Evaluation of Strategic Research Programs: The Case of Danish Environmental Research 1993-2002

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Abstract
The paper reports the mid-term and final informetric evaluations of the Danish Strategic Environmental Research Program (named SMP). SMP consisted of nine virtual research centres during the period 1993-97. Citations are measured 1993-2002. Central indicators are: Centre Impact Factor (CIF) that sums up number of citations received by each centre's SCI-articles; centre Journal Impact Factor (JIF), which is a diachronic IF per journal volume publishing a centre article. Citation and publication data are obtained from the Dialog online version of SCI. Other indicators are the Danish and world domain impact in subject areas selected by the centres from the National Science Indicators.
Top-ranked journal volumes used in SMP in terms of JIF scores were correlated with the corresponding articles' citation values. At the mid-term assessment the Pearson coefficient showed a strong correlation, which disappeared at the final evaluation. The publication behaviour varied substantially between centres. Although SMP as program did not make a strategic difference, measured as a CIF-score 10 % higher than all other indicator values and in particular the Danish domain impact, four centres clearly did. USA was the most knowledge importing country. In wider perspective two-step evaluations of, in particular, cost-heavy strategic programmes have important implications for the continuation, volume and direction of research funding and activities.

Introduction

The contribution reports on the final informetric evaluation carried out 2003 of the Danish Strategic Environmental Research Program (named SMP) that consisted of nine virtual research centres 1993-1997. The motivation behind this report is threefold. First, a mid-term evaluation, made 1999 and covering the publications 1993-95 as well as citations 1993-1998, resulted in assumptions concerning the centres' publication strategies. When researchers published in top-impact journals, their articles also received many citations (Ingwersen et al., 2000). This might be turned into a fruitful publication strategy for future research in the area. The correlation between journal volume impact and the impact of the corresponding articles published in the volumes was then assessed in the final evaluation. Since two-step assessments of entire research programs are rarely done, such mid-term strategic assumptions are seldom tested empirically. Secondly, we wanted to observe whether SMP made a (strategic) difference to the rest of the Danish environmental field and the corresponding world research during the same period. Third: In wider perspective two-step evaluations of so-called strategic research programmes are important to carry out, since they have implications for the continuation, volume and direction of research funding and activities in the particular field. Such programmes may heavily influence the research output from the rest of the research community(ies) concerned over a larger period of time.

SMP attracted approximately 95 million € (700 million DKK) of public funds over the 5 year period (Fisker, 2004). 600 Danish and international researchers participated on an interdisciplinary basis from a range of institutions, connected by Internet communications. Originally SMP consisted of 16 objectives distributed over 13 centres, including humanistic ones. For this reason, only nine centres could be analyzed fairly for citations. They are, with objectives in ( ):

1. Air Pollution Processes & Models (Atmosphere & air pollution)
2. Terrestrial Ecosystem Research (Atmosphere & air pollution)
3. The Groundwater Group (Groundwater; pesticides in groundwater)
4. Agricultural Biodiversity (Soil surface)
5. Root Zone Processes (Soil surface)
6. Freshwater Environmental Research (Freshwater and marine areas)

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7. Strategic Environmental Research in Marine Areas (Freshwater and marine areas)
8. Danish Centre for Eco-toxicological Research (Environmentally hazardous substances in the aquatic and terrestrial ecosystems)
9. Centre for Biochemical and Occupational Epidemiology (Human health)

A few other citation analyses of interdisciplinary environmental research have been done, for instance recently on forestry research (Steele & Stier, 2000). Evaluations, including mid-term assessments, are not common. The SMP programme is also interesting owing to its mixture of hard science fields with medical and more social science-related disciplines.

The contribution is organized as follows. The data collection and analysis methods, including the applied indicators, are briefly described. This is followed by the overall results from the mid-term and final evaluations across the nine centres. Indicator results are compared to the Danish and world indicator measures, respectively. The original correlation coefficients (Pearson) from the mid-term assessments are compared to the final ones, and the implications of the central results for the strategic program, and evaluation methods in wider perspective, are discussed in the ensuing section.

