on fusion R&D program in Korea

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HIGHLIGHTS

- Recently, many studies have been conducted in advanced countries to analyze the spillover effects of big science equipment that has already been constructed, particularly for partnerships with industrial enterprises that have participated in the construction process as well as in terms of relevant technological innovation. However, there has been no systematic study conducted in South Korea on the effect of constructing a big scientific research facility on the participating industrial enterprises.
- The purpose of this study is to conduct an empirical analysis of the spillover effects of a nuclear fusion research and development (R&D) program by investigating cases of actual participating enterprises and identifying implications for relevant policies.
- The Nuclear Fusion Energy Development Plan was begun with the KSTAR construction project under the National Nuclear Fusion R&D Program, established in 1995. Currently, the Program has been divided into the KSTAR project, the ITER project, the DEMO project, and basic research and human resources fostering projects. In addition, about 250 companies are participating in the KSTAR and ITER projects.
- In this article, to verify the presence of theory-based spillover effects in South Korea and to identify relevant implications, the South Korean case of nuclear fusion research was analyzed with respect to the three types of R&D spillover effect described in previous studies, which are market spillover effect, network spillover effect, and knowledge spillover effect.
- In-depth interviews were performed with 24 enterprises (10%) out of about 250 enterprises that have participated in nuclear fusion R&D program (69 enterprises in the KSTAR project and 180 enterprises in the ITER projects). Analytical results show that the economic spillover effect of nuclear fusion R&D program was significant. Spillover effects of each type are shown below. First, with regard to the market spillover effect, the contribution ratio of nuclear fusion R&D program to the increase of the sales of the 24 enterprises that participated in the KSTAR and ITER projects was 19.1% on average; the total amount of sales increase was estimated to be 1,538,600 M KRW. The analysis showed that the 24 participating enterprises have created a sales-increasing effect greater than the financial input to the KSTAR and ITER projects (762,600 M KRW). Second, with regard to the knowledge spillover effect, 238 new jobs were created in the 24 participating enterprises through participation in the KSTAR and ITER projects; a total of 527 human resources in the industrial enterprises have experienced nuclear fusion. Finally, analysis of the network spillover effect showed that 15 enterprises (62%) out of the 24 enterprises participating in the nuclear fusion R&D program have extended their businesses to other relevant technological fields.

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ABSTRACT

This paper is focused on the analysis of spillover benefits of the ongoing R&D program on nuclear fusion in Korea. An empirical analysis was conducted on the economic spillover effects of nuclear fusion research and development (R&D) program by investigating cases of actual participating enterprises. The 24 representative enterprises were selected from about 250 enterprises that participated in the KSTAR and ITER projects. The analysis showed that the effect of increasing sales was a total of 1,538,600 M KRW in the 24 enterprises that participated in the KSTAR and ITER projects; about 527 human resources have been fostered in industrial enterprises. Additionally, network analysis results show some cases in which the participating enterprises have extended their businesses into international and domestic fields of nuclear fusion and particle accelerators as well as into private markets.

1. Introduction

Recently, many countries emphasize efficient governmental investments and management of big science programs, which may lay a burden on national finance. Many studies have been conducted

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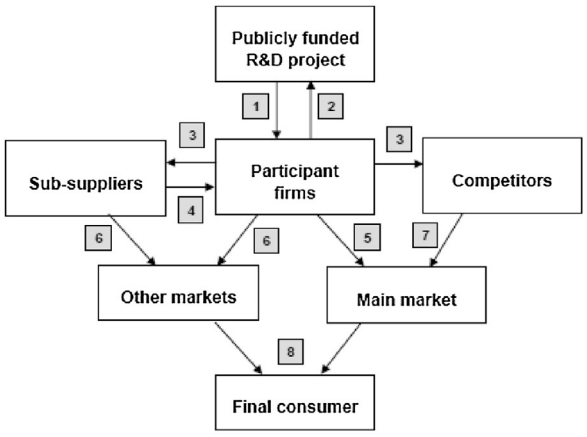
Table 1
A Framework of Analysis.

