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THE EFFECT OF FUNDING MODES ON THE QUALITY OF KNOWLEDGE PRODUCTION

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Abstract
Do funding modes have an effect on the quality of knowledge production? In this paper we develop an approach to investigate this, using the new WoS field on funder data, using climate change research in Sweden and the Netherlands in 2009-2010 as a case. We firstly developed an operational definition of climate change research, and retrieved all WoS records for the countries and years mentioned. We developed a classification scheme for the funding organizations of 13 categories, using dimensions as top-down/bottom-up, large/small research, national/international, and public/private. Then all funding institutions were manually classified in the 13 categories. We then calculated the average impact of the papers for each of the funding categories. The results clearly show differences between the funder types, and also between the countries. The latter indicates that a funding mode may be organized in different ways affecting the effectiveness. Finally, we discuss further research.

Topics
Bibliometric indicators, new developments (topic 1); Science Policy and Research Evaluation (topic 3); Modeling the Science System, Science Dynamics (topic 11).

Introduction
Whereas the research funding landscape in the past was relatively simple, with most funding going as block funds for universities, over the years, the number of funders has grown fast. Of course, national science councils entered the scene, but many other funders in government, private foundations, NGO's and companies are now active, plus many international organizations such as EC, ERC, OECD and so on.
The proliferation of the funding possibilities can be related to the changing relation between science and society, as research has become increasingly important in many realms of society. This changing relation is partly reflected in and constituted by the rise of a variety of new agenda setting arrangements, funding instruments, and new ways of organizing research and the interaction with societal stakeholders.

The development of project funding in its different forms has been studied by Lepori and Van den Besselaar et al [1,2], indicating (i) the growth of project funding in many countries, but (ii) at different levels and paces. A relatively detailed breakdown of the types of funding was developed for the Dutch data [3]. Also the OECD started a project [4,5] to refine the registration of public research funding. The relevance of a better and more detailed classification is obvious, as different types of funding actually may influence the type of research performed, the topical orientation, its relation with societal issues, and the scholarly and societal quality of the output. Only little research has focused on the effect of funding on knowledge production, but the introduction of funding acknowledgements in the Web of Science opens new possibilities. It now becomes possible to investigate the relation between funding mode and research output in more detail. Recent research has shown that the coverage is rather good, although problems of coverage, accuracy and completeness remain, as do problems of identification and disambiguation [6, 7].

In an older study, Cronin found (for information science) no relationship between funding acknowledgements and impact, however without differentiating between the types of funding acknowledged [8]. In a recent study, Rigby studied the relation between the number of funding sources and citation impact within physics and cell biology, and did not find a correlation between the two variables [9]. Costas and Van Leeuwen found that publications with funding acknowledgments present a higher impact as compared to publications without them, again without differentiating between different funders [10]. Wang and Shapira took a different approach and differentiated between funding institutions and types of funding institutions in nanoscience research in several large countries [6]. First of all, they found a predominant national orientation of research funding. But different funding arrangements exist in the different countries. Differentiating between funding modes, they found that the more funding is concentrated to a few recipient organizations, the lower the research impact as measured by citation counts is. Also Van den Besselaar et al focused on differences between research funders, when studying internationalization of research [7, 11].

Over the years, there has been a proliferation of funding (and related agenda setting) arrange-ments. This proliferation is the result of expanding science policy goals, translated by science policy makers into dedicated funding instruments (mechanisms). The more traditional funding modes, such as institutional block funding, and the responsive mode of the research councils are considered insufficient. We have witnessed the emergence of mission oriented, strategic and applied funding schemes, funding schemes for thematic consortia, applied and thematic public research institutes, etc. One may distinguish between four funding modes defined by two dimensions: bottom-up versus top-down, and institutional block grants versus project grants. Each of these four research modes can be organized using a variety of mechanisms, e.g., institutional funding for basic research may go to universities, or to public research insti-

