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Selecting the key research areas in nano-technology field using technology cluster analysis: A case study based on National R&D Programs in South Korea

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Abstract

In the early 21st century, Korean government issued a policy recommendation that Korean public research institutes should select strategic research fields to concentrate their resources, based on a careful review of the various strategic R&D factors. The government has emphasized the "selection and concentration" strategy for the efficient use of R&D resources and as a way to increase the national competitiveness of Korea. This paper suggests a method, a "Technology Cluster Analysis," for selecting the strategic research areas, mainly targeting large, multi-disciplinary and long-term programs. The technology cluster analysis groups near technologies together based on key indicators. In this study, the method is applied to national R&D programs in the nano-technology field. Fifty-six nano-technologies are analyzed and grouped into three main clusters based on the survey data from 180 experts. Technological distances and correlations among individual technologies are depicted by hierarchical dendrogram. Three main clusters in nano-technology field are found and termed *nano-materials*, *nano-devices*, and *nano-bio*. These three clusters are expected to be the core technology clusters in nano-technology field in South Korea.

Keywords: Technology cluster analysis; Nano-technology; Core technology areas; Proximity index

1. Introduction

The national competitiveness of Korea in the 21st century hinges on the effective distribution and utilization of limited resources based on the strategy that guides the policy makers to specify target technology fields. Korean government and research institutes alike have exerted their concentrated efforts to develop world-class technologies by carefully examining future economy, market outlook, technological trends, and the current level of science and technology. In an effort to respond to such a demand, Korean government has introduced the 'selective focus and concentration' strategy where a great portion of national R&D resources are distributed primarily to the areas of strategic importance according to future strategic needs, technological competitiveness, and national growth/development agenda. One of the challenging issues in this regard is to locate the core areas of research on which national R&D investment efforts are to be exerted. Such areas should be those of great importance in enhancing industrial competitiveness of Korea and those which will create enormous market demand in the future at the national level. They should also represent the promising technologies, best utilizing human resources with a high potential of success, which make commercial links to the existing technologies and products possible (Tassey, 1997).

Although many prior studies (Shehabuddeen et al., 2006) have focused on various technological prospects in an effort to find effective R&D mechanisms, in particular regarding national innovation systems of Korea (Lee, 2004; Lee and Park, 2005; Chung, 2001), studies to estimate promising future technologies based on the trends in technological complexity and convergence are scarcely few. Furthermore, the system of technology estimation and forecasting, which can be used to identify and plan core researches, is not yet well established. This paper is an attempt to rectify such a situation. The current study

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suggests the 'technology cluster analysis' as a method to select key fields of research, and applies it to the national-level R&D initiatives to derive important areas of research. We utilize the method to estimate the structure of R&D in the field of nano-technology and classify various sub-technologies into meaningful groups for R&D concentration.

The method of identifying core research fields is comprised of three steps: (1) classifying technologies according to their purposes, (2) conducting a survey for a relevant group of researchers and scientists on the similarities and differences among sub-technologies, and (3) performing the technology cluster analysis. This research focuses especially on the technology cluster analysis step, where we group together those technologies with similar patterns of technological changes. We believe that the results can be used to assist planning for major research projects or to devise policies for different fields of technology. This research aims at applying the methodology to selecting core technologies in the nano-technology field in order to identify important sub-technological categories within the nano-technology field.

This paper is structured as follows. Next part deals with the basic concepts of technology cluster analysis along with a short introduction to the related past studies. We then conduct a study applying the technology cluster analysis to the nano-technology field. Our findings are presented at the end with possible implications of the findings.

2. Research method: technology cluster analysis

Researchers in technology management have utilized two different methodologies to estimate technological distance and proximity. One is to perform bibliometric studies such as citation analysis and patent mapping based on a set of objective data, also called bibliometrics, including academic papers, patent materials, and researcher's information; the other is to perform cluster analysis using survey data with questionnaires that tap into the researchers' knowledge base.

Past research in bibliometric studies has focused primarily on computing the technological distances between industries, mainly utilizing patent data (Jaffe, 1986; Verspagen, 1997; Yun, 1999). For example, a recent study by Jaffe and Trajtenberg (2002) addressed a number of issues related to aggregate citation frequencies at industry level. Their findings provide useful information on the major differences in citation patterns among R&D fields. Despite various positive methodological competences, prior studies have been performed mainly at industry level or national level and are not quite suitable for estimating technological distances among more detailed, specific technologies within the same technological field. A different method is therefore needed to conduct a fine-grained, specific analysis on technological proximity.

We believe that a more effective method is to perform a survey-based technology cluster analysis, which utilizes the specialists' knowledge base on specific technologies. The survey method allows us to investigate the cognitive insights of the respondents regarding the current status of the inter-relationships among the target technologies and future trends of technological changes, which cannot be found in bibliometric data. Previous study that utilized survey method for technology cluster analysis includes Ronde (2001). Ronde (2001) conducted a survey on 98 specific technologies of biotechnology in France and, based on the cluster results, came up with three important technology groups. Ronde's study was intended to identify core fields of biotechnology research at a national level. The characteristic of this study is in general closer to that of Ronde (2001) in that it identifies important technology groups in the newly emerging nano-technology field for national-level R&D projects.

Technology cluster analysis is a clustering method that groups together diverse technologies with similar characteristics based on technological distance or proximity. Technology cluster analysis can be used effectively in planning R&D programs for emerging technologies like nano-technology. When policy makers and R&D planners design national R&D programs in emerging technology fields, they may consult other nations' previous experience. However, benchmarking approach usually works only to a certain limit. The technological growth path of a nation is likely to differ from that of other advanced nations because of differences in technological endowment, economic and technological growth strategies, national policies and agenda. Under such circumstances, policy makers and planners should gather experts' opinions extensively and construct a list of emerging technologies to be developed. Then, they can create various R&D programs based on the structured list of technologies.

Technology cluster analysis can contribute at this stage. Technology cluster analysis can be used to identify core research areas both in private and public sectors and both at national and organizational levels. While technology development strategy should be constructed by top-down fashion in private sector and at organizational level, the gathering process of experts' opinion is much more emphasized for the national R&D programs. Because the philosophy of technology cluster analysis is related to building a cognitive mapping based on experts' opinions, it is more useful in planning national R&D programs. It is particularly so in planning R&D programs in emerging technology fields, as we are short of information on patents and academic papers. In this case, technology cluster analysis can act as a substitute for citation analysis and patent mapping.

Meanwhile, an important contribution that the current study may have over and above the previous studies is that, while the prior studies showed planar results in identifying the technology groups, the current study provides a comprehensive structure of the technological relationships by analyzing the proximity of individual technologies.