Data Collection and Analysis Methods

Data were collected from two sources: the online version of Science Citation Index (SCI) hosted by Thomson-Dialog and National Science Indicators (NSI), constructed by ISI, 2001. Each centre provided a list of research publications. For the mid-term evaluation the lists covered the period 1993-95. Similarly, the centres provided a supplementary list for the final evaluation covering 1996-97. Hence, at the time of the mid-term evaluation in 1998/99 the entire volume of research output was actually known – but became not fully explored prior to the final evaluation. The entries of the lists were all searched online in SCI to establish whether the applied journal was indexed by SCI or not. The non-SCI journals tend to be broader practice-related international journals or magazines in Danish. If indexed, then the entry was verified and journal names were checked against the SCI journal name index, in order to conform the journal data across all centres and time periods. 434 internationally published journal articles constitute the total data population at the final evaluation, with 344 indexed by SCI (79 %). At the mid-term assessment the number of publications was 201 and 151 (75 %), respectively.

The number of citations received up to a given year (1998 and 2002, respectively) was retrieved online for each article, whether being originally indexed in SCI or not, *and* from each corresponding journal publication year. In that way, we are able to calculate the diachronous journal impact factor (JIF) (Egghe & Rousseau, 1990) online (Christensen & Ingwersen, 1996) for each time a journal was used by a centre. This type of JIF is a fair and *realistic* impact factor, in contrast to the much-criticized synchronous JIF produced annually by ISI (Seglen, 1997), because the diachronous JIF can be compared directly to the real impact of the research articles.

When summed up for each centre, and for SMP as such, the number of citations received by the SCI-articles constitutes one primary indicator: the *Centre Impact Factor* (*CIF*). Similarly, the corresponding sum of JIFs per centre and SMP as a program establishes another primary indicator – the *centre JIF*. An overall CIF indicator (*CIF**) corresponds to the total of citations found in SCI to *all* centre publications.

The Danish and the world citation impacts per centre, based on the scientific fields for each centre, constitute secondary indicators. They are calculated by the application of NSI, and are comparable to the CIF and centre JIF covering the same time windows. Each centre had previously pointed out the relevant NSI subject fields from Current Contents that corresponded to their research area. For SMP as a program all the NSI categories applied to all the nine centres were summed up. This means that the Danish and world citation impacts are calculated in terms of *weighted* subject profiles (van Raan, 1999). They mirror the distribution of NSI categories over SMP as a program, defined by its centres. One may say that they act as a kind of '*shadow*' SMP program. For instance, the category 'Environment/ecology' appears 8 times and 'Biochemistry & biophysics' three times, etc., in the final SMP profile. Since data was not available covering the entire period, NSI data covering 1991-2000 was used to simulate the actual period, 1993-2002. The assumption is that trends in Danish and world impact and volume are similar within such a short time shift.

The Pearson correlation coefficient was applied to the top-25 (mid-term) and top-40 SCI-journal volumes (final evaluation), i.e., the diachronic JIF for each volume was paired to the number of citations received by the corresponding article published in that volume. We applied Pearson although the distribution of citations over journals and articles is not a normal distribution.

Finally, also as secondary indicators we observe the patterns of *knowledge export* by means of listing by frequency a) the citing countries and b) the subject categories in the journals that cite a centre. Identical sets of indicators are applied to the two evaluations for comparative reasons.

Major Results of the Analyses

First, we report the results concerned with publication activities and citation impact comparisons. This is followed by the major findings concerned with knowledge export over the entire time window of SMP. Finally, we discuss the article-top-journal impact correlation results, both with respect to the mid-term and the final evaluation.

Publication Activity

The SMP research publication activity in terms of the 344 SCI indexed articles is displayed in Table 1. The number of articles doubles from 1993-1994 and re-doubles from 1994-1996. It triples from 1993-1995. In comparison the entire Danish production in Environmental-ecological research raises from 149 to 256 articles, Table 1. This seems to indicate that the environmental research community remaining outside SMP does *not* keep up a steady line of productivity towards the end of the observed period. SMP seems increasingly dominant on the Danish scene. In 1993/94 SMP constitutes approx. 20 % of all Danish environmental output, but covers approx. 33 % in 1995/96, increasing to approx. 40 % in 1997.

