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The changing role of museums in the global scientific landscape

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ABSTRACT

This paper presents the results of a combined study to the research performance of the Dutch Leiden-based National Museum of Natural History Naturalis, in the context of the global changing position of museums in the open scientific literature. In the Netherlands, the museums are stimulated to create a research portfolio, an initiative which has many consequences. One of the consequences is the assessment of the research conducted within the walls of the Dutch Museums. The study of Naturalis' research performance consists of two parts, one based on publications in the Web of Science (WoS) and one part of documents not covered as source material in the WoS, but cited in the WoS. The results of the present study for Naturalis are put in the context of the world-wide changing pattern of publication output of museums in the open scientific journal literature.

Keywords: Bibliometric analysis, Museums, non WoS citation impact analysis

INTRODUCTION

In the Netherlands, research is evaluated cyclic. A protocol initiated by Association of Universities VSNU, the national research council NWO and the Royal Academy of Sciences of the Netherlands KNAW, clearly describes the guidelines according to which research should be assessed. While the Dutch universities and research institutes financed by NWO and KNAW are confronted with the issue of the societal relevance of the research conducted through this standard evaluation protocol (SEP), we conversely notice that Dutch museums are confronted with the question of the scientific relevance of their collections and the research work based on these collections.

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Only a few attempts have been documented in which the role of a museum in a research context have been analyzed.[1,2] In this paper, we will describe the global situation of museums all over the world publishing in the open scientific journal literature as covered in the Web of Science (WoS), making break downs to the country of origin of the museum publications and the scientific domain the publishing belong to. Next to a focus on output numbers, we will show the impact scores related to the publications from museums all over the world. Next, we will show the results of the research assessment of the Leiden based National Museum of Natural History Naturalis. As a zero measurement, the research performance of the researchers attached to the museum was recently assessed. For this assessment study, we conducted an analysis that focused on both the WoS based publications of Naturalis, as well as the output published outside the realm of the WoS (e.g. journals not covered by WoS, books, book chapters, proceedings papers, etc.), but cited in the journals covered by the WoS.

In an ever changing landscape in the Netherlands, in which the role of typical research organizations such as universities are asked for their societal role and museums,

as typical representatives of the cultural sector in a country, are asked for their scientific role, an analysis of the global position of the museum is required, in order to understand where the Dutch museum sector stands on a world-wide scale.

DATA AND METHODOLOGY

The data used for the study were retrieved from the in-house version of the WoS at CWTS. The study only focused on articles, letters and reviews that appeared in journals processed at any moment for the WoS during the period 1981-2009. This bibliometric database of over 30 million publications contains unified and clean names of research organizations from all countries in the world. Next to clean names, a sector coding is added to the data, which makes it possible to conduct the analyses necessary for an analysis of museum output on a global scale. Based on algorithms and manual treatment of the data, this sector coding is added to the database. We collected all publications in the database that contained the sector coding M (useum) in the address set of our WoS database. It is important to note that the focus is not only on the main organizational level, but also on lower levels of aggregation. This is important as sometimes museums are part of an academic structure and publications appear in the journal literature under the main heading of the university rather than under the museum itself.

Next, data for the analysis of the museum Naturalis were supplied by Naturalis itself, in an Excel file, with tab-delimited bibliographic details and labels attached to it indicating the department within the museum from which the publication was originating. The three departments within Naturalis are Entomology (ENTO), Geology (GEO) and Zoology (ZOO). This input set covered the period 2001-2008. These publications were matched with the in-house WoS database, in order to make a distinction between WoS and non WoS covered publications.[3]

The indicators we present in the first part of the paper are the number of publications *P* and the field normalized impact indicator MNCS.[4] This analysis covers the period 1981-2009 and describes the research performance of all identified museums world-wide, across all countries. The publications are labeled with a main field coding used in the Dutch Observatory of Science and Technology,[5] which is based on aggregates of Journal Subject Categories used in the WoS (every JSC is attributed to only one main field, while the attribution of JSC's themselves is not limited to one journal).

The second part of the paper contains somewhat more indicators, as we also include absolute numbers of citations (C), means citations scores (citation per publication [CPP]**)**, percentages of self-citations **(**%SC) and publications not cited (%Pnc) when we conduct the WoS-based analysis, as not all indicators are applicable in the non WoS-based analysis, we are limited to P, C, CPP and compare these with the WoS-based results. As the study conducted for museum Naturalis was still under the previous set of indicators applied by CWTS, we here used the CPP/JCSm, which is the comparison of the actual impact of a set of publications with the journal average expected value of the journals in which the publications appeared, the CPP/FCSm stands for the field normalized impact of a set, in which the actual impact is compared to the expected field impact scores and finally JCSm/FCSm is the indicator describing the impact position of the set of journals chosen for publications, compared to the field (s) to which the journals belong. In all normalized impact indicators, the value of one is the world average impact level.

