

Are Productivity, Impact and Visibility Indicators Appropriate for Measuring the Quality of Research Conducted in Universities?

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Abstract

The outcome of scientific activity conducted by universities materializes in a number of ways, including publications, the research projects, the attainment of scientific repute and the PhD theses awarded. This communication contains the preliminary results of a research project designed to evaluate the quality of Spanish public universities' scientific activity on the grounds of a wide range of indicators that take into consideration most of the aspects involved in this activity.

The objective sought here was to determine the relationship between bibliometric indicators for productivity, impact and visibility and indicators of scientific repute, external funding and researcher training capacity in Spanish public universities.

The present study was based on a review of Spanish public universities' scientific activity in 2002-2006. The relationships between indicators were computed in terms of the determination coefficient (R^2), which measures the percentage of data variability that can be explained by such associations.

The results revealed that bibliometric indicators are only scantily related to other measures of scientific activity relevant to university research.

Introduction

Any number of bibliometric and science metric researchers (Calero-Medina, *et al.*, 2008; Moed, 2006; Van Raan, 1999, 2005 and 2008, to name a few), working from different vantages, have attempted to verify the accuracy (appropriateness) of productivity, impact and visibility indicators as a measure of the quality of research conducted by research centres.

In all fields of science, it is increasingly important to determine the quality of the research published. Ascertaining which of all the many papers published meet quality standards and contribute to the scientific *acquis* is fast becoming a pressing need. This is particularly pertinent in university institutions, where research results have a direct impact on many other domains, such as teaching, innovation or knowledge transfer, and where research assessment processes are determining the role that universities are to play in their respective regions.

The publication of scientific papers is but one of several avenues through which the scientific activity conducted in university environments materializes. Others include the award of research projects in competitive processes, the number of PhD theses defended and the merits earned after each six years of service based on peer reviews of papers published, which in the Spanish university system are remunerated and known as "sexennials". Other authors are working in the same line (Gómez, *et al.*, 2008)

Objective

This communication contains the preliminary results of an exhaustive research project designed to evaluate the quality of Spanish public universities' scientific activity on the grounds of a wide range of indicators that take into consideration most of the domains where such activity is conducted.

The objective sought here was to determine the relationship between bibliometric indicators for productivity, impact and visibility and indicators of scientific repute, external funding and researcher training capacity in Spanish public universities.

Methodology

The present study was based on a review of Spanish public universities' scientific activity in 2002-2006.

The quantitative indicators chosen were: number of publications per professor, number of citations per paper, percentage of papers published in journals in the top quartile of *Journal Citation Reports (JCR)* listings, and percentage of papers published in the JCR's top-3 journals (ranked by impact factor) in the respective category.

In addition, indicators of a different type, associated with peer review, were also analyzed: No. of "sexennials" or six-year research merits earned (scientific repute), No. of research projects (external funding) and No. of PhD theses defended (training capacity).

The scientific production, impact and visibility values were retrieved from *Web of Science* and *JCR* databases. The data on "sexennials" were obtained from the National Commission for the Evaluation of Research Activity (Spanish initials, CNEAI). The data on research projects and PhD theses were obtained from the Ministry of Science and Innovation. To ensure comparability of the results despite the wide variations in size in Spanish universities, the values were weighted by the number of full-time researchers at each university.

The linear relationship between variables was analyzed with simple regression models in which the determination coefficient (which establishes the proportion of the total variability of the dependent variable (Y) that can be explained by the linear relationship) was used to measure goodness of fit. All peer review-related indicators were plotted against the bibliometric indicators.

Results

Figures 1 to 4 show the determination coefficients (R^2) found when the productivity (paper/resear.), impact (citations/paper) and visibility (1st quartile journal, top-3 journal) indicators were plotted against "sexennials". Note that the best fit was obtained for the productivity indicator – "sexennial" relationship, where 62.44 % of the variability in researcher productivity proved to be associated with the number of six-year merits earned. Other authors have also found relation between these indicators (Buela Casal, *et al.*, 2009).