Table 1. SCI-indexed articles published by all centres combined in the SMP program and Danish environmental research (Sources: the centres & NSI, 2001)

Publication Year	No. of SCI-articles	Proportion in %	Danish SCI-articles
1993	24	7	149
1994	48	14	222
1995	79	23	231
1996	93	27	269
1997	100	29	256
Total	344	100	1127

The proportion of SCI-articles vs. all articles from SMP as program was quite stable over the period, but with some variation between the centres. For instance, the Groundwater centre published only 20 SCI-articles out of a total of 35 (57 %) whilst the Freshwater centre produced 36 SCI-articles out of 42 (86 %). The difference between the two kinds of articles essentially mirrors quite different approaches to research publication behaviour among the SMP centres. One of the reasons for the final result of the CIF vs. centre JIF impact scores per centre, Figure 1, probably derives from this dissimilarity in publication behaviour.

Citation Impact Analyses

The final evaluation per centre and for SMP as a program in terms of the primary indicators is displayed in Table 2. It concerns alone the SCI-articles and journals. In addition, the table demonstrates the Danish and world impact during the same period, as well as the total centre impact (CIF*), for reasons of comparison.

One should note that the average SMP 'Domain DK' and 'Domain W' indicators – in their (more unfair) *un-weighted versions* – would have been 17.49 and 14.93 citations per SCI-publication respectively. The Danish domain impact would hence increase with almost one citation, and pass the mean SMP *CIF*, while the world impact would decrease slightly[1]. Further, 329 of the 344 SCI-articles

[1] This supports van Raan's (1999) proposal of applying weighted comparative indicators.

were cited at least once, corresponding to almost 96 %, including self-citations during the entire period. This figure is higher than the Danish (94 %) and world shares of cited articles (88 %). At the mid-term evaluation this proportion for SMP as program was slightly lower, i.e., 89 %.

Table 2. Final evaluation of the nine SMP centres. Primary and secondary indicators, publications 1993-1997, cited 1993-2002. Sources: SCI, Dialog online version & NSI (ISI).

Center	SCI Publ.	Cit.-SCI	CIF	DiachronicJIF	Domain DK	Domain W.	All Publ.	All Cit.	CIF*
Air Polution	29	446	***15.4***	*12.7*	14.7	11.1	34	481	14.1
Terrestrial ecology	39	529	***13.6***	*11.0*	12.4	11.5	51	553	10.8
Groundwater	20	288	***14.4***	*13.9*	12.7	10.7	35	318	9.1
Agro biodiversity	20	209	***10.6***	*7.0*	11.7	9.7	31	267	8.6
Root zones	54	796	***14.7***	*10.4*	10.7	7.8	67	989	14.8
Freshwater	36	1009	***28.0***	*11.0*	20.0	19.9	42	1062	25.3
Marine ecology	33	709	***21.5***	*18.4*	20.0	19.9	38	739	19.4
Eco-toxicology	79	891	***11.3***	*13.2*	15.2	14.2	98	1034	10.6
Biochem.epidem	34	864	***25.4***	*16.6*	23.1	22.5	38	881	23.2
Mean total - *SMP*	***344***	***5741***	***16.7***	***12.8***	***16.6***	***15.2***	***434***	***6324***	***14.6***

