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Bibliometric evaluation of the research performance of the Greek civil engineering departments in National and European context

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Abstract Quality evaluation and its assurance in higher education institutions constitute an obligation and scope of most European Universities. To accomplish this, quantitative indices, known as bibliometrics, are recruited which are considered a useful evaluation tool particularly for academics' and Universities' research performance. In the present study, the research quality of the five Greek civil engineering departments (Athens, Patras, Thessaloniki, Volos, Xanthi) is assessed by means of several advanced bibliometric indices calculated separately for each academic. Statistical analysis of the data is also performed to compare the observed differences in the mean values of the calculated indices. The study is conducted both in department and academic rank level to explore how research activity is distributed among the various ranks. In addition, to evaluate the research status of the Greek departments in the European context, their research output is compared with that of London civil engineering department. To explore the dependence of bibliometrics on seniority, bibliometric analysis considering the research activity of all academics only during the last decade is also made. Finally, the temporal progress of the research productivity leads to interesting findings about the impact of the European economic crisis on research performance. In general, bibliometrics demonstrate that Patras department host academics of better quality, but Athens exhibits higher scientific activity over the last decade. Superiority of London department is evident but few bibliometrics are comparable with the ones of the Greek departments. Results also indicate that no common standards in hiring/promotion of academics are established, while the European socio-economic crisis has significant negative impact on research productivity.

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Introduction: research aims

The University is regarded as the most important social space for the promotion of ideas and intellect (Garcia-Aracil and Palomares-Montero 2010). Regardless of the discipline area, the University constitutes the place where young students' mind and spirit are cultivated and their skills are boosted, gaining at the same time all the required theoretical background in order to become the future professors and/or scientists. As such, rigorous and internationally accepted criteria and procedures should be established to ensure its quality.

Quality evaluation and its assurance in higher education institutions constitute a core component of most European countries and several indices are used to quantify all these factors which quality in Universities encompasses. However, since quality is a general term and hard to define when it refers to higher education (Lagrosen et al. 2004), prerequisite is to agree internationally on terms such as levels, standards, effectiveness and efficiency (Frazer 1994).

In this respect, the European Association for Quality Assurance in Higher Education (ENQA) has been established, which, among other activities, was invited by the Bologna Process to develop agreed set of standards, procedures and guidelines on quality assurance (ENQA 2009), while structural, legislative and institutional reforms should also be implemented in all member countries to comply with the Bologna Process.

According to the above, a new legislation (Legislation 3374/2005) was also enacted in Greece to set the standards and procedures of quality assessment of Greek higher education institutions. According to the above law, widely accepted qualitative and quantitative indices must be used in order to evaluate the quality of:

- Tuition
- Research
- Curriculum
- Other services

From the aforementioned four axes, the research performance of University faculty can easily be quantified and assessed by means of bibliometrics, which have gained considerable ground the last years due to the internet proliferation. Bibliometric indices are used as tools for monitoring scientific development, funding purposes and the evaluation of individuals (Aksnes 2009), since they offer a relatively impartial way to compare the research activity (productivity and impact) between researchers and Universities of the same discipline (e.g. Lazaridis 2010; Zachos 1991).

In this respect, only a handful of studies have been conducted regarding the evaluation of Greek University departments using bibliometrics (e.g. Katsaros et al. 2008; Lazaridis 2010; Vaxevanidis et al. 2011, 2013; Zachos 1991). Only recently, Altanopoulou et al. (2012) evaluated 93 major Greek University departments retrieving the scientific record of 3,354 academics, while Kazakis et al. (2014) made a bibliometric analysis and comparison of the seven (7) medical schools in Greece retrieving individually the bibliometric profiles of 1,803 faculty members. This large-scale work was conducted both in school and academic rank level leading to interesting results concerning the scientific activity of the medical schools studied as units and of the various academic ranks separately.

Towards this respect, in the present work the research output of the five (5) Greek civil engineering departments which host a total of 261 academic staff members is studied by means of various bibliometric indices, as described below. Such a study is of great interest since civil engineering has been over the last decades one of the most favoured disciplines among students who seek University admission and pursue a bachelor degree in Greece. At the same time, the research performance of the Greek civil engineering departments is also compared with one of the most recognizable departments in the world to demonstrate its current status in the European context.

The scope of the present paper is manifold. First, to assess the efficiency of researchers of the same discipline (i.e., civil engineering) and record with detailed bibliometric indices for the first time, to the Author's best knowledge, the research activity of all Greek civil engineering departments. Second, to compare the performance of the academics of the various ranks serving these departments in a nationwide basis revealing how research activity is distributed among the various academic ranks and to discuss potential variations. Third, to validate the current research status of the Greek civil engineering departments in European context, comparing it with the research output of one of the most reputable civil engineering departments in Europe. Fourth, to explore the dependence of bibliometrics on academic seniority making an additional bibliometric analysis considering the research profiles of all academics only for the last decade and fifth, to investigate the effect of the European economic crisis on the research productivity of Universities.

Methods

Data retrieval methodology

The required scientific data of each researcher necessary to calculate the bibliometric indices were retrieved using the Scopus scientific database. Selection of Scopus as the suitable tool for the discipline studied in the present work (civil engineering) was based on preliminary case studies as suggested by Bar-Ilan (2008) (see also Kazakis et al. 2014).

In the present work the five Greek civil engineering departments were studied which host 261 academic staff members in total of all ranks, namely Lecturers, Assistant Professors, Associate Professors and Professors in ascending order of hierarchy. It should be noted that possession of a doctorate degree (Ph.D.) and an adequate number of publications is prerequisite for all four academic degrees.

The following list shows the departments studied, which are located in different geographic regions in Greece:

- Athens civil engineering department, National Technical University of Athens
- Patras civil engineering department, University of Patras
- Thessaloniki civil engineering department, Aristotle University of Thessaloniki
- Volos civil engineering department, University of Thessaly
- Xanthi civil engineering department, Democritus University of Thrace

For comparison purposes, the research performance of one of the world's most acknowledged and reputable civil engineering departments was also studied:

- London civil engineering department, Imperial College London

The above department hosts academics of various ranks, which however differ from the Greek academic titles. Thus, only the 57 academics that hold a doctorate degree (Ph.D.) were taken into consideration in the present study.

The methodology followed was similar to the one of Kazakis et al. (2014). In the beginning of the study, the names, surnames, academic rank and scientific specialty of all the academics were recorded in excel files separately for each department and they were categorized according to their academic degree. These data were retrieved from the departments' websites on September 9th 2013. Only tenured and at present active academic staff was included in the survey, while emeritus Professors were not taken into account.

As already mentioned, the Scopus database was used to locate an individual's publication record and more specifically the Author search form. The same procedure was followed for all 318 (=261 + 57) academic staff members studied.