RESULTS ON A GLOBAL LEVEL

The analysis necessarily starts with a focus on the total output of the set of publications from museums world-wide. In total, this set covers 84.014 papers in the period 1981-2009, of which 68.570 are articles, letters, or reviews). A breakdown of output per year is presented in Figure 1.

The output development of the sector shows two remarkable points of change, a first one from 1996 to 1997 and a second one in 2000-2002. As the WoS has been subject to serious changes in coverage, the first point might be influenced by such a database artefact, whereas the second is not. Furthermore, the output development round 2003-2005 is also due to a database coverage effect.

Table 1 presents the national numbers of publications from the museum sector of the top-25 most producing countries. Please note that the last period is covering only 4 years of publications. When we put this into a perspective of growth in time, by taking the period 1981-1985 as the basis/index period, we can express the periodical relative growth of the museum output in these countries. Countries in which the output of the museum sector is relatively

large are the US, France and Great Britain. Particularly the position here of France is remarkable, as France does not have such a high ranking position when it comes to the overall national output in a global context. Another remarkable fact is the absence of China in the top of this list, while this country has now grown to one of the most scientific output producing countries in the world. Finally, South Africa takes a remarkable 10th position in the world ranking with its museum output.

Table 1: Output across countries from museums, 1981 to 2009 (ranked by descending number of publications, please note that the last period covers 4 years only)

Country	81-85	86-90	91-95	96-00	01-05	06-09
USA	2586	2638	2944	2772	3713	3695
France	1341	1381	1631	1983	2241	2246
Great Britain	1266	1367	1449	1825	2318	2530
Australia	316	417	436	525	937	1137
Canada	373	485	652	620	611	606
Germany	417	430	349	493	673	950
Japan	106	102	221	391	704	821
Sweden	160	190	260	355	557	639
Netherlands	185	208	234	246	334	519
South Africa	101	207	306	326	250	254
Switzerland	173	190	168	218	291	336
Argentina	22	61	106	187	354	475
Hungary	133	92	122	129	143	263
Kenya	52	123	134	162	183	174
Austria	40	63	88	109	185	240
Denmark	73	79	107	120	145	181
Belgium	22	33	64	110	181	203
New Zealand	82	92	67	109	119	127
Norway	134	101	94	69	81	49
Taiwan	5	6	18	82	189	205
Spain	15	63	113	95	94	119
Czech Republic	86	56	52	70	128	280
Peoples Republic China	67	21	27	59	65	206
Italy	6	12	9	69	103	107
Russia	30	41	44	83	73	56

In Table 2a, the relative growth for the 10 largest producing countries when it comes to museum output is displayed. Please note that the last period can show a somewhat lower relative growth compared to the previous period, but this is due to the missing year 2010. Within the top-10, the largest growth is observed for Japan, followed by Sweden and Australia.

In Table 2b, the countries from the museum sector produced the largest growing output are displayed. The countries with the relatively largest growing museum output are Taiwan, Argentina and Italy (with growth rates that are 10 times or more the start volume). From the top largest in volume, we find again Japan, Sweden and Australia, which means that these countries not only produced many papers, but also in a very strong pace.

Table 3 presents the scores across seven main fields of science, of which Multidisciplinary journals consists of the JSC of the same name in the WOS system, a field in which Nature, Science and *P* NAS of the USA play a dominant role. The exact composition of the fields can be found on the NOWT website (see www.nowt.nl). Among the seven fields, we observe a strong increase in output numbers for two fields: Medical and Life Sciences and Natural Sciences.

