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ASSESSMENT OF THE EXCELLENT RESEARCH GROUP PERFORMANCE

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Abstract

In this paper we assessed the evaluation process of research groups' performance in the region of Valencia over the period 1998-2002, and the efficiency of such groups. The efficiency is assessed through the method of data envelopment analysis (DEA). Our findings show that publications in SCI/SSCI and the number of *sexenios* are the most determinant indicators of excellence in a research group. In terms of efficiency, we find that excellent research groups belonging to universities, in particular those in natural science, and R&D public organizations are the most efficiency.

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1. Introduction

Increasingly, evaluation studies of research performance conducted during the past years focus on the identification of research of “highest quality”, “top research”, or “scientific excellence”. Achieving and maintaining excellence has always been crucial for leading researchers and scholars working in the international frontiers of science. The ability to access that level, and to be competitive in the international arena, has also become a strategic goal and an explicit target of research institutes as a whole (Harvey et al., 2002; Goldfinch, 2003).

Identification of excellence is a matter of *ex ante* assessment or *ex post* evaluation of research performance. Clearly, such a broad and ambiguous concept is not directly measurable in a generally accepted valid manner. To begin with, there are numerous definitions of “scientific prestige”, “elite scientists” and “hierarchies of reputation” in the sociological literature, their exact meaning depending on the school of thought, theory or methodological context (Cole & Cole, 1967; Collins, 1982). However, most of these notions can be applied to individual researchers or socio-cognitive collectives, rather than to institutional aggregates.

At the level of entire research groups, departments and institutions, the conceptual and operational problems are further compounded given the diversity of research goals capabilities, resources, facilities and outputs characterizing research organizations and their units (Loch & Tapper, 2002; Ball & Butler, 2004). Managers of research institutions, funding agencies and supra-national governments all face, for different reasons and goals, the same pervasive evaluative question: how can one define, recognize and compare excellence as objectively as possible? (Hauser & Zettelmeyer, 1997; Werner & Souder, 1997).

The peer review process is one of the most widely accepted by the Scientific Community for selecting and assessing excellence (Gillett, 1989; Roberts, 1999; Kuldell, 2004). New developments in the field of quantitative studies of science offer methods to support peer review in order to keep it objective and transparent. Although, not surprisingly, open and fair applications of peer review evaluation may be difficult to achieve (Horrobin, 1990; Moxham & Anderson, 1992).

Regarding research, it is paradoxically difficult to evaluate it in research-oriented universities and research institutes around the world (Johnes, 1990; Korhonen et al., 2001; Tijssen et al., 2002; Coccia, 2004). The problem is universal and particular attention has been devoted to the problem of how, in the absence of market prices for non-profit public sector organisations, to aggregate across heterogeneous inputs and outputs. On one level, this has led to the development of performance indicators, each of which attempts to measure the output (input) of a group of nearly homogeneous products (factors of production). On another level, the aggregation of various measures of performance poses problems which have also been the subject of much research. The difficulty of aggregation across performance indicators is accentuated by the lack of data concerning the weight that should be applied to each measure of performance; in the not-for-profit sector, market prices are not present to guide us. Since overall measured performance can be very sensitive to the weight attached to each individual performance indicator (Johnes, 1990).

Developments in the field of linear programming—in particular data envelopment analysis—enable light to be shed on this issue.

This paper contributes to these discussions. Our concern is the assessment of research groups' performance in the region of Valencia over the period 1998-2002. In particular, we address questions concerning the processes used in the selection process conducted by the Valencian government peer review to assess research performance and to determine if a research group is excellent, and the efficiency of such groups.

The paper is organized as follows: Section 2 offers an overview of the Spanish scientific and technological policy. Section 3 presents a descriptive analysis; section 4 covers empirical model and presents the empirical findings. Finally section 5 provides a summary and conclusions.

2. Spanish scientific and technological policy

The three key lines of action of the Spanish scientific and technological policy are the National Plan for Scientific Research and Technological Development (National R&D Plan), the actions by the Ministry of Industry, Tourism and Trade (MITYC) and the implementation of the National Agency of Evaluation and Assessment (ANEP). In addition, there are also international actions (joint programmes with European or Latin American countries, etc.), regional actions from the different autonomous communities and even some established by the Central Administration itself (Ballesteros & Rico, 2001; Albert & Plaza, 2004). It should be noted that in Spain there are 17 autonomous regions. As a result of the regionalisation, all agents involved in R&D activities depend on 18 authorities, one central and 17 regional governments, with different political ideologies and irregular knowledge of what scientific and technological policy is and what it should be.