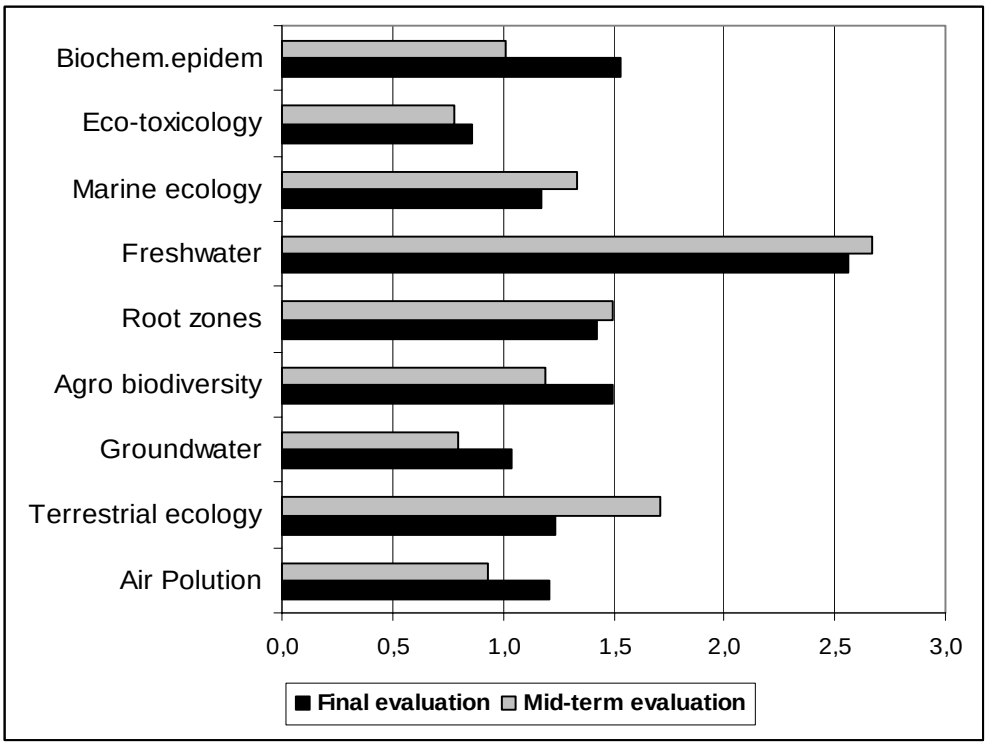

Figure 1. Diagram of the nine SMP centres' citation impact (*CIF*) vs. the corresponding *centre JIF* 1993-2002. Index 1.0 = centre JIF. Source: SCI (ISI, Dialog online version).

Knowledge Export from the SMP Centres

One kind of knowledge exports concerns which countries that make most use of, i.e., give most citations to, the individual centres. Quite interesting one may observe that USA five times out of nine is the most *highly citing* country with Denmark as the most citing country. This is an interesting when one considers that self-citations are included. The following cluster of countries constitutes the locations from which ≥ 10 % of each centre citations are given, i.e., the countries to which 10 % of the knowledge export goes; with number of countries represented across the centres in ( ):

1. USA (9) – most citing in 5 centres;
2. Denmark (9) – most citing in 4 centres;
3. Germany (7)

4. United Kingdom (7);
5. The Netherlands (2);
6. Canada (1); France (1); Japan (1); Sweden (1)

A second kind of knowledge export concerns the research areas from which credits are given in the form of citations. We do not demonstrate samples of centre export for lack of space. But obviously the subject categories ranked by the Dialog software can be compared to the subject areas chosen by each centre from NSI (i.e., Current Contents) as representative of their research. Checked in this way, it could be observed that, for instance, the Freshwater and Marine centres probably had selected areas (Biology; Biochemistry) somewhat too broad or/and out of tune of their real research foci and of too ambitious nature, i.e., with too high world (and Danish) citation impact.

The Use of Top-Impact Journals

In the mid-term evaluation there was a quite strong correlation between the JIF of the applied journal volumes and citations given to the corresponding articles (Pearson's r = .59 for the 151 journal-article pairs with p= .005; CV= .25). For the top-25 journal volumes' JIF and corresponding articles' citations, r equaled .68 with r^2 = .47 (p= .005; CV= .487) – see Figure 2. One might state that there existed a quite robust correlation between the *expected* impact of the journal used for publication (the diachronic JIF) and the *actual* citation impact per article.

