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Scaling-Down Teaching and Research Indicators is Crucial to Define the Holistic Performance of Universities

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Abstract. This article proposes a two-dimensional model that allows for the evaluation of teaching and research based on quantitative indicators. Regarding teaching performance, the hours of face-to-face classes and those of supervised theses were considered. In the case of research activity, several indicators were proposed (e.g. books and book chapters, articles in JCR journals, patents and translations), which allow for the application to multiple academic disciplines in the fields of Arts & Humanities, Science, Engineering, Health Sciences and Social & Legal Sciences. Our model has been applied to 119 academic disciplines in the 2010s and the results obtained were analyzed under various perspectives: (i) performance timeline, (ii) comparative analysis among different academic disciplines, (iii) scale-down of the analysis to diverse units (e.g. departments, research groups), as well as to the quantification of the individual effort of each faculty member, and (iv) gender perspective. As a model use case, the Department of Chemical Engineering at the University of Santiago de Compostela (USC) was studied. One of the key takeaways of this analysis was that understanding teaching and research reference levels is crucial in defining university-specific targets, both individually and collectively. In fact, this is even more relevant for less hierarchical and more assembly-based academic institutions, where it is difficult to define a minimum standard of research activity.

Keyword:

Teaching commitment, Research performance, University and faculty evaluation, Productivity indicators, Two-dimensional model, Gender perspective

1. Introduction

University rankings have proliferated in recent years as an impactful marketing element. It has certainly become a successful business, as consolidated rankings have even begun to establish additional sub-rankings to categorize specific disciplines or university features. Most of the rankings incorporate various criteria with the aim of quantifying the two main missions of the university: teaching and research. Beyond the advantages or disadvantages that each ranking may have for tactical or strategic decision-making in the management of universities and their impact on the effective improvement of teaching and research [1], the challenge comes in when putting the strategy into practice at smaller scales, such as divisions, departments, research groups or among the staff itself. Closing this gap is essential for all university members to feel recognized with the results of the rankings, particularly in less hierarchical and more assertive institutions where it is not possible to define individual targets due to their structural constraints. Therefore, there are two main issues to be addressed: (i) indicators need to be applied independently of the hierarchical level under scope and the academic discipline considered; (ii) indicators should enable the comparison between all individuals and units, determining their contribution to the collective effort [2]. Both factors would make it possible to define, encourage and implement impactful measures at both the individual and institutional levels [3].

There are different plausible strategies when monitoring the activity carried out by faculty members and researchers, depending on whether they take into consideration quantitative and/or qualitative aspects [4]. Quantitative indicators for teaching include directly observable criteria (e.g. number of courses taught, size of student groups, hours in class and theses supervised), whereas qualitative indicators have a more subjective perception component (e.g. results of student satisfaction surveys). For our model, indicators with a quantitative nature have been selected, since their application to the 119 academic disciplines under study (which also represent up to 85% of those existing at the USC) enables: (i) the use of standardized indicators that are common to all disciplines; (ii) the validation of a overarching comparison within the institution.

In terms of research performance, there is a lack of unanimity when defining the right balance between quantity and quality indicators to measure research [5,6]. For instance, it is not only relevant to count the number of scientific articles published, but also to consider which of those have been published in first quartile (Q1) journals. The number of citations is another widely used parameter in the calculation of other bibliometric indicators, such as highly cited authors or the h-index [7]. The linear application of citations when comparing different fields of research demonstrates some of its possible limits; since fields with a greater number of researchers invariably lead to a greater number of citations and a higher impact index of the journals in the categories related to those fields. Several methods have been proposed to normalize these bibliometric indicators [8], [9]. However, depending on the academic discipline under study, other dissemination channels may be more relevant and consequently must also be considered, such as book chapters and aspects related to knowledge transfer, such as patents and spin-offs.