The National R&D Plan, adopted in 1988, sets the priorities for action, manages the resources available and integrates the R&D actions of the productive sectors, research institutions and universities. The economic efforts of the National Plan are materialised in the provision of the National R&D Fund. They are largely aimed at the enhancement of basic scientific research and the promotion of communication and concerted actions between universities, firms and public research institutions. Thus, while the actions of the National R&D Plan are oriented towards basic research and the precompetitive development of technology, Spanish technological policy is mainly carried out by the MITYC with a view to favouring industrial innovation. The intervention is designed, among other things, to provide an incentive to the efforts in technological development and the incorporation of advanced technologies in firms, and to improve the competitiveness of Spanish industry through an improvement in the quality of its products.

Furthermore, the ANEP was created in 1986 as a mechanism of scientific evaluation, to assess—with maximum rigor and independence—all public scientific-technical research proposals, research groups and entities that request funds to carry out research and/or technological programmes and projects. The ANEP's scientific evaluations are carried out by anonymous experts using peer review and are used by the corresponding institution responsible for the financing. The fact that the evaluation is carried out by a different and independent institution to the one, responsible for the funding and for making the last decision of financing the action or not, is an additional mechanism of guaranteeing the evaluation quality. The criteria used to achieve its main objective have been described in detail in several reports (Sanz Menéndez, 1995; Modrego, 1995; Fernández de Caleva, 2003; MEC, 2004).

In our particular case, Valencia, a peripheral region of the European Union (OCDE, 1997) with a low absorptive capacity (Cohen and Levinthal, 1989, 1990), is characterized as a small and open economy, based on a traditional micro- and small-sized firm industrial structure, where the owners lack modern business education or research tradition (COTEC, 1999). Moreover, the Valencia level of R&D spending is lower than the already low Spanish level, 0.6 and 0.9 percent of GNP, respectively (INE, 2002). This region's profile has an important influence on the research group's performance.

In this context, the Valencian Government tries to lead and impel a science and technology policy in order to bring the average level of public and private investment up to that of the most advanced regions of the rest of Spain and Europe. Taking as reference the actions planned in the European and National Frameworks, the Valencian Scientific Research, Technological Development and Innovation Plan (PVIDI) was conceived in 1997 (Generalitat Valencia, 2001).

The Valencian Administration proposes through the PVIDI a number of actions to develop the regional potential, mitigate its deficiencies and establish suitable orientations for the future. A "*public call for excellent research groups*" has been included in this plan, the main objectives being related to encouraging creation, consolidation and projection of research groups in the region of Valencia. Competitive bidding has become the habitual procedure for the actions, by means of annual public calls that guarantee an objective criterion of excellence in the granting. Thus, the excellence of the group and its ability to reinforce it and spread it beyond its own members is mainly assessed by the regional government using peer review process (group of experts using the ANEP criteria of scientific and technological evaluation).

Relatively little is known about the decision processes used by the regional government peer review to assess the research performance of research groups that apply for the "*public call for excellent research groups*". However, we know that in a scale up to 100 points, the criteria established to define excellence was: for experience a research group could score up to 70 points (including number of papers, patents, participation in projects under the European Union R&D Framework Programme or under the National R&D Plan, collaboration with other organizations and so on); for the scientific-technological newness and importance of the proposal up to 15 points; for the composition, structure and consistency of the group up to 5 points; and, for the adequacy of the R&D activities developed by the research group for the PVIDI framework up to 10 points.

In this paper, we try to assess excellence features of research groups in the region of Valencia and the efficiency of such groups. According to scientific literature, we analyze a range of qualitative and quantitative indicators, each one focusing on different aspects of a group's performance, in order to provide a reasonable and reliable estimate of the contribution to scientific progress made by excellence groups and its influence on the determination of efficiency.