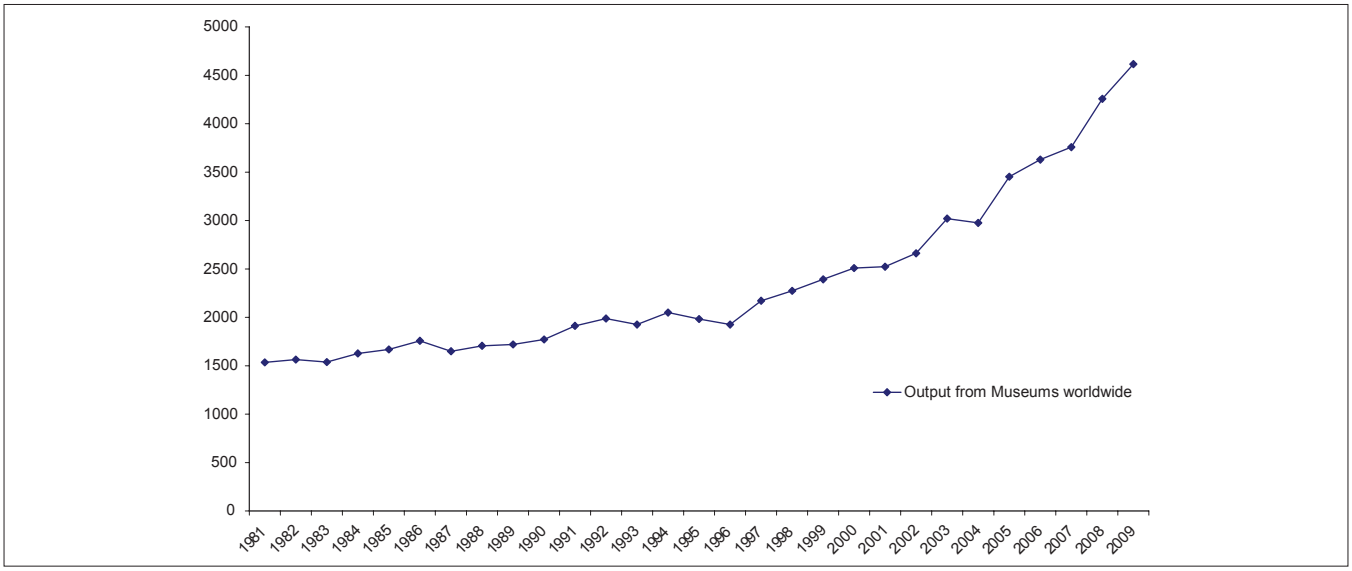

Figure 1: Output of museums worldwide, 1981-2009

Table 2a: Indexed output from museums across the top-10 countries, 1981-2009 (ranked by descending number of publications, `81-`85=100)

Country	81-85	86-90	91-95	96-00	01-05	06-09
USA	100	102	114	107	144	143
France	100	103	122	148	167	167
Great Britain	100	108	114	144	183	200
Australia	100	132	138	166	297	360
Canada	100	130	175	166	164	162
Germany	100	103	84	118	161	228
Japan	100	96	208	369	664	775
Sweden	100	119	163	222	348	399
Netherlands	100	112	126	133	181	281
South Africa	100	205	303	323	248	251

Table 2b: Indexed output from museums across the top-10 most strongly growing countries, 1981-2009 (ranked by strongest growth, `81-`85=100)

Country	81-85	86-90	91-95	96-00	01-05	06-09
Taiwan	100	120	360	1640	3780	4100
Argentina	100	277	482	850	1609	2159
Italy	100	200	150	1150	1717	1783
Belgium	100	150	291	500	823	923
Spain	100	420	753	633	627	793
Japan	100	96	208	369	664	775
Austria	100	158	220	273	463	600
Sweden	100	119	163	222	348	399
Australia	100	132	138	166	297	360
Kenya	100	237	258	312	352	335

Table 3: Distribution of output from museums across main fields of science, 1981-2009 (ranked by largest output)

Main field	81-85	86-90	91-95	96-00	01-05	06-09
Medical and Life Sciences	3891	4606	5110	5812	7978	9321
Natural Sciences	1806	2022	2738	3795	5776	6549
Law, Arts and Humanities	1641	1522	1720	1673	1374	1213
Multidisciplinary Journals	577	629	598	510	493	482
Social and Behavioral Sciences	411	334	381	409	413	483
Engineering Sciences	67	110	85	108	99	118
Language, Information and Communication	124	101	78	76	53	56
Medical and Life Sciences	100	118	131	149	205	240
Natural Sciences	100	112	152	210	320	363
Law, Arts and Humanities	100	93	105	102	84	74
Multidisciplinary Journals	100	109	104	88	85	84
Social and Behavioral Sciences	100	81	93	100	100	118
Engineering Sciences	100	164	127	161	148	176
Language, Information and Communication	100	81	63	61	43	45

In these two fields, on average 2000-1500 publications/year appear respectively from the museum sector in the last periods of the analysis. Given the large quantity of publications involved and the strong increase over time in these two fields, we can conclude that these two fields strongly dominate the global visibility of the museum sector among the world-wide journal literature.