2. Model parameters

Companies use a two-dimensional model of both economic and environmental aspects to monitor the eco-efficiency of their products throughout their life cycle (ISO 14045) with the aim of aligning their policies with the sustainable development goals set by the UN. A two-dimensional model for evaluating departmental and individual research was proposed by [10], where the first dimension considered the total number of publications and the second consisted of the frequency of citations by others. In this study, it is proposed to monitor teaching and research efforts through their integration in a two-dimensional model (Figure 1).

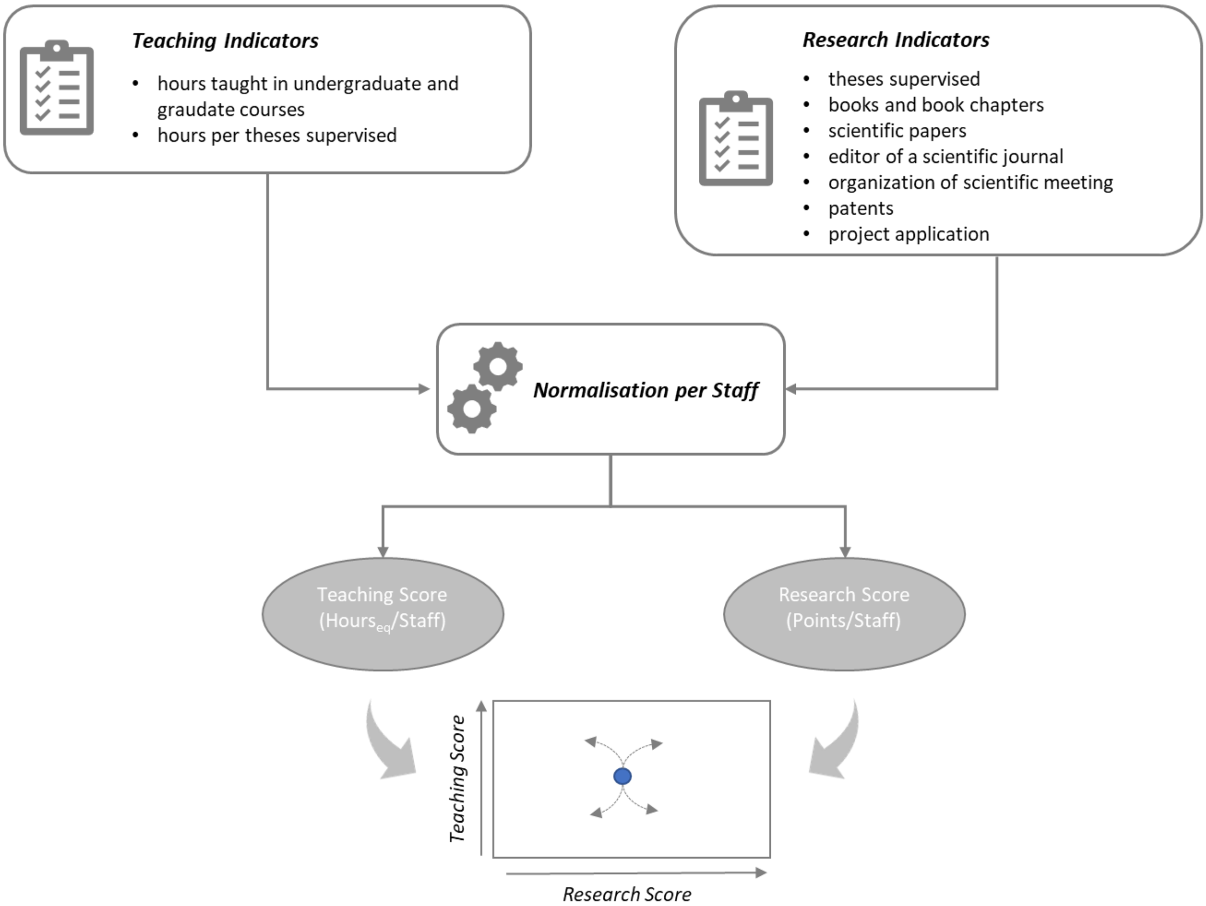

Figure 1. Characteristics of the two-dimensional model proposed for monitoring the performance of teaching and research in universities.