3. Descriptive Data

The data used in this paper was taken from the study *"Análisis de la Especialización Temática del Entorno Científico y Tecnológico de la Comunidad Valenciana"* carried out in 2004 by the Valencian government. The information includes those research groups inside the scientific and technological Valencian system that applied in 2003 for the "*public call for excellent research groups*", a public aid announcement from the regional government. The data base with 227 observations was built up, of which 185 correspond to university research groups, 22 were R&D public organizations, 12 were part of the R&D foundations and the remaining were technological institutes. The subject areas covered were natural sciences, engineering, medical science, agriculture, social science and humanities. Usable responses were obtained from 4.310 staff, representing a total response rate of approximately 20 per cent. This rate leaves open the possibility of a systematically biased sample. It seems probable that researchers with low research activity rates or a low level of publications were under represented in the sample. We cannot forget that our sample is composed by groups that supposedly had high scores in indicators as average experience of the group in research activities (experience in project management, technology transfer and other R&D activities), patents granted, publications, conferences, cooperation with other organizations, number of fellowships, number of PhD steering and defended in the research group, scientific-technological newness and importance of the subject researched according to the regional, national or European R&D framework program, and so on.

The information collected was divided into two groups: (i) questions on general characteristics of 2002 research groups, such as size, organization structure, personnel academic status, and so on; (ii) information about the research activity performed by the research group during the period 1998-2002, such as the number of articles published in international refereed journals, number of *sexenios* (for each period of six years, a tenured professor or scientist can present his/her most relevant scientific contribution to a national committee of experts for each discipline in the hope of receiving a positive assessment of his/her individual research activity – the so-called *sexenios*), papers presented in international conferences, funds coming from European, national or regional projects, and funds coming from contracts with different organizations.

3.1 General characteristics of 2002 research groups

Table 1 shows the general characteristics of research groups by type of institutions. Excellence was coded 1 for those research groups that regional government peer review considered as excellent, and 0 for those research groups not evaluated as excellent. Size comprises the number of members. Academic status was coded as 1 if the personnel of the research group got a PhD degree, 2 means personnel with tertiary-education-type-A degree (ISCED 5A), 3 means personnel with tertiary-education-type-B degree (ISCED 5B), and 4 means technical research assistant (OECD, 2004). Labour market status was also measured as code 1 if the personnel had a permanent contract and code 0 if the contract was temporary. Age of group members was coded in years.

Table 1. Research group's characteristics by type of institution, 2002.

Research groups	Excellence		Size	Academic Status*				Labour Status*		Age
	No	Yes		1	2	3	4	Perm.	Temp	
Universities	73	112	18.8	52.5	43.6	1.6	2.2	80.8	19.2	41.2
Tech. Institutes	7	1	20.3	25.5	62.1	2.5	9.8	25.8	74.2	40.4
R&D Foundations	4	8	18.4	42.0	46.1	1.2	10.7	53.5	46.5	42.8
R&D Pub. Organizations	2	20	20.4	45.9	37.9	4.5	11.7	70.7	29.3	41.5
Total	86	141	19.0	50.4	43.8	1.9	3.9	76.5	23.5	41.3

*Note: * rows add 100 percent.*

As we can observe in Table 1, 91.0 percent of research groups belonging to R&D public organizations were marked as excellent research groups, followed by the groups in R&D foundations and the groups established in universities, 67.0 and 61.0 percent, respectively. On average, slight differences were found with respect to group's size (19 members). Regarding academic status, we can see that about one half of the personnel holds a PhD degree, except in the case of research groups belonging to technological institutes, where 62.1 percent of the staff holds a tertiary-education-type-A degree. The proportion of tertiary-education-type-B degree personnel was relative high for R&D public organizations (4.5 percent) and for technological institutes (2.5 percent) compared to the overall percentage (1.9 percent). Technical research assistants represented one-tenth of the personnel in R&D public organizations (11.7 percent) and R&D foundations (10.7 percent). With respect to labour status, Table 1 shows that altogether over 76 percent of the research group members had a permanent contract. Finally, we can observe that age was quite similar across all types of institutions.