The low values found for the determination coefficients in all the other indicators were an indication of the lack of association between research "sexennials" and the number of citations/papers published, or between such merits and the number of papers published in 1st quartile or top-3 journals.

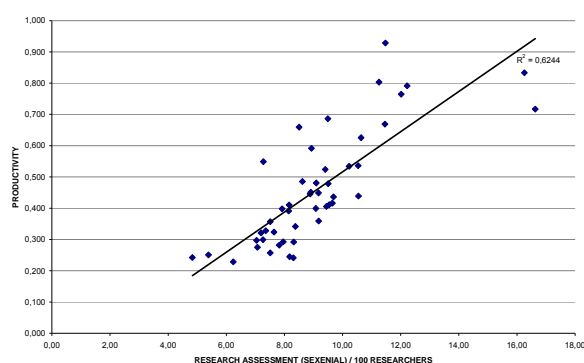


Fig. 1 paper/resear. vs "sexennials": $R^2=0.6244$

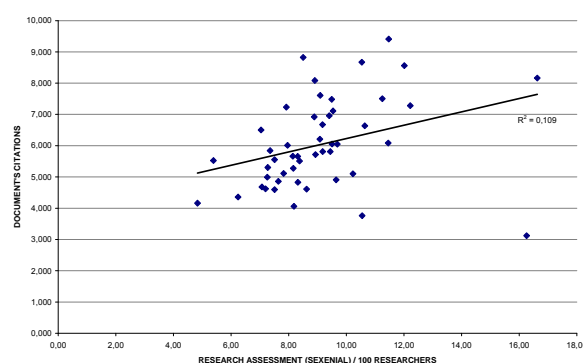


Fig. 2 Citations/paper vs "sexennials":
 $R^2=0.109$

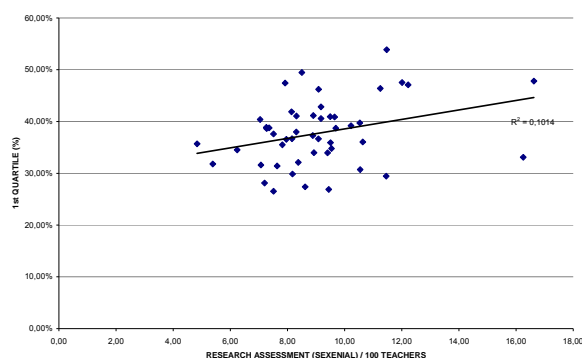


Fig. 3. 1st quartile journal vs “sexennials”:
 $R^2=0,1014$

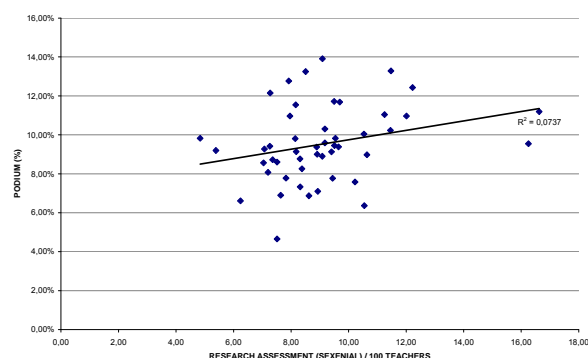


Fig. 4 Top-3 journal vs “sexennials”: $R^2=0,0737$

Figures 5 to 8 show the determination coefficients (R^2) found when the productivity (paper/resear.), impact (citations/paper) and visibility (1st quartile journal, top-3 journal) indicators were compared to the number of research projects awarded. Here, as in the preceding case, only productivity was observed to be linearly related to project awards, with an R^2 value of 0.7062. In other words, in 70.62 % of the cases analyzed, researcher productivity was related to the award of projects.