2.1. Teaching score

The total number of hours of undergraduate and master classroom lectures per academic year are included in the teaching score. In addition, each PhD thesis is allocated 35 hours in the academic year where the doctoral defense takes place, since this number of hours is approximately equivalent to the number of classroom hours in a standard undergraduate course. Thus, a thesis presented in 2013 implies that our model adds 35 hours to the professor's academic discipline in the academic year 2013-2014 only, and not throughout the previous years. For the standardization per professor, the number of faculty professors, non-permanent professors and researchers with teaching activity were considered.

2.2. Research Score

One of the options for measuring research uniformly across all academic disciplines is the conversion of the different scientific inputs into "research points". Table 1 shows the different weighting values that are applied in each of the units within the University of Santiago de Compostela. For example, an article in the first quartile (Q1) obtains a score of

12 points which are allocated to each of the authors whose affiliation corresponds to the USC. Theses have a double accounting in the two dimensions by combining both the teaching effort (PhD student training) and the research performance (innovation).

For the 2013-2107 period, research performance at USC was 125,648 points. Articles published in scientific journals represented the highest percentage (up to 65%), being the articles in journals of the first quartile the ones that registered an outstanding contribution. This is due not only to the higher value of their score but also to the importance of publication in Q1 journals for the curricular evaluation systems of researchers and departments, both in Spain and internationally, which prioritizes the publication of scientific works in these journals [11].

Table 1. Weighted value of each quantitative indicator to obtain the research score at the USC

ITEM	**Research points**		
1- Doctoral Theses	**With International Mention**		**Without Mention**
Cum Laude qualification	10		8
Other qualifications	8		6
2- Non-periodical publications			
2.1. Books	International Publisher		
	Author		Editor
	12		6
	Spanish Publisher		
	6		3
2.2. Book chapter	International Publisher		Spanish Publisher
	5		3
2.3. Short term publications	1		
2.4. Translations and transcriptions	1		
2.5. Articles from conferences	International		National
(with ISBN or ISSN)	3		1.5
2.6. Reviews	2		1
3.- Periodic publication			
3.1. Article in scientific journals			
Q1	12		
Q2	8		
Q3 or Q4	4		
No impact factor	2		
3.2. Editor of a scientific publication (depends on the category of the journal)	6/4/2/1		
4. Congress organization	**International**		**National**
	3		1
5. Patents	**International**		**National**
	5		1
6. Project application	**International**	**National**	**Regional**
	8	4	2

3. Teaching-Research binomial by academic disciplines at USC until 2017-2018

The joint analysis of teaching and research in the various academic disciplines of the University of Santiago de Compostela shows a widely diverse reality across both parameters. Figure 2 showcases the average value of the teaching effort for the academic years 2013-14, 2014-15, 2015-16, 2016-17, 2017-18, together with the average research activity carried out during the same years.