The impact scores presented here in Figure 2 cover the field normalized impact score over a 5 year time frame of output and 6 years of citations impact. We selected those periods that coincided with blocks of publications years. When we observe the development of the impact of the museum publications, we can clearly see the taking off of the impact from the period 1991 to 1995 onwards, with a small drop in impact in 2001-2005, followed by a next increase in the last period of the analysis, until the last period, when the impact increases toward a level above world-wide average impact level.

In Table 4a, the periodical development of the 10 countries with the largest museum sector output are displayed, both the impact scores as the relative change. The fact that France and Germany are somewhat behind in impact scores is due to the language effect, an effect that influences the overall impact of a land, as well as that of organizations.[6,7] France and Japan are the only two countries for which we observe a more or less continuous increase of the impact over time.

Table 4b displays the impact scores of the countries which show the fastest growth rates in the output of museums. As the data clearly show, most of these countries started in the early 1980's with low to very low impact scores in relation to this particular part of the national output. As the starting output for the three top ranking countries (Taiwan, Argentina and Italy) was very small, the impact scores and its' development over time show some strong fluctuations for these countries. Furthermore, also for Kenya we observe a particular development, namely of a drop in impact, after an initial very high impact score in the early 1980's. However, overall we notice a strong increase of the impact of these 10 countries, which becomes particularly important in the context of their strong increase in output.

Table 5 shows the impact scores per main field in the museum sector. Only Law, Arts and Humanities and Social and Behavioral Sciences start with a somewhat higher impact position in the early 1980's, all other fields have lower impact scores. We notice a strong increase of the most fields over time when it comes to publications

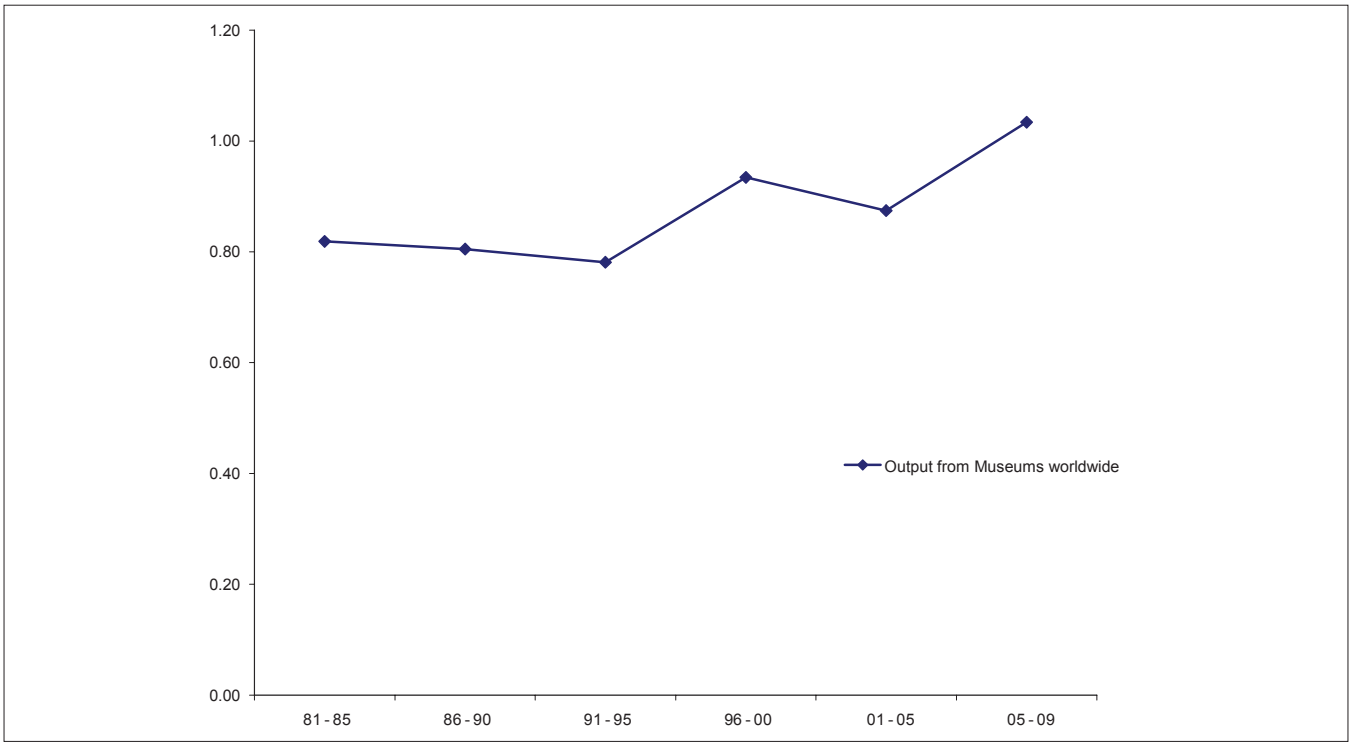

Figure 2: Impact development of output of museums worldwide, 1981-2009

Table 4a: Impact scores related to output from museums across countries, 1981-2009 (ranked by largest output)