By subject area, Table 2 presents the same research groups' characteristics as above. We can see that the proportion of excellent research groups was the highest in natural science (70.1 percent). Humanities came next (66.7 percent). Regarding group's size, slight differences were found among the groups. The academic status structure shows us the importance of PhD personnel, specially in humanities (74.1 percent) and social science (59.6 percent). Close to this category was the tertiary-education-type-A staff with high percentages in medical science (48.7 percent), natural science (45.9 percent) and engineering (44.5 percent). In general, personnel with tertiary-education-type-B degrees and research assistants were only representative in engineering and agriculture. Labour status data shows a general tendency to permanent contracts across all areas. Permanent contracts were clearly lower than average for those research groups in agriculture, medical science and engineering. On average, age was very similar throughout all scientific areas (around 41 years old).

Table 2. Research groups' characteristics by subject area, 2002.

Research groups	Excellence		Size	Academic Status*				Labour Status*		Age
	No	Yes		1	2	3	4	Perm.	Temp	
Natural Science	32	75	18.7	49.7	45.9	1.0	3.4	77.6	22.4	41.1
Engineering	19	27	21.7	48.3	44.5	2.1	5.1	76.0	24.0	40.4
Medical Science	16	15	15.4	45.9	48.7	1.9	3.6	74.8	25.2	43.6
Agriculture	5	8	19.5	46.5	37.2	5.3	11.0	69.7	30.3	40.9
Social Science	12	12	20.5	59.6	35.0	4.5	0.8	77.0	23.0	40.7
Humanities	2	4	15.5	74.1	25.9	0.0	0.0	81.6	18.4	42.7
Total	86	141	19.0	50.4	43.8	1.9	3.9	76.5	23.5	41.3

*Note: * rows add 100 percent.*

3.2 Research activity performed by the research group during the period 1998-2002

Table 3 shows the activity research for those excellent groups and for those non-excellent. We can observe that the number of *sexenios*, publications in SCI/SSCI and publications in international congresses were higher in excellent groups than in non-excellent groups. With respect the funding structure coming from regional, national, international project and competitive actions, measured in thousand euros, we found that the main financial resources came from national project, followed by international projects. On average, the amounts were higher in excellent than in non-excellent research groups. Table 3 also shows, for the same period 1998-2002, the funding structure coming from R&D contracts, technical support contracts, and other contracts related to consultancies and other similar services provision, measured in thousand euros. We can see that non-excellent groups got their funds mainly from contracts related to service provision and technical support in contrast to their excellent counterparts.

Table 3. Research activity performed, period 1998-2002.

Research activity	Non-Excel	Excel.	Total
Quality of research			
Sexenios	8.1	10.7	9.7
Pub. in SCI/SSCI	23.9	49.5	39.8
Pub. Inter. Congress	21.6	30.7	27.3
Funds coming from projects (thousand euro)			
Regional	74.6	76.5	75.8
National	276.2	349.7	321.8
International	130.7	172.2	156.5
Competitive actions	48.4	51.0	50.0
Funds coming from collaborations with firms and administrations (thousand euro)			
R&D	133.0	136.3	135.0
Technical support	64.3	42.9	51.0
Service provision	120.1	35.5	67.6

4. Empirical models and results

To clarify the effect of each explanatory variable on the classification of a research group as excellent, we estimate an econometric model. Our dependent variable took two outcomes: (1) if the research group is excellent, (0) otherwise. To reflect our discrete dependent variable, if the research group is excellent or not, we use a probit model. Thus, maximum-likelihood estimation of the model is carried out (Green, 1997). The explanatory variables are classified into four categories: general characteristics, quality of research, funds coming from project and funds coming from collaborations with firms and administrations. Additionally, the subject area and type of institution in which the research group belongs to are included as control variables. The estimation results are presented in Table 4.

Table 4. Probit estimates for excellence of research groups

Variables	Coef.	z-value
General Characteristics		
Size	-0.013	-1.251
Temporal staff	0.001	0.071
Pre-doc. Fellowship	-0.002	-0.063
Post-doc. Fellowship	0.189	1.320
Quality of research		
Sexenios	0.069	2.645
Pub. in SCI/SSCI	0.014	3.047
Pub. Inter. Congress	0.004	1.011
Funds coming from projects		
Regional	-0.001	-0.094
National	0.001	0.181
International	-0.001	-0.120
Competitive actions	0.001	0.933
Funds coming from collaborations with firms and administrations		
R&D	0.001	0.770
Technical support	0.002	1.450
Service provision	-0.001	-1.678
Subject area (ref. natural science)		
Engineering	0.018	0.066
Medical Science	-0.463	-1.508
Agriculture	-0.127	-0.297
Social Science	0.010	0.030
Humanities	0.011	0.021
Type of Institution (ref. R&D public organization)		
Universities	-1.178	-2.375
Tech. Institutes	-1.975	-2.100
R&D foundations	-0.449	-0.670
Intercept	0.302	0.500
Observation	*227*	
LRchi2(22)	*66.42*	
Prob>chi2	*0.000*	
Log Likelihood	*-117.4*	