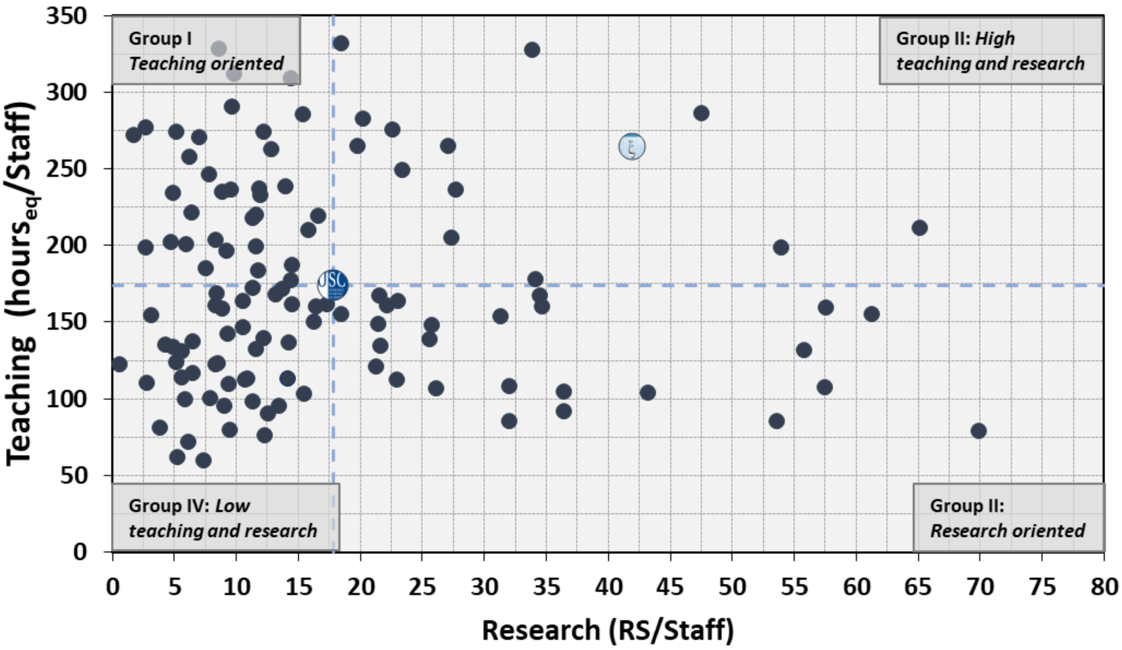

Figure 2. Distribution of the research score for the period 2013-2017 according to each of the quantitative indicators considered

For the period evaluated, the staff of the University of Santiago had an average classroom time of 173.9 hours in undergraduate and graduate courses, and an average research score of 17.8 points. Taking both these average values as reference, each academic discipline may fall within four quadrants depending on their teaching and research performance:

- Group I (28.8% of academic disciplines). It includes disciplines that are teaching an average number of hours higher than the reference value, while displaying a research score lower than the average. Therefore, these disciplines are more focused on teaching than on research activities.
- Group II (11.9% of academic disciplines). This group is composed of those academic fields that present higher values in both indicators. Consequently, these disciplines succeed in having a good performance in both teaching and research.
- Group III (22.0% of academic disciplines). Disciplines in this group follow a behavior opposite to that of Group I, as their research score values are higher than the average reference value and teaching activity is lower than the average. As a result, they are more research oriented.
- Group IV (37.3% of academic disciplines). This quadrant includes those disciplines displaying a lower performance than the university average in both teaching and research initiatives.

Depending on the coordinates where each academic discipline is located, specific targets can be defined to improve either teaching performance or research effort. There is no doubt that from an institutional point of view, those disciplines far from the reference values require more attention and a deeper diagnosis. For instance, a SWOT (strengths, weaknesses, opportunities, and threats) and CAME (correct the weaknesses, adapt to/adjust to the threats, maintain the strengths, explore the opportunities) analysis can help them define a roadmap that will allow them to keep up with the rest of the institution. Additionally, if each discipline defines specific targets to mitigate its deficiencies with respect to the average values, the entire institution can benefit as a whole in terms of teaching and research quality, eventually visible in international and consolidated rankings.

4. Scale-down of the analysis

In the field of Chemical Engineering, the goal when scaling down is to create a pilot-scale or lab-scale system that mimics the performance of an industrial plant. Process variables that represent the same physical phenomena can be more easily replicated and tested, as they are sensitive in both systems (small and large scales). In regards of the methodology proposed in this article, the intention of scaling down is to also demonstrate its applicability to the teaching and research performance of the small units that compose a university.