The determination coefficients found for the remaining cases were low, reflecting the scant linear relationship between impact or visibility and the number of research projects awarded.

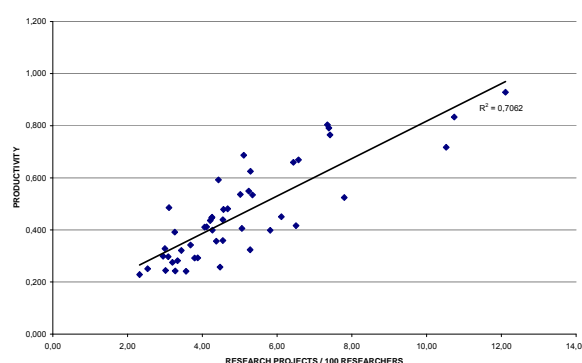


Fig. 5 Paper/resear. vs research projects:
 $R^2=0.7062$

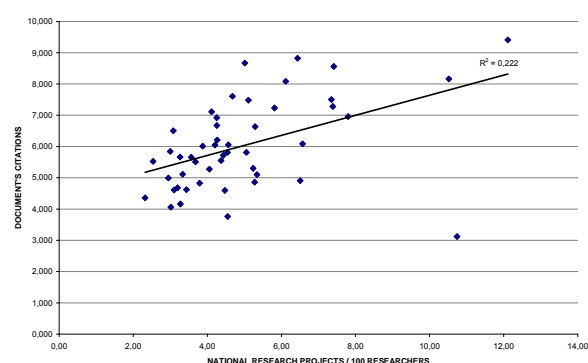


Fig. 6 Citations/paper vs research projects:
 $R^2=0.222$

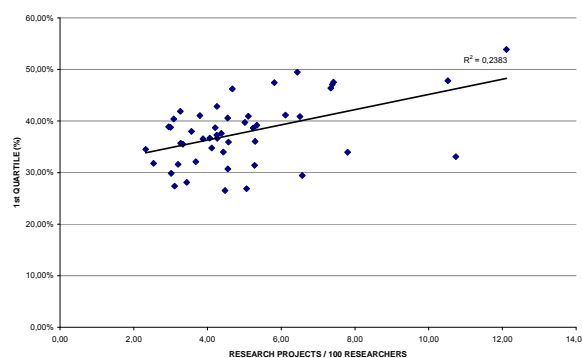


Fig. 7 1st quartile journal vs research projects:
 $R^2=0.2383$

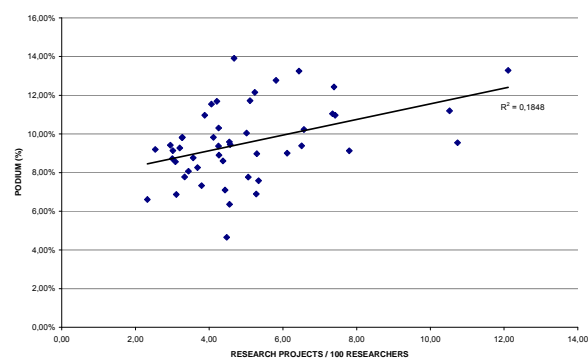


Fig. 8 Top-3 journal vs research projects:
 $R^2=0.1848$

The linear fit and respective determination coefficients (R^2) between productivity (paper/resear.), impact (citations/paper) and visibility (1st quartile journal, top-3 journal) indicators and the number of PhD theses defended are shown in Figures 9 to 12. Inasmuch as the values of the coefficient were very low in all cases, productivity, impact and visibility can be said to be unrelated, on average, to researcher training capacity.