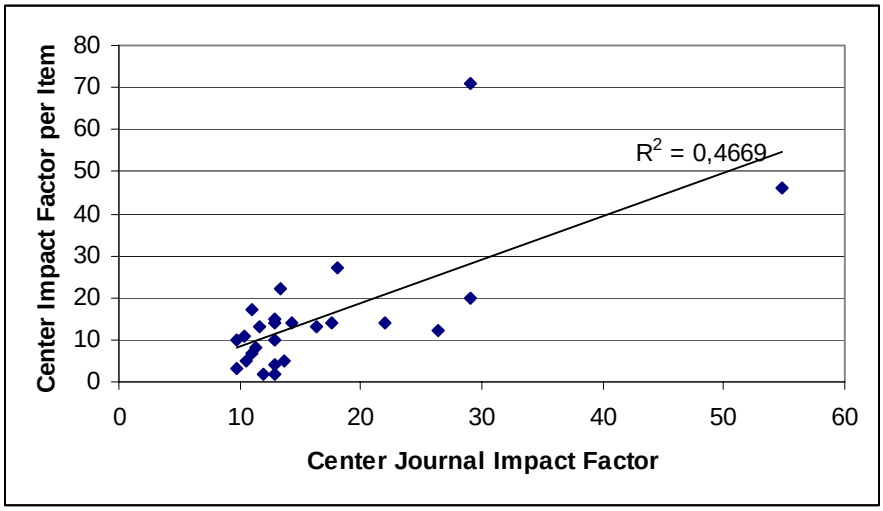

Figure 2. Correlation between the JIF of the top-25 journal volumes and the citation impact of the corresponding articles published by SMP as program 1993-1995, cited 1993-1998.

This correlation changes somewhat at the final evaluation. Two kinds of correlation analyses are carried out. One observes the top-40 journal volumes from the entire SMP program – see Figure 3.

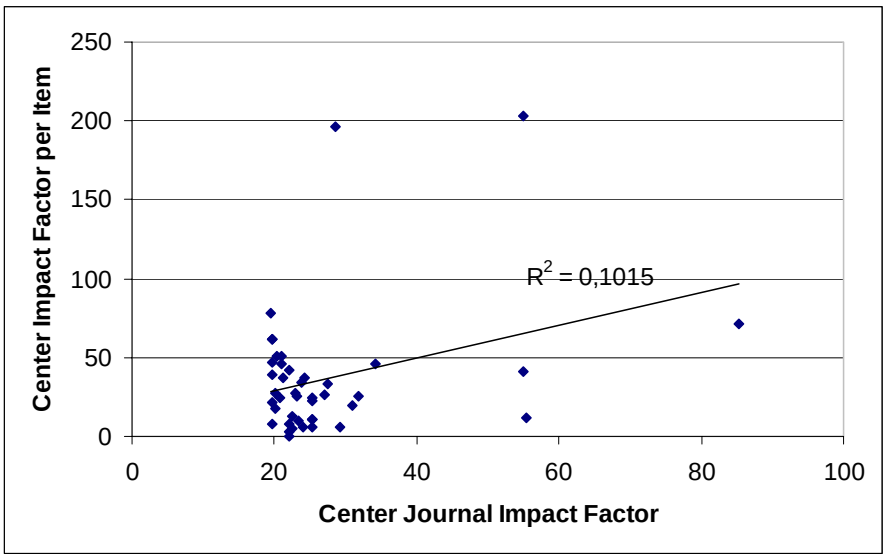

Figure 3. Correlation between the JIF of the top-40 journal volumes and the citation impact of the corresponding articles published by SMP as program 1993-1997, cited 1993-2002.

Because the Agro biodiversity centre displays quite low JIFs the centre did not become represented in that analysis. Hence, a second analysis takes the upper 10 % of the journal volume JIFs per centre. In total 35 JIFs – and all nine centres – are represented.

Pearson's *r* is equal to .32 with r^2= .102 (p = .005; CV= .41) for the top-40 correlation analysis. This is a *remarkably weak* correlation far below the critical value. Only in the application of one out of ten high-impact journals a correspondingly high article impact became the case. At the mid-term evaluation almost every second high-impact journal volume applied for publication also carried a high-impact centre article. The second correlation is similarly weak, *r* = .38, CV= .42.

Discussion

The growth rate from year to year, and over the entire five-year period of research, is impressive and substantially higher than the corresponding Danish production growth – Table 1. Denmark produced in total 1127 articles including the 344 items during 1993-1997. The growth rate demonstrates that in terms of productivity the SMP program became a clear success.