Results show, that the number of *sexenios* and of publications in SCI/SSCI has an important influence on the determination of a research group as excellent (Tijssen et al., 2002). Neither size nor personnel labour status influence excellence. Contrary as we expected, the total amount of funds coming from projects and from collaborations with firms and administration do not influence the determinations of a research group as excellent (Debackere & Glanzel, 2004). Nevertheless, funds coming from contracts related to service provision have a negative influence on excellence. This finding implies that collaboration activity moves away from excellence. When exploring the segmentation of different subject areas, we note that those research groups in medical science tend to be less excellent that those in natural science, the omitted reference category. With respect to the type of institution, those research group in universities and technical institutes tend to be less excellent that those in R&D public organizations, the omitted reference category.

Next, we move to analyse the efficiency of our research groups. The efficiency of production processes is commonly evaluated using the method of data envelopment analysis (DEA). In our study, we view research performance as analogous to production processes in economics. Such processes have inputs and outputs. The analogy between research and production processes is not novel and some other authors, in the same spirit as we have, also proposed the use of DEA to evaluating research performance. In this context, our decision making units (DMU) are the different type of institutions split by the characteristic of being excellent or non-excellent. A drawback of the DEA technique is that the relative efficiency score achieved by each DMU can be sensitive to the number of inputs and outputs specified (Sexton, 1986; Nunamaker, 1985). In general, the more input and output variables are included in the model, the higher will be the number of DMU with an efficiency score equal to unity (Nunamaker, 1985). In any application of DEA it is therefore important to test the sensitivity of the results to changes in input-output specification. To this end, we initially use the input minimization model, considering the size of the group as input and the number of *sexenios* and the publications in SCI/SCCI as outputs (see Table 5). We select that variables as outputs due to they represent the most determinants of excellence in a research group according to the previous analysis (see Table 4). Second, we change the optimization mode to output maximization model (see Table 6). Efficiencies remains the same under both schemes, but reasons underlying the efficiency calculations and improvement strategies change.

Table 5 shows that the most efficiency research groups are those excellent groups belonging to universities and R&D public organizations, and the least efficiency are those groups in technical institutes. Examining the potential improvements, it suggests that for the case of non-excellent research groups in universities, they should increase their number of publications in SCI in 40.1 percent and reduce their size around a 26.4 percent. For the case of excellent research groups in technological institutes, it is suggested reducing their size in 53.2 percent to become efficiency groups. However, looking at Table 6 (the optimization mode have been changed to output maximization model), for an excellent research group belonging to a technological institute, it should increase both number of publications in SCI/SSCI and number of *sexenios* around the double compared to the actual situation.

Table 5. DMU details, input minimization model.

Type of Institution	Score	Actual Pub. SCI	Actual Sexe-nio	Actual Size	Target Pub. SCI	Target Sexe-nio	Target Size	Potential Improvement (%) Pub. SCI	Potential Improvement (%) Sexe nio	Potential Improvement (%) Size	Rating
Non-Excellent											
Universities	73.6	25.6	8.9	19.1	35.8	8.9	14.1	40.1	0.0	-26.4	5
Tech. Institutes	15.0	6.3	1.9	19.6	7.5	1.9	2.9	18.8	0.0	-85.0	8
R&D foundations	91.4	34.0	3.5	12.8	34.0	4.6	11.7	0.0	30.8	-8.6	3
R&D public organizations	68.8	6.0	8.5	19.5	34.2	8.5	13.4	469.7	0.0	-31.2	6
Excellent											
Universities	100.0	47.4	11.8	18.6	47.4	11.8	18.6	0.0	0.0	0.0	1
Tech. Institutes	46.8	32.0	6.0	25.0	32.0	6.0	11.7	0.0	0.0	-53.2	7
R&D foundations	90.7	56.3	3.5	21.3	56.3	7.6	19.3	0.0	116.3	-9.3	4
R&D public organizations	100.0	59.8	8.1	20.5	59.8	8.1	20.5	0.0	0.0	0.0	2

Table 6. DMU details, output maximization model.

