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Role of policy in innovation and international trade of renewable energy technology: Empirical study of solar PV and wind power technology

Kyunam Kim [a,*], Yeonbae Kim [b]

[a] Korea Information Society Development Institute, 18 Jeongtong-ro, Deoksan-myeon, Jincheon-gun, Cungcheongbuk-do 365-841, Republic of Korea
[b] Technology Management, Economics and Policy Program, Seoul National University, 599 Gwangang-no, Gwanak-Gu, Seoul 151-742, Republic of Korea

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ABSTRACT

To develop renewable energy technologies for sustainable economic growth as well as environmental solutions, firms must consider domestic technological diffusion and foreign trade competitiveness. In this paper, we identify interrelations between domestic R&D and international trade as well as seek to determine the role of renewable energy policies. We estimate the model by using unbalanced panel data, obtained between 1991 and 2008, from 16 countries using solar PV and 14 countries using wind power. The empirical results confirm that international markets may affect domestic R&D of mature technologies more than that of immature technologies, and intensified domestic R&D corresponds to increased exports and imports. This study also shows that wind power is in a virtuous cycle with respect to R&D and exports. In addition, public R&D and tariff incentives are significant instruments for increasing international trade as well as domestic R&D.

Contents

1. Introduction

1.1. Domestic R&D and international trade

The global market for renewable energy has been growing stably due to strengthened global regulations, such as those

* Corresponding author. Tel.: +82 10 8578 2720; fax: +82 43 535 4695.
E-mail address: knkim@kisdi.re.kr (K. Kim).

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recommended at the Climate Change Convention, and the massive investment for renewable energy installation in Annex I countries. Recently, the global market for renewable energy is not only scaling up but also becoming more open. This comes from the two primary reasons. First, initial efforts for renewable energy development were focused on solving global environmental problems; however, recently each country seeks to improve energy security and to accomplish sustainable economic growth with renewable energy [19]. Second, the renewable energy industry, even while undergoing consolidation, shows more competition as developing countries enter the market. For example, China plays a key role in driving the manufacture of renewable technologies, particularly wind power, solar photovoltaic (PV), and solar hot water systems [45].

Interaction between domestic R&D activities and international trade is increasing at these more open and competitive markets. With support of government policies, R&D investment into development of new and advanced technology boost interest in the market of renewable energy in electricity utilities as well as declined renewable-energy technology costs. Furthermore, R&D efforts can affect advances into foreign markets as renewable energy firms seek to enter both global and domestic markets. Domestic R&D activities and government policies, therefore, may exert direct and indirect impact on international trade, including exports and import.

Many researchers have identified the relationship between domestic R&D and international trade. For example, Zhao and Li [14] analyzed the impact of R&D investment on export propensity for Chinese manufacturing. They showed that increases in R&D innovation enable firms to export and thus increase the export volume of the related industry. Greaker [35] stressed that new market creation induces firms' market access, and as a result, firms' increased R&D activity exerts a positive influence on exports.

Furthermore, the some empirical literatures show the relationship between firm-level productivity, ownership, the company's characteristics and export decisions [10,13,5,12]. These studies provide strong evidence that through R&D more firms decide to enter the export market, which results in increases in their export profits [5]. Recently, Lim [12] focused on the renewable energy industry and determined the relationship between R&D and export. He finds that knowledge accumulation through increased R&D has a major positive effect on exports.

Conversely, international trade activities can also affect domestic R&D, serving as a channel for technology in- and out-flow and influencing innovation strategy and market diversification. Increases in the absorption of foreign technology through imports may complement or substitute domestic R&D activity, while increased exporting may promote domestic R&D through learning-by-exporting and global market expansion.

Tan and Hwang [29] determined the impact of technology imports on in-house R&D at the firm level. They discovered that the relationship between imported technology and in-house R&D is complementary, but technology inflows induce higher R&D expenditure as a firm adapts foreign technology for domestic conditions. Teixeira and Fortuna [3] also suggested that important characteristic of international trade is the complementary nature with technological change. Through empirical analysis for the Portuguese economy, they found that R&D effort through capital goods imports is a powerful contributor to improve total factor productivity.

Recently a number of studies regard R&D as productivity enhancement and try to determine the feedback from international trade, including learning-by-exporting, to a firm's R&D [34,42,25,7,28,27,1,24]). These studies approach empirical analysis and examine a learning-by-exporting effect that firm's performance can enhance through exposure to the knowledge stocks of trading partners [24]. They say that exporting activity can affect positive impact on increasing R&D investment and furthermore enhancing total factor productivity (TFP). De Loecker [25] emphasizes that firms can become more productive by starting export and the productivity gains are higher when firms export toward high income regions. Ito and Lechevalier [28] found that there were the complementarities in innovation and exporting strategies by using Japanese firm-level panel dataset. They also emphasized that firms to conduct R&D have experienced the more improvement in productivity by starting export than non-R&D firms. Love and Ganotakis [24] assessed learning-by-exporting effect for UK high-tech SMEs and concluded that exposure to export markets helps firms to overcome innovation hurdle.

The previous studies, however, examined the one-way effect of R&D on trade and vice versa. In other words, the past studies do not take into account the interactions between R&D and trade, including exports and imports, which exclude mutual endogeneity of domestic R&D and trade. However, domestic R&D is a start point for innovation, and it also acts as an intermediate connector between international trade and domestic innovation. Domestic R&D can affect international trade activities, advancing a firm's productivity and expanding domestic and global markets, and at the same time, it can be affected by international trade activities, serving as a channel for technology in- and out-flows and responding to international situations. For example, imports of foreign technology may affect domestic R&D, while exports of domestic technology may influence the domestic R&D strategy. Therefore, when analyzing the interrelations between domestic R&D and international trade, the R&D activity must be considered simultaneously with the export and import stages that are affected by changes in the technology marketplace.

Furthermore, each stage may interact with the others in complicated ways to create a virtuous cycle as shown in Fig. 1: The more technologies are exported, the more related learning and the larger market promote domestic R&D and technological progress. In addition, the reduced cost and new technology created by R&D encourages more technology exports, which completes the long-term virtuous cycle.

This paper, therefore, estimates the interactive system of R&D and international trade in renewable energy technology. Interactions between R&D, import, and export activities are explained for the renewable energy industry through empirical, simultaneous equations. Very few studies offer empirical analysis for policies within the R&D-trade system, but this study explains whether the relationships between R&D, import, and export activities are complementary or act as substitutes. This analysis will provide significant information to help policy makers understand the policies effective for long-term efficient strategies for sustainable economic growth as well as for import and export performances.

1.2. Static and dynamic impact of renewable energy policy

The effect of domestic renewable-energy policies on international trade must be identified because the domestic policies related to technology push and market pull can affect exporting and importing performance through intensive R&D activity and market expansion.

For this we consider five representative policies for renewable energy – public R&D, public investment, tariff incentives, renewables obligations, and environmental taxes – as the primary players involved in the technological change system of renewable energy.

Public R&D is a major technology-push policy supported by government finances. Foundations, private firms, and public institutions can conduct research with the help of public R&D. This