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Measuring and comparing the R&D performance of government research institutes: A bottom-up data envelopment analysis approach

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ABSTRACT

Government-funded research institutes (GRIs) have played a pivotal role in national R&D in many countries. A prerequisite for achieving desired goals of GRIs with the limited R&D budget is to be able to effectively measure and compare R&D performance of GRIs. This paper proposes the bottom-up approach in which the performance of a GRI is measured based on the efficiency of its R&D projects. Data envelopment analysis (DEA) is employed to measure R&D efficiency of projects, and nonparametric statistical tests are run to measure and compare the R&D performance of GRIs. We apply the bottom-up DEA approach to the performance measurements of 10 Korean GRIs conducting a total of 1481 projects. The two alternatives for incorporating the relative importance of the output variables – the assurance region (AR) model and output integration – are also discussed. The proposed bottom-up approach can be used for formulating and implementing national R&D policy by effectively assessing the performance of GRIs.

1. Introduction

As R&D has been considered a major driver for national competitive advantage, developing as well as developed countries have been continuously boosting investments in national R&D. In many countries, public research institutions or government-funded research institutes (GRIs) have played a pivotal role in national R&D as a key player of the national innovation system (NIS) or as a major component of the triple helix model of innovation system (Shapiro, 2012). As the scale of national R&D investment increases, resource allocation draws more attention in national R&D policies (Abramo & D'Angelo, 2014); thus, the strategic importance of performance evaluation of GRIs is more highlighted than ever. In response, a few efforts have been made to measure R&D performance of GRIs or public research institutions in several countries such as France (Bonaccorsi & Daraio, 2003), Belgium (Luwel, Noyons, & Moed, 1999), Spain (Ortega, López-Romero, & Fernández, 2011), Taiwan (Liu & Lu, 2010), and China (Meng, Zhang, Qi, & Liu, 2008).

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Measuring GRIs' performance is particularly important for countries where government has dominance in their NIS such as Korea. Over that last forty years, Korea has achieved remarkable economic growth through its strong NIS, and government and GRIs have led the NIS of Korea. The Korean government has tried to strengthen the national R&D capability by establishing GRIs since 1970s, and previous studies pointed out that GRIs have played pivotal roles in Korea's economic development (Yim & Kim, 2005). Among OECD countries, Korea is the only country where GRIs rather than universities play a relatively greater role in national R&D (Eom & Lee, 2010). Currently, the Korean government manages more than 20 GRIs in various science and technology fields, and the amount of government subsidy given to those GRIs in 2014 is about 1.6 billion dollars which accounts for 66.1% of total financing of GRIs. More emphasis is thus imposed on how to effectively measure the performance of GRIs for achieving the national goals as well as efficient resource allocation, but the current practice is still not satisfactory. Performance measurement of GRIs highly depends on conventional bibliometric measures supplemented with qualitative assessments. Bibliometric measures can only provide partial indications on their performance. Qualitative assessments are inherently subject to bias and vulnerable to political pressure. In addition, metrics are only focused on outputs or outcomes of R&D rather than inputs, although the efficiency perspective needs to be considered for resource allocation.

As a response to these limitations, recent years have seen an increasing use of a nonparametric technique – data envelopment analysis (DEA) – for measuring R&D performance at various levels from the efficiency perspective. DEA is a linear programming model for measuring the relative efficiency of decision making units (DMUs) (Cooper, Seiford, & Tone, 2007). Since DEA is capable of handling multiple inputs and outputs, it can provide an overall measure of R&D performance by taking various dimensions of R&D activities including financial inputs and bibliometric outputs into consideration. Also, DEA is a non-parametric approach which does not require any assumptions about the functional form of a production function as well as information on preferences between variables. It can thus be employed where the relationship between inputs and outputs are unknown and there is no agreed view on relative importance between them, which is the exactly the context of R&D performance measurement. DEA has thus been widely used to measure R&D efficiency at various levels, such as cross-country comparisons (Guan & Chen, 2012; Kocher, Luptacik, & Sutter, 2006; Lee & Park, 2005; Rousseau & Rousseau, 1997, 1998; Sharma & Thomas, 2008; Wang & Huang, 2007), university research (Abramo, Cicero, & D'Angelo, 2011; Abramo & D'Angelo, 2009; Agasisti, Catalano, Landoni, & Verganti, 2012; Cherchye & Abeele, 2005; Groot & Garcia-Valderrama, 2006; Johnes & Johnes, 1995), and R&D projects (Guan & Wang, 2004; Hsu & Hsueh, 2009; Lee, Park, & Choi, 2009; Linton, Walsh, & Morabito, 2002; Revilla, Sarkis, & Modrego, 2003)

Nevertheless, relatively few attempts have been made to utilize DEA for performance measurement of GRIs. This may be attributed to the following two problems that occur when considering a GRI as a unit of analysis. First, in most cases, the number of GRIs that can be considered DMUs is relatively small compared with the number of input and output variables for DEA. Many of the GRIs are then likely to be identified as efficient in DEA, weakening the evaluation's discriminatory power. The second problem is the information loss due to aggregation. The R&D of GRIs is usually undertaken by the project unit, but aggregating project-level data onto the GRI-level may produce distorted results.

Our tenet is that the performance of a GRI should be measured based on the performance of its R&D projects. This paper thus proposes a bottom-up DEA approach to measuring GRIs' performance, in which each project, not each GRI, is treated as a DMU. DEA is run for the whole set of R&D projects carried out by all GRIs. Nonparametric statistical tests are then conducted to evaluate and compare among the GRIs' overall performance. This paper applies the bottom-up DEA approach to the performance measurements of 10 Korean GRIs conducting a total of 1481 projects.

The rest of this paper is organized as follows. Section 2 reviews the previous research on measuring R&D performance using DEA and introduces the DEA models used in this study. The variables and data used in this study are explained in Section 3, and the results of the performance measurement and comparison are presented in Sections 4 and 5. The paper ends with conclusions and directions for future research in Section 6.

2. Theoretical backgrounds

2.1. Measuring R&D performance of GRIs

Bibliometric methods have received a strong boost in national R&D evaluation (Abramo et al., 2011). The conventional approach to measuring R&D performance of GRIs is also to use bibliometric indicators capturing production, productivity, and impact of research organizations (Luwel et al., 1999). The most widely used measures are the number of papers/patents for production, the number of papers/patents per researcher for productivity, and the number of citations to those papers/patents for impact (Narin & Hamilton, 1996). It is widely accepted that the bibliometric methods are more efficient than peer review in terms of costs and time, but individual bibliometric indicators can only capture fragmentary performance of R&D activities of GRIs. Such indicators are also nearly all output-oriented ones, although financial inputs matter too, particularly for resource allocation. For a more comprehensive evaluation, it is required to produce a single composite indicator that can incorporate various dimensions GRIs' R&D performance including inputs.

DEA can be a promising alternative to this purpose because it can provide a single measure of R&D performance by capturing multiple inputs and output of R&D activities. However, relatively few attempts have been made to utilize DEA for performance measurement of GRIs in contrast to a surge of applications of DEA to various contexts of R&D performance measurement. As mentioned before, the reason for this is because of the low discriminatory power and the information loss occurring when each GRI is considered a DMU. An exception is Bonaccorsi and Daraio (2003), who measured the relative