	81-85	86-90	91-95	96-00	01-05	05-09
USA	1.04	0.90	0.88	1.18	1.06	1.26
France	0.43	0.54	0.66	0.64	0.79	0.94
Great Britain	0.87	1.01	0.97	1.23	1.03	1.29
Australia	0.65	0.89	0.58	1.02	0.80	0.95
Canada	0.67	0.90	0.72	1.17	1.06	0.99
Germany	0.74	0.54	0.49	0.74	0.67	1.03
Japan	0.29	0.43	0.63	0.57	0.70	0.76
Sweden	0.86	0.91	1.35	1.43	1.17	1.24
Netherlands	0.66	1.04	1.53	1.15	0.81	0.91
South Africa	0.98	0.69	0.46	0.65	0.85	0.93
USA	100	86	84	113	102	121
France	100	124	153	147	182	218
Great Britain	100	116	111	141	118	148
Australia	100	137	90	157	123	147
Canada	100	133	108	174	158	147
Germany	100	73	67	100	90	138
Japan	100	148	219	197	243	262
Sweden	100	106	157	166	136	145
Netherlands	100	157	231	173	123	138
South Africa	100	70	47	66	87	94

Table 4b: Impact scores related to output from museums across countries, 1981-2009 (ranked by fastest growth)

	81-85	86-90	91-95	96-00	01-05	05-09
Taiwan	0.12	0.00	1.62	0.16	0.40	0.52
Argentina	0.25	0.85	0.35	0.34	0.40	0.66
Italy	0.14	1.16	0.19	1.08	1.14	0.93
Belgium	0.68	0.20	0.73	0.85	0.61	1.05
Spain	0.70	0.30	0.39	0.55	0.65	1.49
Japan	0.29	0.43	0.63	0.57	0.70	0.76
Austria	0.73	2.25	0.18	0.41	0.58	0.79
Sweden	0.86	0.91	1.35	1.43	1.17	1.24
Australia	0.65	0.89	0.58	1.02	0.80	0.95
Kenya	1.66	1.30	0.98	1.36	0.88	0.96
Taiwan	100	0	1371	131	335	439
Argentina	100	336	139	134	160	264
Italy	100	808	131	752	795	652
Belgium	100	30	107	125	90	155
Spain	100	43	56	79	93	214
Japan	100	148	219	197	243	262
Austria	100	310	24	57	79	109
Sweden	100	106	157	166	136	145
Australia	100	137	90	157	123	147
Kenya	100	78	59	82	53	58

from the museum sector on this scale. Overall, Language, Information and Communication remains globally on a low impact score, with the only exception the output in this field in the period 1986-1990.

RESULTS ON THE MUSEUM LEVEL

In Table 6, the results of the data collection and the linking with the in-house WoS-version are displayed.

Some 20% of the total output in the period 2001-2008 is covered by the WoS, consequently 80% is not. Of the departments of Naturalis, two of them have percentages somewhat smaller than 80% covered non-WoS output (GEO and ZOO), while the department ENTO has a somewhat larger non WoS part of the total output (nearly 90%).

Table 5: Impact scores from museums across main fields of science, 1981-2009 (ranked by largest output)

	81-85	86-90	91-95	96-00	01-05	05-09
Medical and Life Sciences	0.74	0.68	0.70	0.83	0.73	0.96
Natural Sciences	0.87	1.00	0.96	1.05	1.00	1.12
Law, Arts and Humanities	1.19	1.17	0.89	1.18	1.15	1.30
Multidisciplinary Journals	0.50	0.40	0.47	0.67	1.28	1.29
Social and Behavioral Sciences	1.06	1.28	1.10	1.37	1.18	1.52
Engineering Sciences	0.71	0.79	1.01	0.82	0.80	1.24
Language, Information and Communication	0.72	0.95	0.46	0.36	0.31	0.76
Medical and Life Sciences	100	92	95	113	99	129
Natural Sciences	100	115	110	120	115	129
Law, Arts and Humanities	100	99	75	99	97	110
Multidisciplinary Journals	100	79	93	133	254	257
Social and Behavioral Sciences	100	121	104	130	112	144
Engineering Sciences	100	111	142	115	112	174
Language, Information and communication	100	132	63	50	43	106