On the other hand, it can also be argued that SMP increasingly seems to devour resources – like a cuckoo in a nest – and by its increasing domination may inhibit the common development in the rest of the field during the same period (Fisker, 2004). From that stand it may not be seen as giving a strategic edge to the field in question.

The SMP productivity showed also high variation from centre to centre – Table 2. Six centres each produced below the average of 48 articles – and below 38 SCI-articles. Similarly, the proportion of *non-SCI articles* varied across centres. The highest ratio was observed for the Groundwater centre (43 % non-SCI articles), and the lowest for the centres of Biochem. Epidem. (11 %), Marine ecology (13 %) and Freshwater (14 %). Nonetheless, this does not mean that centres with a high ratio of non-SCI articles do not receive a high impact, see Tables 2-3. The Groundwater centre has the edge across other indicators. Only the Agro biodiversity centre (36 % non-SCI articles) demonstrates a weak *CIF* compared to the Danish impact – and, in contrast, the Eco-toxicology centre with a low ratio (19 %) shows a *CIF* far below all other indicators.

Citation Impact Comparisons – the Strategic Difference

During the mid-term evaluation period 1993-95, 151 SCI-articles were produced that yielded 1386 citations 1993-1998. The same 151 articles received 1486 citations 1999-2002 – not a bad yield over this extended period in such interdisciplinary research areas.

In total, the 344 SCI-articles from 1993-97 provided the SMP program with 5741 citations at a mean of *CIF* = 16.7 citations per SCI-article – far above (23 %) the diachronic *centre JIF*. In that sense SMP demonstrates a strategic difference. However, the JIF indicator is relative. It displays the

expected citation impact for the publishing journal volume. It does not state anything about the level of impact value. For that analysis it is very important to look into the balance between the *centre JIF* and the DomainDK (and world) indicators, as done below.

Table 3. SMP centres with equal or more than 10 % difference between *CIF* and the other indicators (source: SCI, Dialog online version; NSI, ISI, 2001).

Centre	CIF	Centre JIF	DomainDK	DomainW
Terrestrial ecology	13.6	11.0	12.4	11.5
Root zones	14.7	10.4	10.7	7.8
Freshwater	28.0	11.0	20.0	19.9
Biochem. epidem.	25.4	16.6	23.1	22.5

The issue here is that the *CIF* is almost identical to the weighted Danish domain impact (16.6) and only 1.5 citations above the weighted world impact. As briefly mentioned above: had the former impact traditionally and unfairly been un-weighted it would have beaten the *CIF* score by .8 citations. In contrast, the world impact would have decreased and been further beaten by the SMP *CIF*.

In order to demonstrate a clear strategic difference, a SMP centre should show a rather higher *CIF* than any of the other indicators – for instance at least a 10 percent positive difference. This constitutes a conservative measure. Obviously, the Danish impact factor in itself is 10 % higher (1.5 citations) than the world impact; in addition, it contains the *CIF*. The *Danish research* as such thus demonstrates a *strategic difference* in the Environmental sciences – probably dominated substantially by the SMP initiative. On the other hand, the mean SMP *CIF* does *not* demonstrate any clear strategic edge compared to the Danish research. However, four centres indeed do show a robust strategic difference in relation to all other indicators, Table 3.

The interesting observation is that the first and second centres both show quite homogeneous impact factors whereas the last two centres demonstrate very high *CIF*, Domain DK and DomainW indicators – but rather low *centre JIF*. The former centres have applied the journals 'common' to the research area worldwide as a publishing strategy. The latter centres, in contrast, have applied much *lower-impact journals* than ordinarily used in the areas in general as well as in Denmark. In line with the top-impact journal discussion below, these observations clearly demonstrate that the positive average SMP *CIF* score does *not* really derive from publishing in top-impact journals *and* obtaining much more citations than expected. Two centres (*Freshwater* and the *Biochem. Epidem*. centres) did actually publish in lower-impact-than-average journals, but with success – and thus received a much improved centre impact (*CIF*).