Type of Institution	Score	Actual Pub. SCI	Actual Sexe-nio	Actual Size	Target Pub. SCI	Target Sexe-nio	Target Size	Potencial Improvement (%) Pub. SCI	Potencial Improvement (%) Sexe nio	Potencial Improvement (%) Size	Rating
Non-Excellent											
Universities	73.6	25.6	8.9	19.1	48.6	12.1	19.1	90.3	35.8	0.0	5
Tech. Institutes	15.0	6.3	1.9	19.6	49.8	12.4	19.6	693.1	567.5	0.0	8
R&D foundations	91.4	34.0	3.5	12.8	59.8	8.1	20.5	0.0	0.0	0.0	3
R&D public organizations	68.8	6.0	8.5	19.5	49.7	12.4	19.5	727.8	45.3	0.0	6
Excellent											
Universities	100.0	47.4	11.8	18.6	47.4	11.8	18.6	0.0	0.0	0.0	1
Tech. Institutes	46.8	32.0	6.0	25.0	68.3	12.8	25.0	113.5	113.5	0.0	7
R&D foundations	90.7	56.3	3.5	21.3	62.0	8.3	21.3	10.2	138.4	0.0	4
R&D public organizations	100.0	59.8	8.1	20.5	59.8	8.1	20.5	0.0	0.0	0.0	2

It is worth pausing at this stage in order to note that there are some caveats applying DEA exercise in this sample, due to the diversity of the DMU. Thus, results should be taken carefully. Trying to correct this, we make the same analysis but only considering research groups belonging to universities, although we are assuming implicitly that the units are homogeneous enough within and between subject areas. Table 7 shows different efficiency vectors according to the various input/output specifications. First, we use size as input, and number of *sexenios* and publications in SCI/SCCI as outputs (vector I). Second, we consider as input the size and the proportion of permanent staff in the research group, as output the number of *sexenios* (vector II). Finally, all inputs and outputs are taken into account together (vector III). In general, we can see than those excellent research groups in natural science and non-excellent research groups in humanities are the most efficiency. However, those non-excellent research groups in social science are the least efficiency.

Table 7. DEA efficiency scores achieved by research groups in universities.

	Vector I	Vector II	Vector III
Non-Excellent			
Natural Science	50.8	64.8	65.8
Engineering	51.4	58.9	64.2
Medical Science	79.9	74.0	79.9
Agriculture	79.4	77.4	79.4
Social Science	21.4	45.2	45.2
Humanities	100.0	100.0	100.0
Excellent			
Natural Science	100.0	88.9	100.0
Engineering	52.6	77.3	78.7
Medical Science	87.2	79.4	87.2
Agriculture	51.7	74.3	78.4
Social Science	76.7	87.2	87.3
Humanities	65.6	80.2	80.1
Inputs	Size	Size; % Permanent Staff	Size; % Permanent Staff
Outputs	Sexenios; Pub. SCI	Sexenios	Sexenios; Pub. SCI

5. Conclusions

In this paper we assessed the evaluation process of research groups' performance in the region of Valencia over the period 1998-2002, and the efficiency of such groups. The information comes from those research groups inside the scientific and technological Valencian system that applied in 2003 for the "*public call for excellent research group*", a public aid announcement from the regional government.

Our findings show that publications in SCI/SSCI and the number of *sexenios* are the most determinant indicators of excellence in a research group. Neither size nor personnel labour status, the total amount of funds coming from project and coming from collaborations with firms and administrations, influence excellence. These results suggest that research groups only are assessed, recognized and rewarded by their scientific dimension (publications).

With respect to assess the research performance of our research groups in terms of efficiency, several DEA runs has been performed to assess the sensitivity of DEA to input-output specification. In general, we find that excellent research groups belonging to universities, in particular those in natural science, and R&D public organizations are the most efficiency. The value added in this paper is to confirm that there is more that one way to be successful in the pursuit of efficiency.

Further studies should be done to find the real formulas and criteria applied to evaluate a research group as excellent and efficiency. We encourage other researchers to conduct similar analyses as our for other regions or countries.

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