At first, only the surname of the under study researcher was entered in the field "*Last Name*" of the "*Author*", while the field "*Initials or First Name*" and "*Affiliation*" were left blank. This would ensure that all documents corresponding to the entered surname would be retrieved regardless the first name and the affiliation of the Author and that no documents would be excluded from the search. The resulting profile records would be selected or rejected accordingly manually, as described below. For the sake of completeness and to be more correct, all subject areas were selected in order not to exclude documents from an author with multidisciplinary research work.

During the search of an academic's record in Scopus several problems had to be tackled to assure the credibility of the results and the retrieval of the correct data. The most important difficulty confronted was the English transliteration of both Greek surnames and first names (for details see Kazakis et al. 2014).

Contrary to the Greek medical schools, where more than 15 % of the faculty was found to have multiple profile records due to spelling variations of their names, this percentage was <5 % in the present study. In any case, multiple searches were accomplished for each academic studied to cover all possible name spelling combinations (when translating from Greek to English) and avoid neglecting data of the same person due to misspelling.

In all cases, in order to ensure that different variations in names correspond to the same person, several other parameters were also checked (especially when personal web pages or curriculum vitae were not available):

- The subject area of the published documents should be relevant to the under investigation researcher's discipline (e.g. engineering).
- The affiliation was checked if it was the correct one.
- Affiliation and journal discipline were of great importance, since both contributed to avoid confusion between academics with the same name (homonymy), but of different Universities.
- If the affiliation was not the expected one, but the subject area and journal discipline matched, then it was also checked whether the co-authors of any of the resulting documents belong to the same faculty with the under study academic member, since a few researchers used in their publications past affiliations.

In each search, citation data of the academic were exported in a.csv file, which comprised the documents (with all metadata, such as year of publication, title, journal etc.) and the citations of each document.

When multiple searches were needed to compose a researcher's record due to spelling variations, then the various.csv files were subsequently merged in one single file consisting

of all available data (documents and citations). For all researchers, all bibliometric indices were also calculated manually, depending on the under-study time period (years 2004–2013 or with no time limit).

All academics' data were collected from 9th September 2013 to 16th September 2013 following the above described procedure. Finally, all data were tabulated for each department sorted by the academic ranks, in order to facilitate the calculation of all indices.

Bibliometrics calculation

The raw data, which composed the bibliometric profile of each academic based on which the aggregate indices of each department and academic rank were calculated, consisted of the:

- Number of published documents per year.
- Number of citations that corresponds to each document.
- *h*-index (Hirsch 2005), which takes into account both the number of publications and the number of citations. According to Hirsch (2005), a scientist has index *h* if *h* of his/her N_p papers have at least *h* citations each, and the other ($N_p - h$) papers have no more than *h* citations each.
- *g*-index (Egghe 2006), which gives more weight to the highly cited articles. According to Egghe (2006), a researcher has a *g*-index *g* if *g* is the highest rank such that the top *g* papers have, together, at least g^2 citations.

Isolated indices cannot lead to concrete conclusions regarding the research performance of academics. An accurate and complete bibliometric analysis should be based on a combination of several scientometric indices for all different axes of research output to be taken into account, namely productivity, impact, efficiency and hybrid (i.e., productivity + impact) (Martin 1996; Vaxevanidis et al. 2011). In this respect, to compare the researchers in both department and academic rank level, the following bibliometric indices were calculated:

- Total number of academics for each University (n) and for each academic rank separately: lecturers (n_l), assistant professors (n_{assi}), associate professors (n_{asso}) and professors (n_p) (obviously $n = n_l + n_{assi} + n_{asso} + n_p$).
- Total number of published documents for each University faculty (P) and for each academic rank separately: lecturers (P_l), assistant professors (P_{assi}), associate professors (P_{asso}) and professors (P_p).
- Average number of publications per academic in total (P_{ave}), given by the ratio of the total number of publications to the number of researchers of all ranks (P/n), and for each academic grade separately, given by the appropriate ratio (total number of publications of researchers of one academic rank divided by the number of researchers of the same rank), e.g. for lecturers ($P_{ave\text{-}l}$) it will be P_l/n_l.
- Total number of citations (C_s) for each University faculty and for each academic rank separately.
- Average number of citations per publication (C_{aves}) for each University faculty, given by the ratio of the number of citations to the total number of documents (i.e., C_s/P) and for each academic rank separately (in a similar way as previously described).
- Average *h*-index (h_{aves}) for each faculty (given by the sum of the *h*-indices of all researchers divided by the number of researchers of all ranks) and for each academic rank separately.

- Median h-index (h_{ms}) for each faculty and for each academic rank separately, where median is the numerical value separating the higher half of a data sample from the lower half.
- Average g-index (g_{aves}) for each faculty (given by the sum of the g-indices of all researchers divided by the number of researchers of all ranks) and for each academic rank separately.
- Median g-index (g_{ms}) for each faculty and for each academic rank separately.

It must be noted that the above bibliometrics in department and rank level were calculated twice by:

1. Considering the complete research profile of each academic with no time limit (i.e., from the beginning of their scientific activity).
2. Taking into account only the documents and corresponding citations for the last decade (period 2004–2013) to make comparisons using the same time basis. In this case, the index "10" is added to the symbol of each bibliometric index, indicating that it corresponds to the last 10 (ten) years.

It should also be stated that self-citations were included in the calculation of all indices, since their effect on the research profile of academics seems to be negligible in most cases (e.g. Aksnes 2003; Huang and Lin 2011; Kazakis et al. 2014; Rad et al. 2012; Thijs and Glanzel 2005), especially when bibliometrics are used for comparison purposes.

Statistical analysis

In order to determine whether statistically significant differences between the mean values of the calculated indices exist, statistical analysis of the averaged bibliometrics was also performed as first introduced by Kazakis et al. (2014). For this purpose, one-way analysis of variance (ANOVA) was performed using suitable statistical software (STATISTICA 7, Statsoft, USA). ANOVA is a hypothesis-testing statistical method which tests the equality of two or more population means by examining the variances of the samples used determining whether the differences between the samples are due to random error or they can be attributed to systematic treatment effects, causing the mean value in one group to differ from the mean value in another (Scheffe 1959). After ANOVA, Tukey's HSD Post-hoc test was also performed, when the null hypothesis in ANOVA was rejected, to determine which of the studied groups (i.e., engineering departments) differ significantly (Hsu 1996).