Our model allows for atomization of the analysis to eventually compare the activity of each staff member with respect to that of the units he or she is part of, as well as the institution itself. As an example, Figure 3 shows the analysis for the teaching staff of the Department of Chemical Engineering. At the department level, it can be seen that the average contribution of the teaching activity has a low dispersion (264.1±16.2), which is explained by internal regulation of proportionally distributing the teaching load of the department amongst all its members. On the contrary, research in this department is considered a "voluntary" activity, and therefore is highly dispersed (42.0±37.5). The analysis enables the visualization of a noteworthy weakness in the research activity of this department, as the system is not resilient to changes in scientific production for some of its members, since it would not be compensated by an overall shared capacity. A strength derived from the comparative analysis however, is that the average activity of the professors of one of the Department's research groups is also indicated.

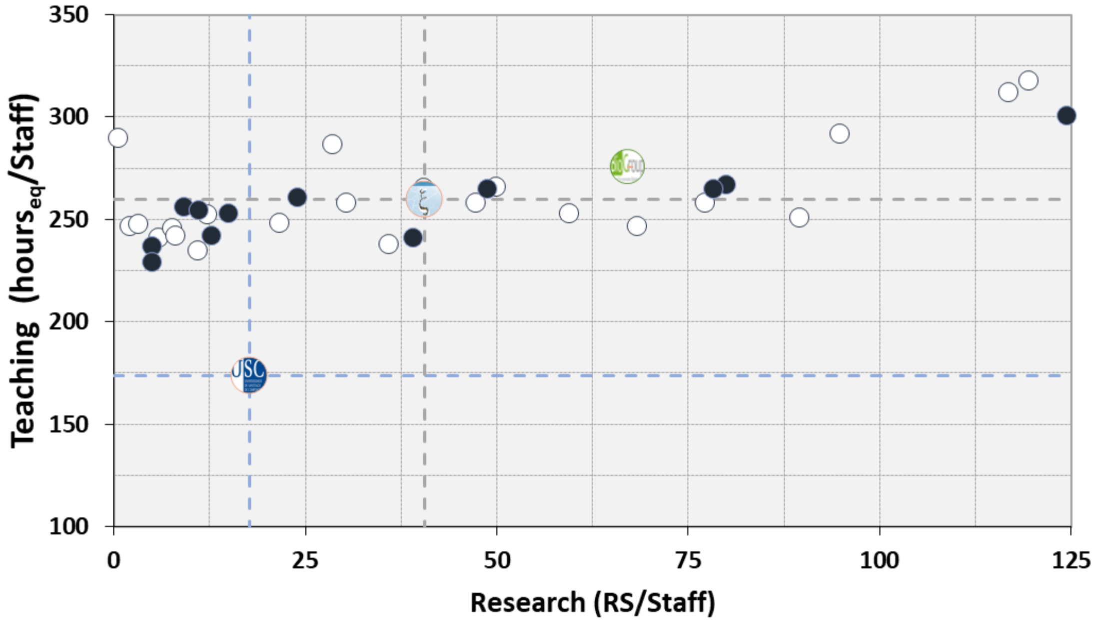

Figure 3. Contribution of each staff member of the Department to teaching (academic years 2013-14 to 2017-18) and research score (period 2013-2017). Symbols: (i) circles represent the activity of the staff, with closed circles for women and open for men; (ii) the USC logo represents the "virtual" professor with an average activity in the institution; (iii) the average values for the Department of Chemical Engineering is indicated with the image "E"; (iv) the "Biogroup" logo represents the average activity for the members of the Environmental Biotechnology research group attached to the Department.

At individual level, each professor can also benefit from such an analysis by quickly comparing his or her productivity with that of their research group, department and/or institution and, consequently, truly understand what the individual contribution is to the collective commitment.