Types of spillover effect		Key items	Analytical method
Embodied	Market spillover effect	Number of nuclear fusion enterprises, sales of participating enterprises (direct and indirect)	Analysis of enterprise databases and interviews with enterprises
	Network spillover effect	Spillover of nuclear fusion technologies to other areas	Analysis of enterprise databases and interviews with enterprises, network analysis
Disembodied	Knowledge spillover effect	Fostering of skilled human resources (spillover of ideas)	Analysis of enterprise databases and interviews with enterprises



1. Knowledge flows from public research centers towards private firms, development of innovative products, process improvements, QMS strengthening, network building, HR(Human Resource) training, financial reward, reputational gains
2. Supply of innovative products, or existing / improved products to public R&D facilities
3. Free knowledge flows to other market players (sub-suppliers, competitors)
4. Induced innovation in sub-supplier companies
5. Sales of innovative products by project participants on the market directly initiated by R&D project
6. Sales of innovative products on other markets (spin-off applications)
7. Development and sales of innovative products on the main market by competitors
8. Consumers' surplus

Fig. 1. Spillovers' Origin and Transmission Mechanisms.
Source: Ref. [2]

on the direct economic effects of nuclear power generation and space sciences, which have been commercialized globally; tangible accomplishments have been made, including the export of nuclear reactors and aircrafts. However, nuclear fusion will require a long time for further development and commercialization, and thus any prediction of its economic effects through commercialization is still limited.

Recently, many studies have been conducted in advanced countries to analyze the spillover effects of big science equipment that has already been constructed, particularly for partnerships with industrial enterprises that have participated in the construction process as well as in terms of relevant technological innovation. However, there has been no systematic study conducted in South Korea on the effect of constructing a big scientific research facility on the participating industrial enterprises.

The purpose of this study is to conduct an empirical analysis of the spillover effects of a nuclear fusion research and development (R&D) program by investigating cases of actual participating enterprises and identifying implications for relevant policies.

2. Theoretical background

2.1. Overview of nuclear fusion energy development program in korea

The Nuclear Fusion Energy Development Plan was begun with the KSTAR construction project under the National Nuclear Fusion R&D Program, established in 1995. Currently, the Program has been divided into the KSTAR project, the ITER project, the DEMO project, and basic research and human resources fostering projects. About 250 companies are participating in the KSTAR and ITER projects.

2.2. Concept of economic spillover effect and review of relevant previous studies

2.2.1. Concept of economic spillover effect

Innovation in terms of the analysis of economic spillover effects and the social earning rate of R&D and study in the context of technological policy have been important issues in the last few decades. According to [1], a spillover effect may be defined as "any positive externality that results from purposeful investment in technological innovation or development." Many empirical studies indicate that R&D spillover effects may have a social earning rate that is considerably higher than the private earning rate [2]. On the other hand, a spillover effect often has an invisible form, because its monetary value is difficult to measure.

2.2.2. Review of previous studies on spillover effects of large R&D programs

Many international and domestic studies have been reported with regard to the economic effect of R&D investments. However, most of the studies were conducted by analyzing the effect of R&D investment on enterprises in the private sector [3] or by analyzing the spillover effects of national R&D investments on macroeconomics [4,5]. In addition, several international and domestic studies have been conducted on the economic spillover effects of basic research [6,7], but almost no studies have been conducted on the R&D spillover effects of big science programs such as nuclear fusion. From the early 2000s, international studies have been conducted on partnerships between big sciences and industrial enterprises, focusing on CERN (European Organization for Nuclear Research). Some examples of study conducted with CERN, which is a representative big science institution in Europe, are a study on technological innovation through the partnership between big science and industrial enterprises [10], analysis of Public-Private Academic Partnerships (PPAPs) in big science [12],

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