Results and interpretation

Comparison of the Greek civil engineering departments in department level

Table 1 gives the aggregate bibliometrics calculated in department level for all departments studied (Greek and London). One can readily observe that Athens and Thessaloniki departments host considerably larger faculty size than the other three (3) Greek departments, justified by the fact that they are the first civil engineering departments founded in Greece and also located on the two largest cities of the country. On the other hand, Volos department which is the most newly-founded (just two decades ago) has only twenty-one (21) academics.

Table 1 Aggregate bibliometrics calculated for all civil engineering departments in department level

Index	Athens	Thessaloniki	Patras	Xanthi	Volos	London
n	67	**93**	32	48	21	57
P	**2,472**	1,700	1,300	1,010	664	3,119
P_{10}	**1,504**	914	569	530	341	2,004
P_{ave}	36.90	18.28	**40.63**	21.04	31.62	54.72
P_{ave10}	**22.45**	9.83	17.78	11.04	16.24	35.16
C_s	**21,387**	10,786	15,128	6,148	7,475	32,860
C_{s10}	**9,128**	3,792	3,371	3,100	1,490	16,058
C_{aves}	8.65	6.34	**11.64**	6.09	11.26	10.54
C_{aves10}	**6.07**	4.15	5.92	5.85	4.37	8.01
h_{aves}	7.79 (5.76)	4.33 (3.86)	**9.16** (7.36)	4.67 (4.11)	7.48 (6.42)	10.63 (8.00)
h_{aves10}	**5.12** (4.12)	2.58 (2.31)	4.38 (3.72)	2.90 (3.20)	3.90 (2.59)	7.82 (5.56)
h_{ms}	6.00	3.00	**7.00**	4.00	**7.00**	9.00
h_{ms10}	**4.00**	2.00	**4.00**	2.00	**4.00**	6.00
g_{aves}	13.10 (9.42)	7.55 (6.44)	**15.72** (12.58)	7.75 (6.99)	13.24 (12.39)	17.51 (13.00)
g_{aves10}	**8.30** (6.58)	4.41 (3.81)	7.22 (6.04)	4.98 (5.59)	6.62 (4.27)	12.81 (8.83)
g_{ms}	11.00	7.00	**12.50**	7.00	10.00	14.00
g_{ms10}	**7.00**	4.00	**7.00**	3.00	5.00	11.00

Numbers in bold font indicate the highest value among the *Greek* departments in each row; Index "10" at the symbols indicate that the bibliometric index was calculated considering the scientific output of only the last 10 years (2004–2013); Numbers in brackets denote the standard deviation

Another observation from the absolute numbers of Table 1 is that Athens and Thessaloniki hold the first two positions regarding the total number of documents published which was actually expected due to the much higher number of academics. However, it seems that this is not the case when values are averaged, since the rest of the bibliometric indices calculated considering the complete scientific profile of all academics depict a different trend.

At this point, it should be pointed that department bibliometrics based on the full research record of each academic from the beginning of their scientific activity, reflects the scientific level/quality of the faculty as researchers/scientists rather than the actual department's research output. To accurately determine the scientific productivity of each department a common time basis should be considered for the research profile of all academics (as discussed later).

According to the above, it seems that Patras civil engineering department exhibits the highest values in all bibliometric indices indicating that academics hosting it have been more scientifically active through their career. Departments of Athens and Volos follow with slightly lower indices. It is worth noticing that these two last departments display comparable indices in all four axes of research output, as previously discussed, despite their considerable difference in both age and faculty size. Finally, Thessaloniki and Xanthi appear to be in the last place and to lag far behind the other Universities, since all bibliometrics are almost 50 % lower than the corresponding ones of the other three departments. As previously discussed, it is also remarkable to notice that Xanthi, whose faculty size is almost half of Thessaloniki's, exhibits slightly higher h- and g-indices than Thessaloniki. The above finding is very interesting, since it seems that faculty size and age of a University is not connected directly to the research quality of academics hosting it.

In order to further assess the above results, statistical analysis of the data was also performed. More specifically, Fig. 1 illustrates the one-way ANOVA of the average h-index (h_{aves}) for all Greek civil engineering departments, performed with confidence interval 95 %, while results of ANOVA are presented in Table 2.

Since $F(4, 256) = 8.57 > 2.41$, the analysis is significant, which means that at least one of the average values of the h-index of the engineering departments differs significantly from the others. In order to further examine the relationship of h_{aves} among all groups, the Tukey's HSD Post-hoc test is performed and the results in the form of p values (significance levels) for the respective pairs of weighted marginal means are given in Table 3.

From Fig. 1 and Table 3, it is evident that results of ANOVA and Tukey's HSD Post-hoc test further support the Patras' superiority. More specifically, the h_{aves} of Patras civil engineering department is the highest one and significantly different from the h_{aves} of Thessaloniki and Xanthi ($p < 0.05$), while it doesn't differ significantly from h_{aves} of Athens and Volos. In the same respect, Thessaloniki has the lowest h_{aves}, which significantly differs from the h_{aves} of the two top departments, namely Patras and Athens, while it is comparable to Xanthi's h_{aves}. In addition, Thessaloniki's value differs also from the h_{aves} of Volos and their statistical association (0.0877) is near the limits of significance (0.05). Finally, Volos' h_{aves} seems not to differ significantly from the rest of the Greek departments, probably due to the small number of academics and thus statistical sample.

Comparison of the Greek civil engineering departments in rank level

Bibliometric indices as a function of academic rank are quite useful since they can be used as an indicator of the "academic health" and the standards followed for promotions or new appointments in a University department.

In this respect, aggregate bibliometrics of researchers of all departments studied (Greek and London) calculated for each academic rank are presented in Table 4. In the case of London civil engineering department bibliometrics only for Professors are presented for comparison purposes, as discussed later, since ranks in the UK academic system are different from those in Greece.

Indices in Table 4 depict that Athens and Thessaloniki hold the first two positions when values are not averaged, since they host the most numerous academics not only in total, but in each rank as well (except of Associate Professors in the case of Thessaloniki).

In other respects, and considering the complete research profile of academics, the ranking seems to be similar as presented in the department level comparison. In general, Patras and Athens exhibit the highest values in most of the bibliometric indices (averaged and median) for all ranks separately, while, on the other hand, Xanthi and Thessaloniki display the lowest values almost in all indices.

Of course several interesting variations are detected demonstrating different research quality of academics of the same rank among the various departments. Lecturers and Assistant Professors of Athens department exhibit the highest values in all indices and thus, appear to be of better research profile, although Assistant Professors in Patras demonstrate marginally higher values of average citations per publication ($C_{aves\text{-}assi}$) compared to Athens.