5. Timeline analysis

Our methodology to evaluate the teaching and research performance of an academic institution makes it also possible to keep track of its evolution over time, as well as that of each of its different units. It is feasible to visualize in the short, medium and long term the result of internal actions (i.e. improvement plans, strategic plans) defined by the institution, as well as to determine the effect of external factors (i.e. health and economic crisis, regulations). Under these premises, the itinerary for the last 5 academic courses (2017-2018 to 2021-2022 has been elaborated (Figure 4).

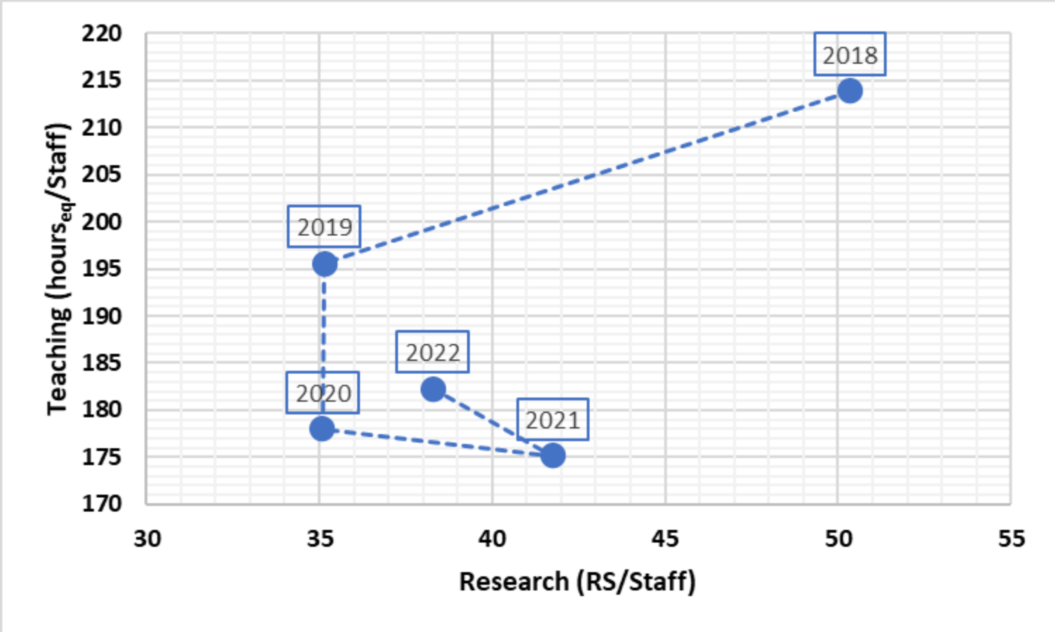

Figure 4. Timeline evolution of teaching and research indicators for Chemical Engineering Department

Regarding the Chemical Engineering Department, a linear decrease in both indicators is observed. The decrease in the number of teaching hours is due to the fact that, after the zero-replenishment period established in Spain for public administrations ended, it was possible to increase the staff of the department, which entails a slight decrease in the number of hours taught by each teacher. In respect of the research score, the impact of the COVID 19 crisis explains the abrupt drop in the graph. After the recovery of 2021, the setback occurred in 2022 has to be analyzed carefully.

6. Gender dimension

This type of analysis can also provide an understanding of the situation from a gender perspective (Figure 5).