Table 6: Distribution over WoS/non-WoS parts of the Naturalis output 2001-2008

Naturalis	*P*	Non-WoS	WoS
	1829	1474	355
ENTO	485	434	51
GEO	651	505	146
ZOO	693	529	164

WoS=Web of science, ENTO=Entomology, GEO=Geology, ZOO=Zoology

Table 7: Numbers of citations received by naturalis non-WoS covered papers 2001-2008

Naturalis	*P*	*P* non-WoS	*P* cited	C+SC	SC
	1829	1474	266	900	149
ENTO	485	434	80	179	28
GEO	651	505	99	257	78
ZOO	693	529	87	464	43

WoS=Web of science, ENTO=Entomology, GEO=Geology, ZOO=Zoology, SC=Self citations, C=Citations

In Table 7, the impact of the non WoS covered part of the output is displayed. We calculated the numbers of citations received and the actual number of publications that were cited. We discuss the situation for Naturalis overall. The total number of 1474 non WoS publications were not all cited in the WoS journal literature. Only 266 were actually cited, receiving in total 900 citations, of which 149 were SC. Some 18% of all non WoS publications get cited in the WoS-covered journal literature (thus 82% does not get cited in WoS-covered journal literature), which is lower compared to the percentage cited WoS-covered journal publications [51%, Table 8]. This is a strong indication of the difference in communication practices in the field of research in which Naturalis is active, as one type of output is hardly cited in the other type of scientific communication.

In Table 8, the standard indicators for the WoS covered output are displayed. Again, we discuss the overall scores for Naturalis first. In total Naturalis produced 355 journal papers in WoS covered journals in the period 2001-2008. These were cited 1.837 times, including SC. On average, Naturalis papers get cited 5.17 times, after correction for SC this is 3.79 times on average. Compared to the journal average, this impact is 0.92, which is slightly below journal average impact level. The comparison with the fields in which Naturalis papers were published is somewhat lower, with a CPP/FCSm value of 0.84. The papers were, overall, published in journals with a somewhat low impact score compared to the field average impact level (with JCSm/FCSm value of 0.91). Finally, the percentage papers not cited in the time frame 2001-2008 is 49% and the percentage SC is 27%. The former percentage is somewhat high, while the latter percentage is within a range we often find in this type of studies (as a rule of thumb, 20-40% SC is considered as a "normal" level).

Table 8: Bibliometric statistics for Naturalis WoS papers, 2001-2008

	P	C+SC	CPP+SC	CPP	% Pnc	CPP/JCSm	CPP/FCSm	JCSm/FCSm	% SC
2001-2008	355	1,837	5.17	3.79	49	0.92	0.84	0.91	27
2001-2004	116	212	1.83	1.29	64	0.79	0.66	0.86	29
2002-2005	131	215	1.64	1.05	64	0.92	0.72	0.82	36
2003-2006	159	375	2.36	1.48	58	0.86	0.79	0.93	37
2004-2007	200	539	2.7	1.76	60	0.84	0.84	0.99	35
2005-2008	239	670	2.8	2.04	61	1.16	0.99	0.87	27

SC=Self citations, CPP=Citations per publication, Pnc=Publications not cited, C=Citations

The description of the trend of the output and impact scores for Naturalis based on WoS covered publications is made below. As Table 8 clearly shows, we notice a strong increase in both the numbers of published journal publications (more than doubled) and even triple times as much citations received.

In Figure 3, the normalized impact scores CPP/JCSm, CPP/FCSm and JCSm/FCSm are displayed. It becomes clear that the trend observed in Table 8, leading to higher CP*P* values, has a result when we compare the Naturalis impact with international journal and field standard values. We notice a strong increase of the impact level, particularly for CPP/FCSm, while CPP/JCSm shows somewhat stronger fluctuations. However, the impact level of the journals in which the output was published shows a decrease in the last period of the trend analysis (2005-2008), ending somewhat below the field average impact level.

So the overall conclusion must be that the situation for Naturalis is changing rapidly, as the output in WoS covered journals increases sharply, followed a stronger increase in the impact. Consequently, the normalized impact scores are changing, in a positive direction. Care must be taken with respect to the choice of journals.

Table 9 shows the comparison between the numbers of citations received by WoS and non WoS covered publications. We will again discuss the overall Naturalis results. Of the total 1829 publications, 1474 were considered as non WoS output. Of this set of publications not all publications were cited, only 266 were cited. If we calculate the mean citation rate of non WoS covered publications of Naturalis, using only the cited publications, we would come up with a score of 2.82. However, if we would apply a similar approach as we apply in the WoS covered part of the output, we should base the calculation of the mean citation rate on all available publications (that is, all non WoS publications). Then the mean citation rate would drop to only 0.51/paper. The WoS covered output is cited 3.79 times on average, thereby taking into account also the Pnc.