Unfortunately, solid conclusions cannot be extracted about the department that dominates regarding the Associate Professors, since it strongly depends on which index is considered for comparison. More specifically, although Associate Professors in Athens display significantly higher average publications per Associate Professor ($P_{ave\text{-}asso}$) compared to the other four (4) Greek departments, when the average number of citations per

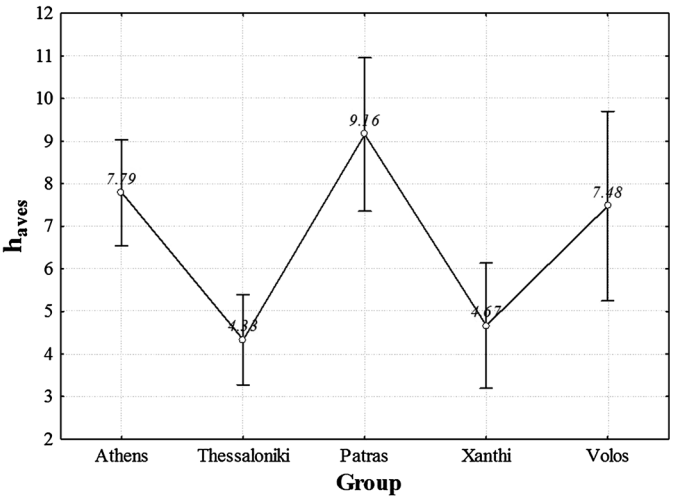

Fig. 1 One way ANOVA of the h_{aves} for all Greek civil engineering departments; *Vertical bars* denote 0.95 confidence intervals

Table 2 Results of one way ANOVA applied on h_{aves} for all Greek civil engineering departments in department level

Source of variation	Sum of squares (SS)	degrees of freedom (df)	Mean square (MS)	*F*	*p* value	*F* critical
Between groups	918.96	4	229.74	8.57	0.000	2.41
Within groups	6,859.86	256	26.80			
Total	7,778.83	260				

Table 3 Results of Tukey's HSD Post-hoc test after ANOVA of h_{aves} for the Greek civil engineering departments in department level

	Athens	Thessaloniki	Patras	Xanthi	Volos
Athens		**0.0003**	0.7354	**0.0123**	0.9992
Thessaloniki	**0.0003**		**0.0001**	0.9963	0.0877
Patras	0.7354	**0.0001**		**0.0014**	0.7766
Xanthi	**0.0123**	0.9963	**0.0014**		0.2312
Volos	0.9992	0.0877	0.7766	0.2312	

Numbers in bold font indicate $p < 0.05$

publication ($C_{aves\text{-}asso}$) is considered instead, then superiority of Associate Professors of the Thessaloniki department is evident. Finally, when hybrid indices, namely $h_{aves\text{-}asso}$ and $g_{aves\text{-}asso}$, are considered for comparison, values of Patras and Thessaloniki seem to stand out respectively.

In the same respect, when the Professors' research profiles of the various departments are compared a less complicated pattern is observed, since dominance of Patras department

Table 4 Aggregate bibliometrics calculated for all civil engineering departments in academic rank level

Index	Athens	Thessaloniki	Patras	Xanthi	Volos	London
Lecturers						
n_{l}	12	**21**	4	5	2	
P_{l}	137	**139**	31	26	21	
P_{l10}	121	**122**	23	24	16	
$P_{ave\text{-}l}$	**11.42**	6.62	7.75	5.20	10.50	
$P_{ave\text{-}l10}$	**10.08**	5.81	5.75	4.80	8.00	
C_{s-l}	**1,875**	753	157	198	110	
C_{s-l10}	**1,040**	498	80	136	90	
$C_{aves\text{-}l}$	**13.69**	5.42	5.06	7.62	5.24	
$C_{aves\text{-}l10}$	**8.60**	4.08	3.48	5.67	5.63	
$h_{aves\text{-}l}$	**3.67** (3.23)	2.33 (1.98)	2.75 (3.10)	2.20 (2.68)	3.50 (4.95)	
$h_{aves\text{-}l10}$	**2.92** (3.06)	1.86 (1.77)	1.50 (2.38)	2.00 (2.35)	2.50 (3.54)	
$h_{ms\text{-}l}$	3.00	2.00	2.00	1.00	**3.50**	
$h_{ms\text{-}l10}$	2.00	1.00	0.50	1.00	**2.50**	
$g_{aves\text{-}l}$	**8.33** (9.09)	4.19 (3.76)	4.50 (4.43)	4.00 (4.85)	5.00 (7.07)	
$g_{aves\text{-}l10}$	**6.33** (6.44)	3.24 (3.06)	2.50 (3.79)	3.40 (3.85)	4.50 (6.36)	
$g_{ms\text{-}l}$	4.50	3.00	4.00	2.00	**5.00**	
$g_{ms\text{-}l10}$	4.00	3.00	1.00	2.00	**4.50**	
Assistant Professors						
n_{assi}	14	**17**	4	16	9	
P_{assi}	**379**	182	30	116	227	
P_{assi10}	**294**	137	16	63	156	
$P_{ave\text{-}assi}$	**27.07**	10.71	7.50	7.25	25.22	
$P_{ave\text{-}assi10}$	**21.00**	8.06	4.00	3.94	17.33	
$C_{s\text{-}assi}$	**3,605**	658	344	356	1,798	
$C_{s\text{-}assi10}$	**2,154**	415	205	169	718	
$C_{aves\text{-}assi}$	9.51	3.62	**11.47**	3.07	7.92	
$C_{aves\text{-}assi10}$	7.33	3.03	**12.81**	2.68	4.60	
$h_{aves\text{-}assi}$	**7.57** (5.12)	2.88 (2.00)	3.75 (2.99)	2.06 (2.24)	5.78 (3.46)	
$h_{aves\text{-}assi10}$	**5.93** (4.55)	2.18 (1.78)	2.25 (3.30)	1.13 (1.59)	4.00 (2.50)	
$h_{ms\text{-}assi}$	**6.00**	2.00	4.00	1.00	5.00	
$h_{ms\text{-}assi10}$	**4.00**	2.00	1.00	1.00	**4.00**	
$g_{aves\text{-}assi}$	**12.50** (8.33)	4.76 (3.31)	7.50 (5.57)	3.00 (3.27)	11.33 (7.18)	
$g_{aves\text{-}assi10}$	**8.86** (7.15)	3.53 (2.90)	4.50 (6.14)	1.75 (2.41)	6.89 (4.73)	
$g_{ms\text{-}assi}$	**11.00**	4.00	8.50	2.00	9.00	
$g_{ms\text{-}assi10}$	**5.50**	3.00	2.50	1.00	5.00	
Associate Professors						
n_{asso}	**17**	6	7	9	4	
P_{asso}	**533**	116	175	157	99	
P_{asso10}	**354**	66	108	98	57	
$P_{ave\text{-}asso}$	**31.35**	19.33	25.00	17.44	24.75	
$P_{ave\text{-}asso10}$	**20.82**	11.00	15.43	10.89	14.25	
$C_{s\text{-}asso}$	**4,090**	1,251	1,315	962	627	