Two other centres, *Air pollution* and *Marine ecology*, are close to have a 10 % advantage over the other indicators; and the *Groundwater* centre is in line with its *centre JIF*. The two remaining centres are less advantageous in comparison to the competing indicators. They are directly below the Danish citation impact (*Agro diversity* and *Eco-toxicology*), the latter centre also scoring below the *centre JIF* and the world impact – see also Figure 1. As a consequence one may argue that 2/3 of the SMP centres really obtained a research *strategic advantage,* which later may be beneficial to the Danish environmental research, e.g., due to the training of upcoming younger researchers during the five-year program. Already the ensuing years, 1998-2000, demonstrated a definitive increase in Danish environmental publications: 315, 299, 321 articles per year.

Finally, Table 2 demonstrates that the overall centre impact for *all* articles, *CIF**, is quite high (14.6), i.e., only 2 citations per article below the mean SMP *CIF*. Whereas the *CIF** for the *Groundwater* centre is quite lower in value than the *CIF*, most other centres possess a *CIF** that is close in value to the corresponding *CIF*. In fact one centre, the *Root zone*, displays a *CIF** (14.8) that is slightly *higher* than its *CIF* (14.7). The reason for this rare phenomenon is that the 13 non-SCI articles all were cited heavily by SCI-journals and thus have appeared to be highly useful to the scientific community. Besides, the CIF*-CIF difference demonstrates the average impact of research information mediated to practitioners of the field in question and the society as such.

Comparing the Mid-term and Final Evaluations

Figure 1 demonstrates that at the mid-term assessment three centres obtained index scores *below the baseline*, 1.0, signifying that their *CIF* did not reach the corresponding *centre JIF*. At the mid-term the

mean SMP *CIF* = 9.2, with a diachronic *JIF* = 7.8. At the final evaluation two centres managed to pass the JIF index baseline (the *Groundwater* and *Air pollution* centres). The high-impact centre, *Freshwater*, just managed to hold its index value and several centres dropped in values at the final evaluation: the *Marine*, *Root zone* and *Terrestrial ecology* centres. These results associates probably with the lack of strategic difference, discussed above.

When comparing the two SMP evaluations, the most interesting results deal with the use of *top-impact journals* – Figures 2-3. At the mid-term study the 25 SCI-journal volumes with top-JIF scores were correlated with the citation scores obtained by the articles published in the same volumes. At the final investigation the top-40 SCI journal volumes were used.

Figure 2 demonstrates that there are few outliers compared to the diagram, Figure 3. In the latter diagram some outliers hold very high article impact scores. However, there are not sufficiently many to observe if those highly cited articles demonstrate properties similar to those observed by Aksnes (2003). Further, there exists a concentration of pairs situated between JIF-values of 20 and 35 citations and article impact values ranging from zero to 50 citations. The reason for the weak to bad correlation coefficient obtained at the final evaluation lies probably in the fact that in too many cases articles published in top-impact journal volumes received much less citations than the corresponding diachronous JIF. Besides, several high-impact articles were published in lower-impact journal volumes. By removing four outliers the improvement is marginal and still very weak (r = .34, p = .005; CV= .41).

The Pearson correlation coefficient is a relative measure in the sense that variation from a mean plays the central role, regardless that mean. The extension to which a journal also holds centre articles with equal (or higher) citation impact scores can be observed at the detailed data level underlying the Table 2 values per centre: For all nine centres a total of 175 articles (of a total of 344 SCI-items = 50 %) yield better impact than the corresponding *centre JIF***.** This proportion of better-than-JIF cited articles is interesting compared to the common trend (Seglen, 1997, p. 498) that "articles in the most cited half of articles in a journal are cited 10 times as often as the least cited half". Centres with a percentage > 50 % typically belong to the four centres showing a *strategic difference* compared to the other indicators, Table 3. Again, this additional indicator specifies that SMP as program did not entirely make a difference – although 4-6 centres actually did.

Methodological Issues

As stated at the start of this discussion section the dominant position of the strategic research programme seems to influence the productivity of the remaining research community outside SMP in environmental research. At the mid-term evaluation one might have made use of all available data in order to gain additional information on the behaviour of the program. One might here think of the research work and articles underway or actually published after 1995 and into 1997/98, when the mid-term evaluation was carried out. We did not take that data into consideration. However, Table 1 on the productivity could (and should) have been made available.

