A New Model to Evaluate the Scientific Performance of Public Research Institutions

Mario Coccia

m.coccia@ceris.cnr.it
National Research Council of Italy,
Institute for Economic Research on Firms and Growth,
Ceris-CNR - Collegio Carlo Alberto,
Via Real Collegio 30,10024 Moncalieri (Torino), Italy

Abstract
Nowadays, in Italy the science sector is doing a strategic restructuring due to budget cuts. The measure and evaluation of research performance of its units (public research institutes) is needed. This paper develops a new model to assess the R&D performance of public research laboratories. The model is successfully applied to 108 public research institutes belonging to the Italian National Research Council, using data 2003. The models of scientific research evaluation can be used as indicators of performance by policy-makers who must decide about the level and direction of public funding for research and by R&D managers in the strategic behaviour of the laboratories.

Introduction

The public research sector is formed, according to Senker (2001), by those institutions that deal with civil research and where the majority of the funding is from public sources: these organizations are public property or under the control of public authorities and their principal aim is to spread the results of their research. The studies on these institutions in many countries, including Italy (Coccia & Rolfo, 2002; Coccia, 2004), the United Kingdom (Harris & Kaine, 1994; Senker, 2001) and Finland (Luwel *et al*., 1999), show a growing interest in evaluating scientific performance (Stainer & Nixon, 1997). The measurement and evaluation of scientific research may reflect the interest of the Government during the reorganization of the research sector, to assign clear objectives to the research laboratories so that they are managed efficiently and efficaciously in the light of the diminishing public resources. This objective can be reached by identifying the high productivity institutes (HPIs) and the low productivity institutes (LPIs). This research presents a new model for measuring the scientific performance of public research laboratories and some management implications.

Theory

Many studies on measurement of the performance of the research bodies consider only the bibliometric (Narin & Hamilton, 1996), technometric (patents) or productive indices, which clearly give partial and non-systemic indications of the productivity of the scientific laboratories. Recent developments have created indicators that measure all the aspects of the activities of the scientific bodies and which are accurately synthesized through particular forms of clustering (Geisler, 1995; 2000; Sexton, 1986; Rubenstein & Geisler, 1991). The purpose of this research is to construct a new model for measuring the R&D performance of public research institutes, using a *systemic approach*, which considers financial, scientific and technological indexes. The output of the model is the research performance score, which is an indicator of the productivity of the research institute.

Research Method

The scientific performance of the research bodies can be measured by a series of seven indices, which consider all the aspects of the life of the R&D bodies, from the financial to the technological and the scientific. The model called *relev* methodology (Coccia, 2001), evaluates the performance of the research bodies on the basis of measurement of *k-key indices* representing the principal activities carried out. The model is kept fairly simple in order to contain the subjectivity within certain limits. This model *relev (research laboratory evaluation)* function (Coccia, 2001), measured R&D performance on various dimensions and gave a single output: the R&D performance score. The weakness point of the relev model was that each operator had the same weighting in the function. A second model Relev was elaborated by Coccia (2004) in order to improve the model I. This research

Proceedings of ISSI 2005, pages 237–241.
Edited by P. Ingwersen and B. Larsen.

presents the Relev Model II adjusted which use new samples and the discriminant analysis with the Wilks Method. The latter is a more reliable measuring tool. The first methodological step of the model II adjusted is to identify two groups of laboratories represented by:

set A or 1: High productivity research institutes "HPIs"

The 13 institutes belonging to set *A*, from various scientific fields, were organizations that combined scientific excellence and high international visibility.

set B or 2: Low productivity research institutes "LPIs"

Set *B* is composed of 10 research institutes, belonging to various scientific fields, that are included in the group because they have low indicator of input and output per head. These institutions were characterized by a mainly administrative and bureaucratic culture within a world scenario that emphasizes organizational and strategic management skills.