Table 4 continued

Index	Athens	Thessaloniki	Patras	Xanthi	Volos	London
$C_{\text{s-asso10}}$	**1,467**	449	473	586	124	
$C_{\text{aves-asso}}$	7.67	**10.78**	7.51	6.13	6.33	
$C_{\text{aves-asso10}}$	4.14	**6.80**	4.38	5.98	2.18	
$h_{\text{aves-asso}}$	7.06 (4.58)	6.67 (4.37)	**7.14** (3.67)	5.11 (1.69)	6.00 (3.83)	
$h_{\text{aves-asso10}}$	3.88 (3.00)	**4.00** (2.61)	**4.00** (2.38)	3.78 (1.79)	2.75 (1.26)	
$h_{\text{ms-asso}}$	6.00	6.50	**7.00**	5.00	**7.00**	
$h_{\text{ms-asso10}}$	3.00	**4.00**	**4.00**	**4.00**	3.00	
$g_{\text{aves-asso}}$	12.35 (8.09)	**12.50** (6.28)	11.86 (5.90)	9.33 (3.35)	10.25 (6.80)	
$g_{\text{aves-asso10}}$	6.29 (5.82)	**7.33** (4.46)	6.43 (3.87)	6.78 (3.56)	4.50 (2.52)	
$g_{\text{ms-asso}}$	11.00	**13.00**	11.00	10.00	11.50	
$g_{\text{ms-asso10}}$	5.00	**8.50**	7.00	6.00	5.00	
Professors						
n_{p}	24	**49**	17	18	6	19
P_{p}	**1,423**	1,263	1,064	711	317	2,093
P_{p10}	**735**	589	422	345	112	1,195
$P_{\text{ave-p}}$	59.29	25.78	**62.59**	39.50	52.83	110.16
$P_{\text{ave-p10}}$	**30.63**	12.02	24.82	19.17	18.67	62.89
$C_{\text{s-p}}$	11,817	8,124	**13,312**	4,632	4,940	23,865
$C_{\text{s-p10}}$	**4,467**	2,430	2,613	2,209	558	11,001
$C_{\text{aves-p}}$	8.30	6.43	12.51	6.51	**15.58**	11.40
$C_{\text{aves-p10}}$	6.08	4.13	6.19	**6.40**	4.98	9.21
$h_{\text{aves-p}}$	10.50 (6.62)	5.41 (4.39)	**12.76** (7.96)	7.44 (4.77)	12.33 (9.52)	18.63 (6.88)
$h_{\text{aves-p10}}$	**6.63** (4.45)	2.86 (2.56)	5.71 (4.06)	4.28 (4.21)	5.00 (3.16)	12.58 (5.91)
$h_{\text{ms-p}}$	9.00	4.00	**10.00**	6.00	9.00	19.00
$h_{\text{ms-p10}}$	**5.50**	2.00	5.00	3.50	5.00	11.00
$g_{\text{aves-p}}$	16.38 (10.34)	9.35 (7.20)	**21.88** (13.74)	12.22 (8.19)	20.83 (19.60)	29.89 (10.94)
$g_{\text{aves-p10}}$	**10.38** (6.49)	4.86 (4.10)	9.29 (6.56)	7.39 (7.32)	8.33 (4.03)	20.37 (9.12)
$g_{\text{ms-p}}$	15.00	9.00	**18.00**	9.50	12.50	28.00
$g_{\text{ms-p10}}$	**9.50**	5.00	8.00	6.00	8.00	20.00

Numbers in bold font indicate the highest value among the Greek departments in each row; Indices at symbols of bibliometrics denote *l* lecturers, *assi* assistant professors, *asso* associate professors and *p* professors; Index "10" at the symbols indicate that the bibliometric index was calculated considering the scientific output of only the last 10 years (2004–2013); Numbers in brackets denote the standard deviation

in this rank is apparent in almost all bibliometrics. The only variance which is worth mentioning is the significantly high average number of citations per publication ($C_{\text{aves-p}}$) of the Volos department indicating the considerably high impact of the documents published by its Professors from the beginning of their career to date.

Comparing the bibliometrics (especially the average ones) of the various academic ranks in each University separately, interesting conclusions can also be extracted about the research quality in rank level for each department.

Figure 2 illustrates the average *h*-index (Table 4) of each academic rank for all Greek civil engineering departments. It should be noted that the observed trend is typical, since it is similar for all hybrid axis bibliometric indices of Table 4 in all Universities.

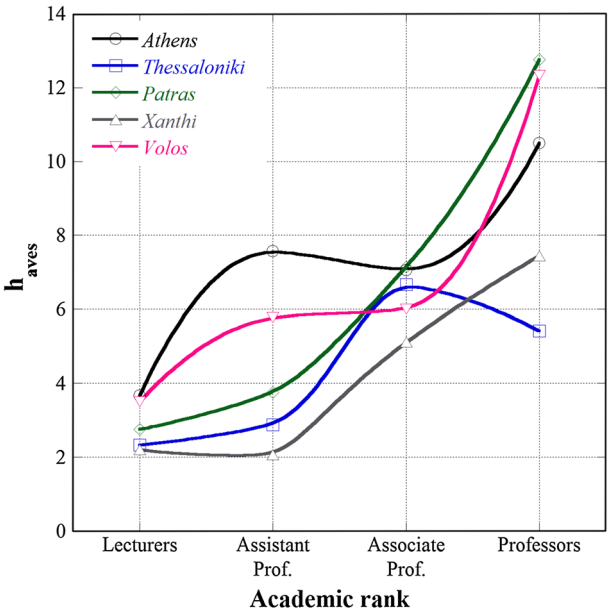

Fig. 2 Average h-index (h_{aves}) of the various academic ranks for all Greek civil engineering departments

From Fig. 2, one can readily observe that in most of the Greek civil engineering departments there is no consistency regarding the research quality among the different ranks, since one should expect that academics of higher ranks should have more improved and acknowledged scientific profile. However, the above expected trend is observed only at the Patras and Volos department, whereas in the other three (3) departments peculiar deviations are discernible. In Athens, Assistant Professors have slightly better scientific profile than Associate Professors, while in Thessaloniki academics of 1st rank, namely Professors, have lower average h-index than Associate Professors. Finally, Lecturers in Xanthi exhibit slightly more improved research experience than Assistant Professors.

Standard deviations of the hybrid bibliometric indices (h- and g-index) (Table 4) in conjunction with a comparison between the average and median values, can give valuable information about the heterogeneity in each rank of the departments studied, regarding the research profile of academics of the same rank.