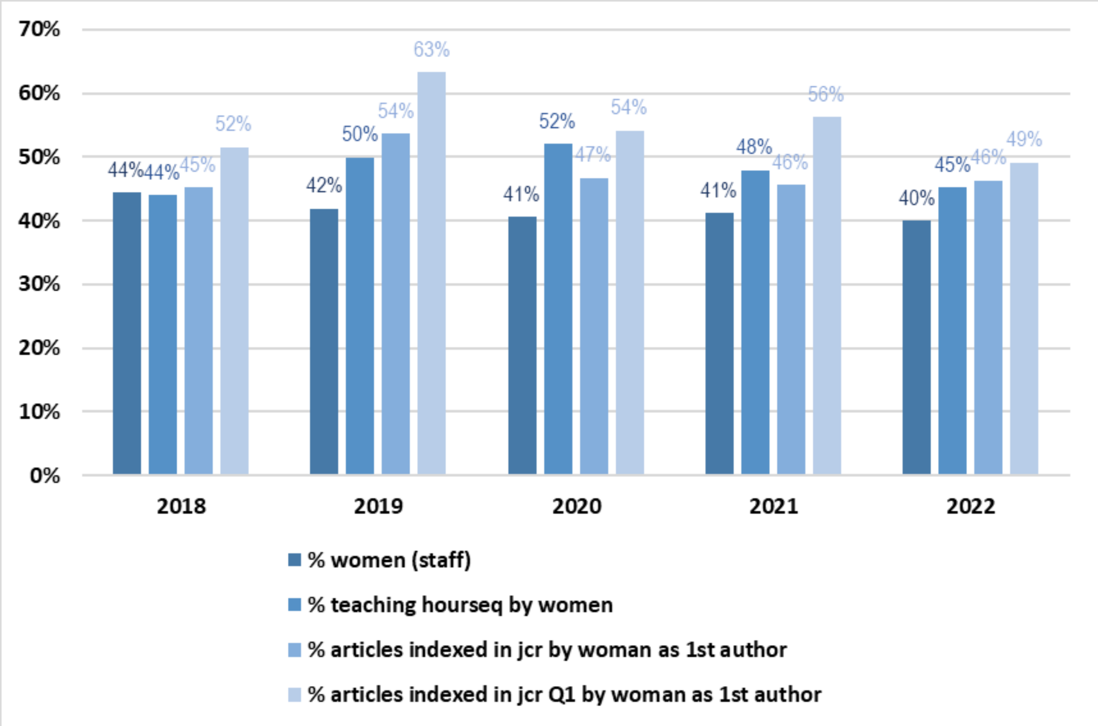

Figure 5. Gender Dimension

When considering the data from the Department of Chemical Engineering, it can be observed that women represent 44% - 40% of the department staff, with an bigger distribution of the teaching load (44% - 45%) and a even bigger distribution of the main factor of the research score, which is the number of articles published and indexed in JCR (45% - 54 %). However, the percentage of articles published in JCR Q1 by women as 1st author are more than the half of the staff members. Some researchers ([12], [13], [14]) have found inequality in research productivity among academic staff. Sax et al. [15], however, concluded that the factors affecting faculty research productivity are nearly identical for men and women, and family-related variables, such as having dependent family members in their care (children or elderly people, a very important aspect in Galicia which, together with Japan, has a high longevity of life), exhibit little or no effects on research productivity. Krampen et al. [10] conducted a bibliometric study of research in a Department of Psychology and found only a weak interdependence with gender.

In the case of the Department of Chemical Engineering at the University of Santiago de Compostela, the explanation for this inequality can be found in professional reasons, such as discrepancies in understanding teaching and research as a binomial, the ability (or lack of) to work as a team, the size of international networks and the driving forces behind professional recognition. Consequently, from a gender perspective, in the Department of Chemical Engineering the difficulty is limited to the structural problem of the Spanish university where there is less incorporation of women in engineering studies.

7. Conclusions

The COVID-19 pandemic has highlighted the importance of having a robust R+D+I system, for which not only external measures to universities and research centers are necessary (e.g. economic resources, society awareness) but also an adequate self-evaluation of teaching and research performance. A two-dimensional model with objective quantitative indicators, that can be transferred unequivocally to all levels of the university, is a key element in decision-making. This analysis allows for the individual contribution to be defined and compared with the university reference values. In addition, accurate information can be derived at different granularities of the institution (e.g. departments, research groups, faculties) and from different perspectives (e.g. temporal evolution, gender dimension), which are essential to have a Deming cycle of continuous improvement in the search for a sustainable future.

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