Once the two sets or groups of the institutions are fixed, you investigate whether it is possible to predict the location of an institute, taken from a given population, in one of the above subsets A or B, on the basis of key variables.
The following ten variables that concern the principal input and output within the public research institute are considered explicative variables of the Relev model adj.

Table 1. Explicative variables of the Relev model II adj.

1. Public funds
2. Payroll personnel
3. Cost of personnel
4. Self-financing (€) deriving from activities of technological transfer from the institute to outside users
5. Training is represented by the number of persons trained within the institute, including stage, thesis, degree students, temporary staff, etc.
6. Teaching is the number of courses held by researchers at universities and other high schools
7. International Publications are those that appear in journal listed in the Social Science Citation Index
8. National Publications are those that have appeared in journal distributed nationally
9. International proceedings
10. Proceedings concerning conferences with national diffusion

Results

The Relev model adj. is constructed using data from the Italian National Research Council (CNR), the body that promotes, coordinates and disciplines scientific research in Italy in order to increase the scientific and technological progress of the country. The institutional scientific activity is carried out by 108 research institutes, operative bodies with the general aims of research in relation to the programmatic objectives of the Italian government. The data analyzed is from 2003 period. Another variable used in the model is a dummy variables which assumes only two of the values, that is $X_j = 1$ (for HPI = High Performance Institute, grouped in the set A), $X_j = 2$ or LPI = Low Performance Institute. This variable expresses for each observation its inclusion in-groups or sets A or B.

Discriminant analysis applied is the stepwise technique, which uses as a selection method to minimize the Wilks lambda. The model Relev adj. has chosen as explicative variables the following: 1-5-6-7-9 (see table 1). The canonic correlation of the discriminant function (Wilks method) is high and equal to R^2_{c1}=0.9596 (table 2).

Table 2. Canonical discriminant functions

Functions	*Eigenvalue*	$\frac{\lambda_1}{\lambda_j}$	*Canonical Correlation*	*Wilks' Lambda*	*Chi-square*	*Degree of freedom (df)*	*Sig.*
1. Stepwise Method of Wilks	11.622	100	0.9596	0.079227	46.906	5	0.00

Unstardardized canonical discriminant function is:

$$F_1 = -5.1038744 + 0.0874307(Teaching\ courses) + 0.00000350498206(Public\ funds)$$
$$-0.0370964(Trainees) + 0.0171910(International\ proceedings) + 0.0210310(International\ pubb.)$$

Table 3. Canonical discriminant function evaluated at group means (group centroids) Standardized canonical discriminant functions coefficients

Group	*Function 1* Stepwise Method of Wilks
1	2.85703
2	-3.71414

Table 4. Classification results

Stepwise Method of Wilks			*% Predicted Group Membership*	
	Group	*No. of cases*	*A*	*B*
Set A (HPI Laboratories)	A	13	13 (10.00%)	0 (0%)
Set B (LPI Laboratories)	B	10	0 (0%)	10 (100.00%)
	Percent of "grouped" cases correctly classified: 100.00%			

By applying the discriminant function (Wilks) on 108 CNR research institutes, with data referring to the period 2003, it was showed that little more than 33% of the institutes fall into the set of the HPIs (table 5).

Table 5. Discriminant analysis applied on Italian research Institutes (results) – data from 2003 period

	Stepwise Method of Wilks	
	Set HPI	*Set LPI*
No. Public research laboratories 108	36	72
Value per head		
Inputs		
1. Public funds	7,779.27	7,124.9
2. Payroll personnel (arithmetic mean)	98.47	48.46
3. Cost of personnel	53,964.57	50,323.1
Outputs		
4. Self-financing (€) deriving from activities of technological transfer from the institute to outside users	24,169.93	13,293.73
5. Training is represented by the number of persons trained within the institute, including stage, thesis, degree students, temporary staff, etc.	0.44	0.33
6. Teaching is the number of courses held by researchers at universities and other high schools	0.25	0.14
7. International Publications are those that appear in journal listed in the Social Science Citation Index	1.04	0.68
8. National Publications are those that have appeared in journal distributed nationally	0.15	0.24
9. International proceedings	1.05	0.73
10. Proceedings concerning conferences with national diffusion	0.53	0.46