A first observation is that the standard deviations of the average h- and g-indices of the Lecturers is considerably high (in some cases even higher than the average value) in all departments, indicating that dispersion and heterogeneity among the indices of academics of this rank is remarkably high in all Greek civil engineering departments.

The opposite appears to be valid for Associate Professors and Professors in all departments. For both ranks average h- and g-indices exhibit relatively low standard deviation, while in most cases the mean values is close to the average ones. This means that the above ranks are of relatively high homogeneity, namely academics have similar scientific profiles.

Finally, heterogeneity of Assistant Professors varies with the department. In Athens, Patras and Volos average indices of that rank display relatively low standard deviations, while the opposite is witnessed in Thessaloniki and Xanthi.

Research quality of faculty in Greek civil engineering departments in European context

Bibliometric indices have also been calculated for one of the best civil engineering departments in the world (Table 1) in order to compare them with those of the Greek departments and investigate potential variations. From Table 1, it is apparent that the London department outnumbers all Greek departments regarding the total number of published documents (P) and the total citations (C_s) despite its lower faculty size than the one of Athens and Thessaloniki. When values are averaged, the London department displays a significantly high average number of publications per academic (P_{ave}), but the average number of citations per publication (C_{aves}) is lower than that of Patras and Volos. On the other hand, the London's hybrid indices (h- and g-index) are higher than those of all Greek departments. To test if the average h-index (h_{aves}) of London statistically differs significantly from the same index of the Greek civil engineering departments one-way ANOVA with confidence interval 95 % is also performed and it is presented in Fig. 3.

From Fig. 3, it can be inferred that London's h_{aves} differs significantly from that of Thessaloniki and Volos, but it is statistically comparable with h_{aves} of Patras, Athens and Volos.

Apart from the bibliometrics of the London's academic faculty in total, the indices have also been calculated for Professors separately and are given in Table 4. Professors in London department exhibit outstanding bibliometrics compared to those of all Greek departments indicating their considerably more advanced scientific activity and experience. As in the case of the department indices, a variation is observed regarding the average number of citations per publication for the Professors ($C_{aves\text{-}p}$), which again is lower than that of Patras and Volos, but this cannot put into question the superiority of the London department's Professors.

Research performance of the last decade: dependence of bibliometrics on academic seniority

Some indicators, such as number of publications and citations or h- and g-index, are cumulative and grow with age. Consequently, when calculation of bibliometrics has been

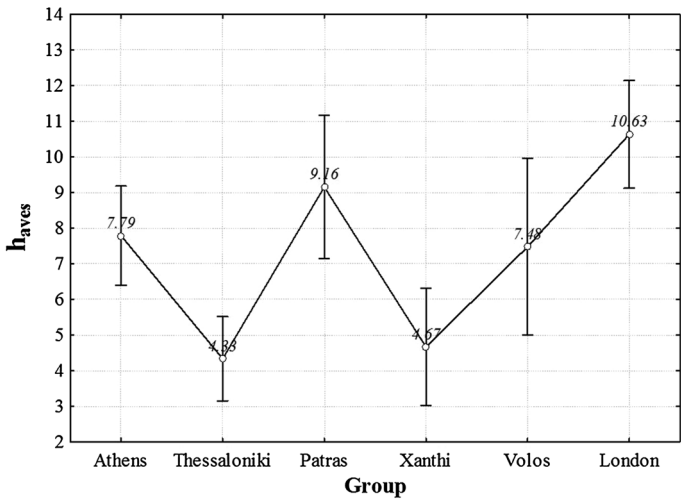

Fig. 3 One way ANOVA of the h_{aves} for all civil engineering departments studied (Greek and London); *Vertical bars* denote 0.95 confidence intervals

accomplished considering the complete scientific profile of each academic, these represent the quality and experience of academics as researchers and can only be used to determine which department hosts the faculty of better research quality, as discussed so far.

In order to compare the actual research conducted in each department, bibliometric indices must be calculated employing a common time basis for the scientific profile of all academics and, thus, eliminating the effect of seniority. That means to consider only publications over the last x years and citations on those publications. In this way, the recent research performance of each department can be assessed, since the scientific activity of academics is limited, to a great extent, to while being in their current affiliation. Of course such a procedure may suffer of few drawbacks, since it is assumed that all of the present academics were in the same department during the under-study time period, while the research activity of currently retired Professors is neglected. However, it is estimated that the above shall implement only minor errors in the comparison of departments of the same discipline.

In this regard, bibliometrics of all academics studied were also calculated considering their research profile only of the last ten (10) years, namely the period 2004–2013 and are presented in Table 1 (in department level) and 4 (in rank level).

Comparison in department level

Inspecting the average indices (Table 1) it is evident that the first position in the department ranking changes hands, since Athens seems to be at the helm of the research activity of the last decade, with Patras and Volos following. Xanthi and Thessaloniki have comparable bibliometrics, especially h- and g-indices (h_{aves10} and g_{aves10}), indicating that research is being conducted with similar productivity and impact results in both departments the last 10 years. Of course the London civil engineering department exhibits significantly higher values in all indices than all Greek departments, which reflect its incessant and innovative research work of the last decade.

In parallel, the percentage of published documents and citations that correspond to the period 2004–2013 have also been calculated for the various ranks and departments and are presented in Table 5.

A first observation from the percentages in department level (Table 5) is that in almost all Greek departments the number of published documents the last decade (P_{10}) is about half (44–54 %) of the total when no time limit is considered (P). In fact, the above ratio is almost 61 % in the case of Athens. In the same respect, citations of these documents (C_{s10}) correspond to less than 50 % of the total citations (C_s), while in some departments (e.g. Patras and Volos) the above ratio drops to 20 %, meaning that most citations which govern the hybrid indices refer to documents published before 2004. On the other hand, 64 % of the total documents in London are published after 2004, while citations of these papers are exactly half of the total ones.