Similarly, one might have made use of the Immediacy Index values, which is the only citation indicator made by ISI of diachronous nature. Such values per applied journal could have been compared to the corresponding article's immediacy impact. The additional data and assessment information might hence have made the mid-term evaluation more comprehensive. The issue at stake is that mid-term evaluations have important implications for the continuation of research funding, its magnitude, and its direction – not only for a large-scale strategic research program like SMP, but for the remaining local research community. It is rarely so that strategic programmes obtain large additional funding – it merely grasps by a given (political) priority what commonly is already in the system. Commonly somebody else receives less.

The application of *weighted comparative indicators* of national and world properties – forming a 'shadow' of the unit under investigation – is also of central methodological importance. Their central role is to be compared to the research program's average as well as single CIFs *and*, in particular, to the *centre JIFs*. The reason is that the latter performance indicator is *highly relative*. We have observed how some units are able to produce article citation impact factors quite high above the average impact of the corresponding journals (the centre JIF) applied by the unit for publication. By comparing to the weighted research indicators of the same field(s) it becomes observable whether the journals used for publishing in a unit are 'light-weight' impact journals or more average or high-

impact journals. See for instance the cases in Table 3 and Figure 3. The interpretation of the evaluation outcome becomes definitively more reliable.

Concluding Remarks

The two-step research evaluation covers as a minimum a citation window of 7 years (1997-2002) with a 12-year widow as maximum (1993-2002). This ensures robustness in the citation analyses. Perhaps owing to the extended citation window at the final evaluation, the variation of citations received per SCI-article increased, and the promising substantial correlation observed at the mid-term evaluation between top-ranked journals and their corresponding centre articles did not continue. Too often a top-cited article from a centre was published in a journal displaying a much lower diachronous *JIF*; but the opposite phenomenon also takes place.

As a program SMP did make a *success* associated with the volume of research publications published over the five-year period. The doubling and tripling of output is significant. But perhaps at the cost of the rest of the field's research development. It becomes hence of interest to follow up the Danish environmental research production from 1998 onwards. Already the years 1998-2000 look promising.

The Danish environmental research as such thus demonstrates a strategic difference in the Environmental sciences – probably helped substantially by the SMP initiative dominating the national field. From a wider perspective, in the cases of assessments of strategic research programs, one should always attempt to carry out a two-step evaluation procedure, which makes use of *all* available data at the time of investigation. Further, one might profit from observing what happens to the research communities outside the program – *its context* so to speak – in terms of publication growth, citation impact, relationships to the program. This is owing the large influence such programs have for a substantial period of time on resource allocation, researcher affiliation and head hunting, and the volume of funding in particular fields.

The variation between the SMP centres in publication behaviour seems quite large. Two centres – *Groundwater* and *Eco-toxicology* – published quite often articles in non-SCI journals without receiving enough citations to compensate. This behaviour resulted in *CIF*-scores below or just on the diachronous JIF baseline. The two centres probably contributed most to the fact that SMP, as research program, *did not* make a recognizable *strategic difference*.

Notwithstanding 4(-6) centres did make a strategic difference compared to the Danish (and world) citation impact in the relevant research areas. The four high-impact centres produced a *CIF* at least 10 % higher than any of the other indicators applied. One of the centres actually showed a *CIF** for all SCI and non-SCI articles that is *higher* than its *CIF* – the *Root zone* centre. Characteristically, the six high-impact centres also demonstrate a substantial proportion of SCI-papers that receive more citations than the mean *centre JIF* scores for each centre. In total 129 out of 225 SCI-articles (57 %) satisfy this condition, which supports their strategic advantage.

Finally, one may observe that in terms of *knowledge export* from the SMP program, the surprising observation is that USA is the predominant knowledge importer followed, not surprisingly, by Denmark.

In a future extended analysis we will explore the correlation between top-ranked journal volumes and the corresponding articles in terms of citation impacts centre by centre to see if centres that make a strategic difference in addition demonstrate any substantial correlation coefficients.

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