Concluding remarks

The models constructed for evaluating the performance of public research laboratories are similar to those used by Altman (1978) for evaluating firms and default risk, using a series of indices of the firms. The problem that can be raised is whether the performance indicators and the statistical-mathematical analysis alone can be sufficient for evaluating the performance of the public research bodies and the state of health of the organization. In the absence of indicators of performance, the elements of judgment could be too great, while trusting only one of the indices and technical statistics could be dangerous. The 36 research laboratories above the cut of point, called HP institutes, are characterized by High input-high output (Coccia, 2005). These laboratories have high public funds and payroll personnel, which yield high outputs and then research performance. The 53.57% of these HPIs belong to basic sciences, 30.3% life sciences, 50% earth and environmental science, 33.33 technological, engineering and information sciences. While the LPIs (set B) can be called *LILO (Low-Input, Low-Output Institute)*. In fact the limited resources (input) of these 72 institutes are used to produce outputs. Their organisation and management structure, as well as the lack of public funds, does not allow for an increase in their productivity and research performances. This group B is composed by: 13 institutes of the basic sciences, 23 life sciences, 5 earth and environmental science, 19 social sciences and 12 technological, engineering and information sciences. A scientific policy of leveling between the various research laboratories should be, apart from the concentration measures already undertaken, the re-location of researchers in order to allow them to choose in which institute to work according to their scientific and personal preferences.

Bibliography

Altman, E.I. (1978). Financial application of discriminant analysis: a clarification. *Journal of Financial and Quantitative Analysis*, 13 (**1**), 185-195.

Coccia, M. (2001). A basic model for evaluating R&D performance: theory and application in Italy. *R&D Management*, 31 (**4**), 453-464.

Coccia, M. (2004). Models for measuring the research performance and identifying the productivity of public research institutes. *R&D Management*, Blackwell Publishers (UK), 34 (**3**), 267-280.

Coccia, M. (2005). A taxonomy of public research bodies: a systemic approach. *Prometheus,* vol. 23, n. 1, March, 63-82.

Etzkowitz, H. & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Research Policy*, **29**, 109-123.

Geisler, E. (2000). *The Metrics of Science and Technology.* Westport, Connecticut, London: Quorum Books.

Harris, G. & Kaine, G. (1994). The determinants of research performance: a study of Australian university economists. *Higher Education*, **27**, 191-201.

Johnes, G. (1992). Performance Indicators in Higher Education: A survey of recent Work. *Oxford Review of Economic Policy*, 8 (**2**), 19-34.

Luwel, M., Noyons, C.M. & Moed F. (1999). Bibliometric assessment of research performance in Flanders: policy background and implications. *R&D Management*, 29 (**2**), 133-141.

Morris Report (1990). *Performance Indicators, Report of a Committee Enquiry chaired by Mr. Alfred Morris*, PCFC.

Narin, F. & Hamilton, K.S. (1996). Bibliometric performance measures. *Scientometric*, **36**, 293-310.

Page, E.S. (1989). Management statistics and performance indicators in British Universities. Paper presented at the *11th European Association for Institutional Research Forum*. Trier, 27-30 August.

Senker, J. (2001). Changing organisation of public sector research in Europe - implications for benchmarking human resources in RTD. *Paper prepared for Human resources in RTD session of the "The contribution of European socio-economic research to the benchmarking of RTD policies in Europe"*. Conference: Brussels, March 15-16.

Stainer, A. & Nixon, B. (1997). Productivity and Performance Measurement in R&D. *International Journal of Technology Management*, 13 (**5-6**), 486-496.