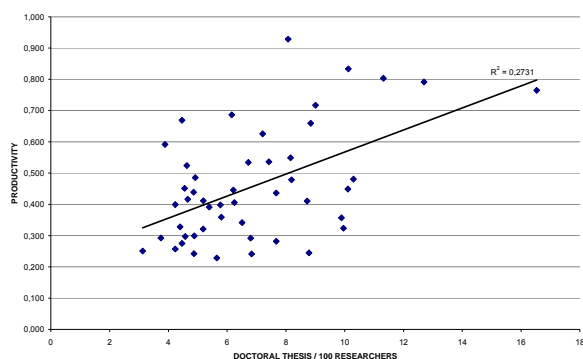


Fig. 9 Paper/resear. vs theses: $R^2=0.2731$

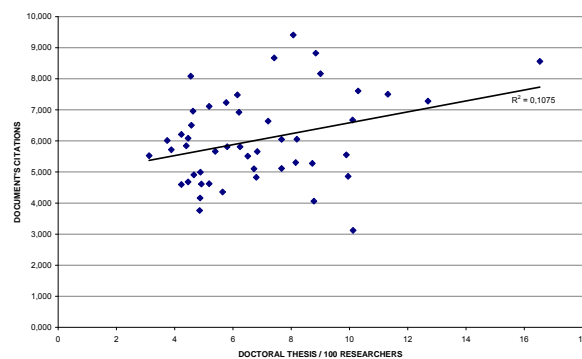


Fig. 10 Citations/paper vs theses: $R^2=0.1075$

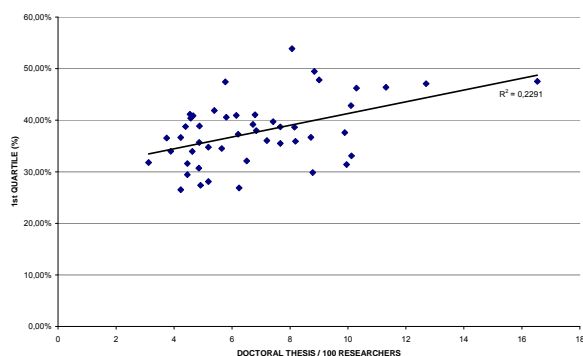


Fig. 11 1st quartile journal vs theses: $R^2=0.2291$

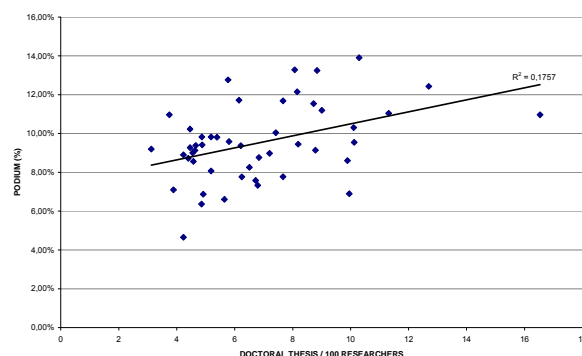


Fig. 12 Top-3 journal vs theses: $R^2=0.1757$

Conclusions

- As a rule, productivity, impact and visibility indicators fail to fully describe the quality of the research conducted by universities. In most cases, the bibliometric indicators for Spanish universities are not linearly dependent on other indicators of scientific activity that are highly relevant in the academic context, such as scientific repute, external funding or researcher training.
- The closest relationship is found between productivity indicators and the number of research projects awarded. Further to the R^2 value (0.7062) for this relationship, in 70.62 % of cases, productivity is related to project awards in Spanish universities.
- Other indicators that are linearly related, although less closely than in the preceding case, are scientific productivity and the number of “sexennials” or remunerated scientific merits obtained. Productivity is explained by (or associated with) “sexennials” in 62.44 % of the cases.
- No correlation is observed between the number of PhD theses defended and productivity, impact or visibility. The determination coefficient values are too small in all cases to establish any manner of dependence between these variables.
- The results of this study suggest that other indicators in addition to productivity, visibility and impact could be seriously considered as criteria for determining the quality of the

research generated in universities. In this regard the assessment of universities' scientific activity would call for introducing other types of measures to supplement bibliometric indicators.

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