In Table 10, the overall impact scores for Naturalis departments are presented, based on their WoS covered output. As the numbers are relatively for one department,

Table 9: Numbers of citations received by Naturalis non-WoS and WoS covered publications, 2001-2008

	P	Non-Wos		CPP (*P* cited)	CPP (All *P*)	WoS	CPP
		P	*P* cited			*P*	
Naturalis	1829	1474	266	2.82	0.51	355	3.79
ENTO	485	434	80	1.89	0.35	51	4.33
GEO	651	505	99	1.81	0.35	146	3.65
ZOO	693	529	87	4.84	0.80	164	3.67

WoS=Web of science, ENTO=Entomology, GEO=Geology, ZOO=Zoology, SC=Self citations, CPP=Citations per publication

Table 10: Bibliometric statistics for Naturalis departments, 2001-2008

	P	C+SC	CPP+sc	CPP	% Pnc	CPP/ JCSm	CPP/ FCSm	JCSm/ FCSm	% SC
ENTO	51	263	5.16	4.33	59	0.92	0.94	1.02	16
GEO	146	729	4.99	3.65	51	0.85	0.83	0.98	27
ZOO	164	879	5.36	3.67	45	1	0.82	0.82	32

WoS=Web of science, ENTO=Entomology, GEO=Geology, ZOO=Zoology, SC=Self citations, CPP=Citations per publication, Pnc=Publications not cited, C=Citations

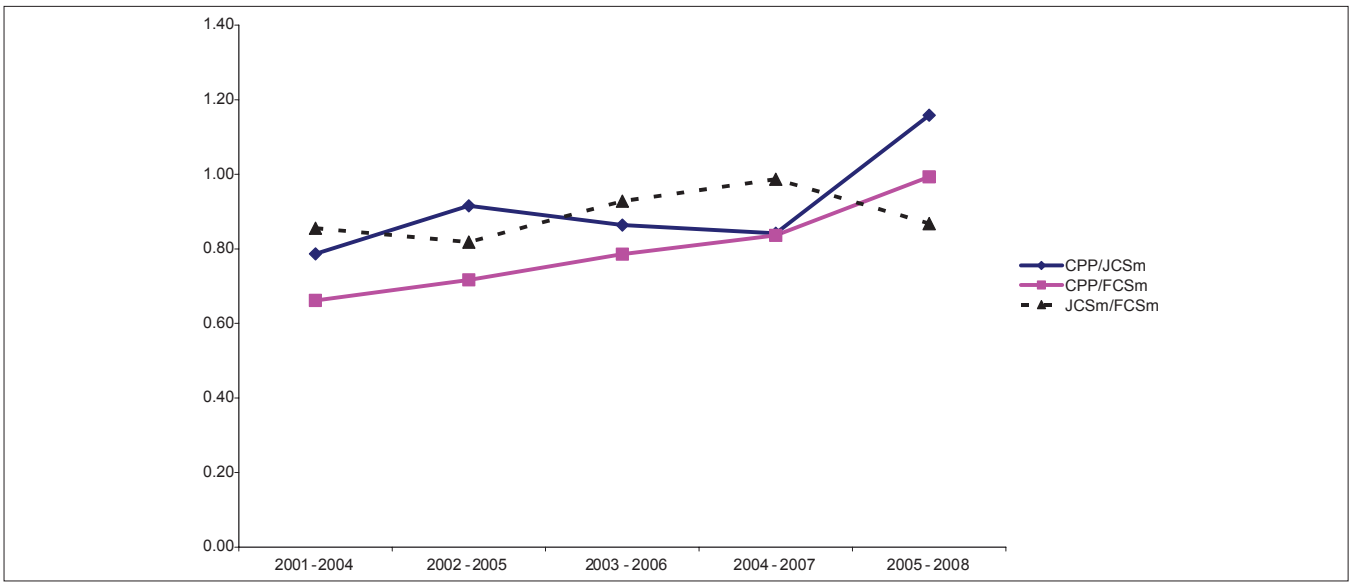

Figure 3: Normalized impact scores for Naturalis output, 2001-2008

we only present the overall output and impact scores for the whole period 2001-2008. Here it becomes clear that no large differences exist between the three departments, although ENTO performs somewhat closer to the world-wide average impact level. Remarkable is the large share of the output (roughly 50%) that is not cited within the timeframe of 2001-2008. Finally, two departments publish their findings in journals of average impact in the field to which the journals belong (ENTO and GEO), while ZOO publishes their findings in journals with a somewhat lower impact position in the field(s).