Comparison in rank level

Last decade bibliometrics are also calculated for each rank and are presented in Table 4. The previously mentioned superiority of Athens regarding the recent research activity is also supported by the last decade bibliometrics calculated for each rank (Table 4). The research performance in Athens department is considerably higher the last decade for all ranks among the Greek departments. One variation is observed concerning the Associate Professors, where the hybrid indices ($h_{\text{aves-asso10}}$ and $g_{\text{aves-asso10}}$) among Athens,

Table 5 Percentage of total published documents and citations that correspond to last decade

	Athens		Thessaloniki		Patras		Xanthi		Volos		London	
	% P	*% C*	*% P*	*% C*	*% P*	*% C*	*% P*	*% C*	*% P*	*% C*	*% P*	*% C*
Lecturers	78.11	67.71	86.71	78.64	56.94	54.99	92.73	85.02	76.19	81.82		
Assistant Prof.	72.86	52.98	74.93	63.08	30.00	41.84	54.97	42.65	70.61	52.37		
Associate Prof.	59.80	37.80	61.81	42.30	51.44	34.95	65.97	59.80	65.63	44.55		
Professors	50.56	42.71	45.09	37.83	37.57	20.26	41.68	37.90	40.29	27.44	60.14	47.86
Department	60.84	42.68	53.76	35.16	43.77	22.28	52.48	50.42	51.36	19.93	64.25	48.87

% P is calculated as $(P_{10}/P) \times 100$

% C is calculated as $(C_{s10}/C_s) \times 100$

Thessaloniki, Patras and Xanthi are comparable, but this is of minor importance and cannot distort the total image of the recent research activity of Athens. In addition, it is also worth mentioning that Professors in London department display exceptional recent scientific work, since their indices are in some cases even double than the corresponding ones of Professors in Greek departments.

Examination of Table 5 can also shed light on the last decade scientific activity for the various ranks, taking into account the present rank of each researcher. It is obvious that both the number of published documents and their citations when they are calculated for the period 2004–2013 (P_{110} and $C_{s\text{-}110}$, respectively) constitute a significant percentage of the total ones (>75 %) in the case of Lecturers. Only in the Patras department this percentage is at the order of 55 % for both publications and citations. The above pattern is actually expected since for most Lecturers this period covers almost their entire, so far, academic career and, thus, small discrepancies can probably be attributed to research work conducted during their Ph.D. and/or Post-Doctoral projects. Of course, moving up to the academic hierarchy a different, but expected, trend is observed for all departments, where percentages gradually decrease. That means that for academics of higher rank, past activity (before 2004) is more intense and of higher gravity. Of course several variations exist, e.g. Associate Professors in Xanthi exhibit significantly higher percentage in both documents and citations than Assistant Professors, indicating their important research work the last decade.

Interesting are also the findings of the comparison between academics of the same rank for the various departments. Lecturers in Patras appear to have shared their activity between the last decade and the previous years, while in all other departments Lecturers have very high percentage of total activity belonging to the last 10 years. Similarly, Assistant Professors in Patras have only 30 % of their work published in the last 10 years, which could probably indicate that these academics are mainly engaged in teaching rather than conducting research. On the other hand, percentage of research work conducted the last decade by both Associate Professors and Professors is relatively high in all departments, indicating that academics of these ranks still remain scientifically dynamic.

Temporal evaluation of research productivity

Since the complete scientific records of all academics are available it would be of great importance to evaluate annual research productivity in the under-study departments the last fourteen (14) years. For this purpose, only the scientific profiles of, at present, Professors were considered, since it is more probable that they were at the same department during the last 14 years. Figure 4 illustrates the annual progress of the Professors' total number of published documents for the period 2000–2013. It must be noted that a similar trend is also observed if records of all academics in all ranks are taken into account.

The general trend witnessed is that research productivity continuously increased for most departments until 2007–2008 and then the number of published documents remained either constant or started to descend up to date. That means that the last 4–5 years the scientific productivity is in a predicament. Interesting is also the fact that the drop in research productivity during this period took place (and still does) with significantly high rate in London. It should also be noted that in Thessaloniki department this "critical" period initiated in 2010, about 2 years later than in all other departments, which could be attributed to the substantially large number of professors and the potentially numerous research projects under their supervision that might be in progress till then.

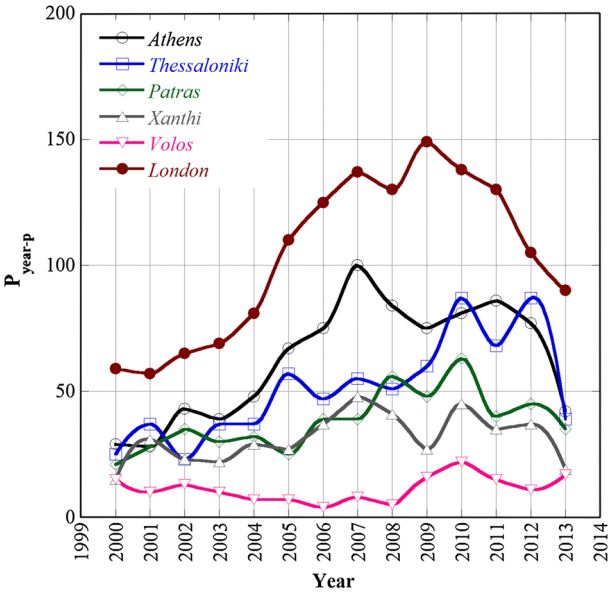

Fig. 4 Annual number of published documents by academics which presently are Professors for all civil engineering departments studied (Greek and London)

Discussion and conclusions

Bibliometrics are employed in the present work in order to evaluate the research quality and performance of academics which are hosted in the five Greek civil engineering departments, since they are regarded as the most useful evaluation tool in terms of robustness, validity, functionality, costs and time of execution (Abramo and D'Angelo 2011). Several indices and their combination were calculated to assess both the research profile and the current performance of all academics both in academic rank and department level.

When the complete scientific record of academics is taken into consideration, from the beginning of their professional career, results indicate that researchers in the Patras civil engineering department are more scientifically active through their career and thus of better quality. In this respect, Athens and Volos seem to share the second place in the ranking displaying comparable average indices in department level. Finally, bibliometrics of Thessaloniki's and Xanthi's academics which reflect their up to date research performance are virtually 50 % lower than the corresponding ones of the other Greek departments. One way analysis of variance of all departments' h_{aves} in conjunction with Tukey's HSD Post-hoc test was also performed which supported the above findings.

These findings indicate that the quality of academics that host an institution does not depend strongly on the age and the size of it. The above is in agreement with the findings of Slyder et al. (2011) who concluded that an author's institutional affiliation had no significant influence on citation rate, e.g. impact of published documents. However, one would expect that larger Universities may lead to higher individual citation rates and bibliometrics, since they provide greater opportunities for scientists to collaborate and work on similar topics (Zucker and Darby 1996), but this is also influenced by the research field and discipline area of the institution.

The "academic health" of each department was also explored calculating absolute and average bibliometric indices for the various ranks. In the majority of the departments there is no consistency regarding the research quality among the different ranks, since one should expect that academics of higher ranks have more improved and acknowledged scientific profile. In addition, considerably high heterogeneity among the indices of academics of the same rank are also observed in few cases along with several variations in the research quality of academics of the same rank among the various departments.

Mishra and Smyth (2013) underline that, although senior academics may not publish more articles in high-rank journals than their less senior colleagues, they still have greater impact when research productivity is measured in terms of *h*- and *g*-indices. Of course this is also a result of their role and contribution in the published research (Costas and Bordons 2011), since senior academics have a role of supervision and leadership of the research (Beveridge and Morris 2007). At the same time, it is widely accepted that the research productivity is the major criteria for hiring and promotion in Universities (e.g. Kasten 1984).

According to the above, it seems that there are no common established standards in the hiring and/or promotion policies in Greek Universities. Each department decides independently and arbitrarily about the criteria to be assessed in hirings and promotions of academics. Additionally, the high heterogeneity of the various ranks, indicative of the different scientific experience of individuals, especially of Lecturers, support the notion that these criteria are quite flexible, not fully established and do not constitute blind guidelines followed in all career advancement cases. The above is also enhanced by the fact that, besides what the average values implicitly point out, several extensive variations between academics of different ranks in individual level were also evident. According to the individual research profiles retrieved, both Lecturers with outstanding performance and Professors with merely a couple of published documents appeared in the Scopus database were found.

This trend can be attributed to several factors. As Lazaridis (2010) states the phenomenon of inbreeding, namely favoritism towards internal candidates in case on new hirings, is very acute in Greece and other European countries. In a similar way, Abramo et al. (2013) note that the international literature has dedicated much attention to the study of academic recruitment and promotion and one of the conclusions is that discriminatory phenomena seem to develop above all when evaluations are based on non-transparent criteria (e.g. Allen 1988). Many forms of favoritism (e.g. nepotism), which clearly distort faculty recruitment and career advancement, are evident and particularly in countries characterized by scarce intensity of competition among Universities (Abramo et al. 2013). Besides the above, another reason for the detected heterogeneity in the academic ranks of the Greek departments is that the research performance of individuals is not the only component evaluated during co-optation processes. Other factors are also considered and in some cases are of more gravity, such as the teaching and/or working experience, participation or supervision in research projects, supervision of theses (M.S. or Ph.D.), administrative skills, collaboration with Universities abroad etc.

In order to evaluate the research quality of academics serving the Greek civil engineering departments in European scale, bibliometrics have also been calculated for the most, Europeanly and globally, distinguished, at present, civil engineering department, the London's department of the Imperial College London. According to the indices, the superiority of the London department is evident, with its Professors displaying excellent research profiles compared to Greek Professors.

This difference between the research quality of the Greek and London faculty can partially be ascribed to the variance between the actual and the accessed record of Greek academics. Since this study is accomplished based on data retrieved by a scientific database of global acceptance, many documents published in local press or low-rank journals, especially Greek ones, have not been taken into account. A meticulous inspection of online available curriculum vitaes reveals that the overwhelming majority of academics in the Greek civil engineering departments have a considerable number of documents published in Greek journals or conferences. Additionally, Pantokratoras (2000) supports the concept that an academic should not only be involved in the fundamental research for the production of scientific knowledge, but also in the applied one oriented towards solving practical problems that will contribute to the development of the local community. It seems that the above concept is also adopted by many civil engineering academics, since numerous are also the studies published which are focused on seeking solutions in issues of applied nature many of them connected to the local community. Unfortunately, all the aforementioned publications are neglected in bibliometrics analyses as the present one and thus, the calculated indices appear lower than the actual ones.

Comparison of the real research being conducted in each department also took place, calculating bibliometric indices under a common time basis (last decade) for the scientific profile of all academics. Athens appears to be more active from a scientific point of view, with Patras and Volos following, while Thessaloniki and Xanthi exhibit the lowest values. The above finding complies with the recent ranking for civil engineering departments by QS World University Rankings, which are widely regarded as the preeminent guide to the relative quality of Universities from around the globe. According to this ranking, London has been ranked top in the world for Civil Engineering, while Athens holds the 25th place, with Patras and Thessaloniki following among the 51–100 rank.

With this method the effect of seniority is eliminated and it is revealed that in higher ranks the productivity rate decreases and past research work plays more determinant role in the formation of indices. This trend is in agreement with the findings of Mishra and Smyth (2013) who accentuate that senior academics tend to inherit a range of administrative and leadership functions in an academic department, which might reduce the available time for research.

Finally, the annual publication rate has also been calculated for the last 14 years, which sheds light on the temporal evolution of research wok in each department. In the period 2000–2008 an increase of productivity was observed in most departments (Greek and London), but then a period of steady or dwindling publication rate followed which spans up to date. According to Sachini et al. (2013), this trend seems to be representative of the research activity in all Greek higher education institutions. Sachini et al. (2013) found that during the period 1996–2009, Greek Universities presented an incredible increase in research productivity with rate considerable higher than the corresponding one in the other member countries of the European Union. However, this ascending course stopped in 2009, after which research activity in Greece declined. The main source of this peculiar trend seems to stems from the European economic crisis which onset in 2008.

European University Association published a report (EUA 2011) in which the effect of this economic crisis on the performance of Universities across Europe is highlighted. According to this report, European countries have been affected at different stages of the crisis, while in few countries Universities confronted the impact of the crisis as early as the beginning of 2009 while others were affected only later. In most cases the research in Universities relies on public funding means and even a minor change in this funding source may have huge impact. In Greece, Universities' academic and maintenance budgets are cut

by 30 %, while United Kingdom belongs to the category of major cuts to public funding of higher education, in which higher education will have to take up to a 40 % cut of its current budget (EUA 2011).

Even a small cut in a department's budget can trigger several chain reactions in the research performance. Less available funded Ph.D. or Post-Doctoral positions, insufficient or no maintenance of advanced instruments and equipment, financial inability to replenish consumable materials and/or to cover instruments' operating cost in general, constitute only few of the direct consequences of funding cut, especially in an engineering department, where research progresses conducting costly and energy consuming experiments. As a result, research performance declines and productivity drops.

At this point it should be mentioned that a similar pattern was also observed in Argentina due to the socio-economic crisis in 2001 (Miguel et al. 2010). According to Miguel et al. (2010) a percentage of 9 % mean annual growth in scientific output for the period 1991–2000 was observed, a situation which changed abruptly, since a sharp decline in the percentage of articles published in WoS and foreign journals is revealed from 2001 to 2005 and the international presence of Argentina declines.

Bibliometrics is a useful tool for quantification of research performance in Universities and as Lazaridis (2010) notes such rankings could spur healthy competition and provide a strong motive for meritocratic hiring practices. The findings of the present study should serve as the starting point for deep consideration and as the driving force for improvement in the research field of civil engineering and adoption of common standards for hiring and promotion of academics by all departments of the same discipline in Greece. It is a matter of future study whether such indices can also be regarded as implicit indicators of other structural parameters and/or operational policies.

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