CONCLUSION AND DISCUSSION

In this study, we have analyzed the changing role and position of museums all over the world in the global science system, as can be measured by the journal literature as processed in the WoS. While museums have a clear cultural function, in which safe guarding their collection plays a dominant role, in close connection to bringing the information related to that collection to the general public, the educational function of a museum, we now observe a third function of the museums. The study has clearly shown that museums all over the world take a more prominent position when it comes to scientific research and more important, publishing about the results in the open scientific journal literature as processed in the WoS. Of course we realize that we are probably looking at the tip of the iceberg, as the second part of the study on the research output of the Leiden based museum Naturalis showed, namely a very strong focus on the scientific communication channels that are not covered by the WoS.

The first part of the study indicated that the museums (as can be identified from the address bylines of the journal publications processed for the WoS) show a strong increase in activity. In a period of nearly 30 years, the annual output of museums increased from roughly 1500 publications/year to 4500 publications/year. This is significantly different compared to the total increase of the volume of publications processed for the WoS, as this volume just doubled over the period 1981-2009. The analysis at country level shows some remarkable findings. A first fact is the position France takes, which is a very prominent position when it comes to publications from the museum sector, as the country ranks second after the USA. Other countries with a remarkable large output from museums are Australia, Sweden, the Netherlands and South Africa. When it comes to increasing output numbers, some smaller countries display a very strong increase of the museum output. Among the most active countries, impact scores increase, while the impact scores of the fast growing countries when it comes to museum publications show some more variations in impact levels. Most publications from the museum sector are published in Medical and Life Sciences and the Natural Sciences, two fields that also show increasing impact levels. The third largest field in the museum output is Law, Arts and Humanities, a field in which we often encounter relative low impact levels when we conduct macro level bibliometric studies. Remarkably, when it comes to the museum output, the impact levels are showing some fluctuation, but are considered to be high in some periods.

The study for Naturalis has showed some very important elements for the analysis of museum output. As museums tend to have a local orientation and the focus on international journal literature is a relatively new phenomenon, at least in the Netherlands and to the degree of international orientation observed in the study. The analysis for Naturalis was designed as such that the publication output that could contain the more collection oriented publications was included as well. This output, indicated as the non WoS output, was analyzed on its' citation impact and compared to the WoS covered publications from the museum. An important drawback here is of course the possibility to apply proper document type and field normalization, as this information is simply not available within the realm of non WoS impact analyses on this scale.

As one notes some analogy to the humanities and most of the social sciences when overlooking the publications output of a museum such as Naturalis, it becomes clear that the application if bibliometric techniques could not only focus on the tool box that works perfectly in the natural, life and medical sciences, but should be extended when it comes to measuring the research performance of the scientists in the museum. For this reason, the non WoS analysis was conducted, but here we also have to note that this approach only partially solves the problems, as indicated above. Therefore, bibliometricians have to keep on trying to improve the bibliometric techniques, in order to create bibliometric tools that fit the specific behavior of the researchers under study in an adequate manner.

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REFERENCES

1. Jokic M. Scientometric evaluation of the projects in biology funded by the Ministry of Science and Technology, Republic of Croatia, in the 1991-1996 period. Periodicum Biologorum 2000;102:129-42.
2. Potts J. Recent developments at the National Maritime Museum, UK, and their potential for capacity building. Marine Policy 2000;24:79-81.
3. Visser MS, Moed HF. How important are conference papers for measuring research performance in Computer Science? Book of Abstract of the 9th International Conference on Science and Technology Indicators, Leuven Belgium; 2006.
4. Waltman L, Van Eck NJ, Van Leeuwen TN, Visser MS, Van Raan AF. Towards a new crown indicator: Some theoretical considerations. J Informetr 2010;5:37-47.
5. Tijsen RJ, Nederhof AJ, van Leeuwen TH, Hollanders H, Kanerva M, van den Berg P. Nederlands Observatorium van Wetenschap en Technologie (NOWT), 2010. p. 170-71. Available from: http://www.nowt.nl/docs/NOWT-WTI_2010.pdf. [Last accessed on 2014 Jan 28]
6. van Leeuwen TH, Moed HF, Tijssen RJ, Visser MS, van Raan AF. Language biases in the coverage of the science citation index and its consequences for international comparisons of national research performance. Scientometrics 2001;51:335-46.
7. van Raan T, van Leeuwen T, Visser M. Non-English papers decrease rankings. Nature 2011;469:34.

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