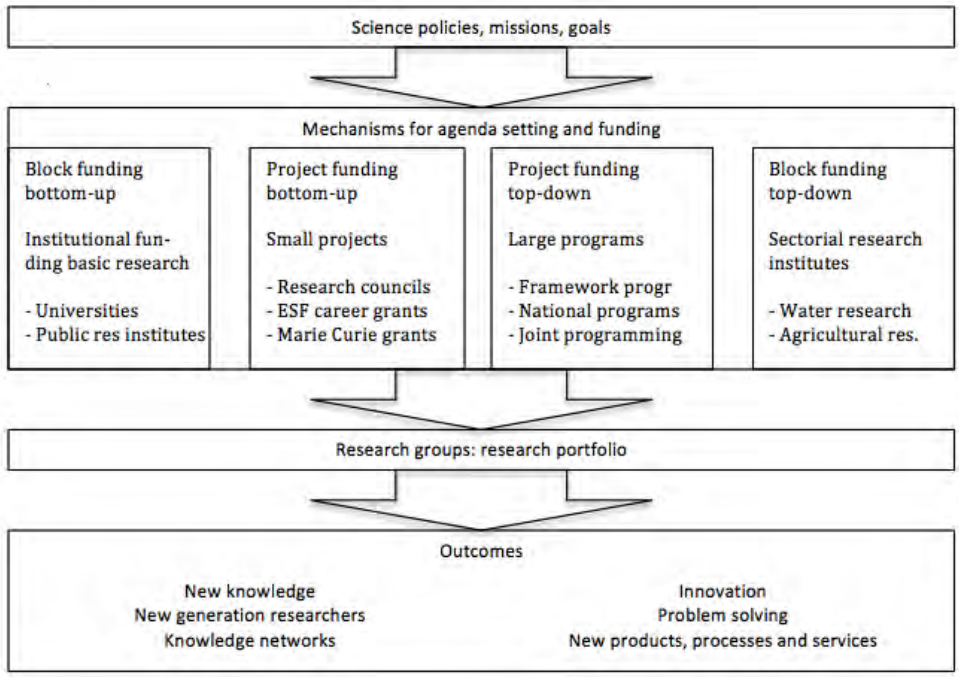

Figure 1: Comparative approach - the effects of funding modes

tutes. Research teams and research performing organizations use one or more of these funding mechanisms to produce their variety of outputs. Figure 1 briefly shows the model.

Several questions come up. Firstly, do these funding arrangements differ in productivity, impact, and originality? These differences can be measured in terms of the numbers of papers acknowledging the funding, and by the numbers of citations these papers receive. Secondly, do these funding arrangements actually fund different types of research and related output (scholarly versus societal output) and/or different topics of research? Are they complementing each other, or are they duplicating (and computing in quality – the first issue) each other? Thirdly, on the systems level, the question can be posed whether the variety of research funding? Is there an optimal variety? In this paper we focus on the first issue: do different funding modes result in different levels of impact?

Of course, we do not only observe differences in funding modes and instruments, but the same type of instrument can be organized in different ways, and this may influence the performance of the instrument. E.g., many ways of organizing applied sectorial research institutes may exist and many different ways of organizing peer review and panel selection processes in councils exist. Furthermore, differences may be related to disciplinary cultures. Therefore, we do not only have to compare the performance of the various funding modes, but also the variety within the modes, also reflecting differences between disciplines.

In order to test the possibilities, we study the different funding practices in one field (climate change) in two countries (Sweden and the Netherlands), in the recent period (2009-2010).

Data and methods

Since 2008 data on acknowledgements to funding units (FU) or funding sources are presented in the Thomson Reuter's database Web of Science as a searchable tag in the database. Data is acquired from the acknowledgements in journal papers (e.g. document types as articles, letters, proceedings and reviews). The indexing procedure copies the spelling mistakes and the different names of organizations presented in the journal papers. This creates a need for disambiguation of names of the funding organizations. One example: The Swedish Research Council can be presented in several different ways:

a.) The Swedish Research Council
b.) Vetenskapsrådet
c.) VR

The first of the above, (a), is the official name in English, (b) is the official name in Swedish, and (c) is the abbreviation of the Swedish name of the organization. There are several more possible versions and combinations of each of these names. Indeed, as we found elsewhere also for other funders, a funding organization may have hundreds of different ways of spelling. Also, there are possible homonyms and synonyms that altogether create a problem that might be solved through a more or less systematic disambiguation of organization names. Although the example above seems quite simple there are many public and private funding sources that can hardly be identified and disambiguated in a correct manner without manual procedures using the Internet or other sources of information.

In our sample, about 70 per cent of papers do have an acknowledgement of funding sources, what is higher than what would be expected as only about half of total Swedish and Dutch papers do have FU-information during the period. Distribution over areas has to be taken into account when we discuss figures of papers with and without acknowledgement of funding.

Classifying funding organizations and funding modes

For Sweden, the ten most frequent funding sources, accounts for more than 20 % of all acknowledgements in the Swedish sample data. The numbers of unique funding sources are about 1,000, which illustrates the problem and the need for disambiguation of funding names. A complete disambiguation of all funding sources is impossible as there are many that only consist of a project of program abbreviation. Under all circumstances, it is necessary to categorize the different funding sources according to the financiers' mission and procedures for evaluation of proposals.

How to account for different funding modes? We started from a two-way matrix based on the distinction between open and thematic mission for a funding

organization on the one hand and the distinction between bottom-up and top-down procedures on the other hand (figure 1). We added the distinction between national and international funding. Basically, we would like to be able to use the distinctions proposed by van Steen [4; 5] between institutional, block grant funding, on the one hand and project funding on the other. Unfortunately that is not possible due to limitations in the FU-data. Therefore, we cannot test hypothesis related to that distinction (although category 9 and 12 can be related to that question). All other categories are dominated by project funding schemes of different sizes and arrangements. Bourke and Butler [15] had more detailed information in their path-breaking study. Heinze [16] focuses more on peer review as mode of funding procedure and concentrates on some main schemes applied. Later on we hope to be able to use that type of granularity. In this investigation we consider the different types of funders that are revealed by the FU tag in the Web of Science. In our understanding, while some of the categories are associated with frequent use of modified peer review in a responsive mode, others are associated with less academic and more open evaluations of proposals (e.g. category 2, 4, 5, 6).

The following categories are used to classify funding organizations:

1. Research Councils bottom-up, open,
2. Organizations, private foundations, NGO's, etc.
3. Foreign
4. Applied funders, county councils, Nordic council
5. Mission-oriented bottom-up
6. Applied research institutes
7. EU framework, Marie Curie etc.
8. University
9. Research Institutes, fundamental research
10. Missing category
11. Companies
12. Large programs, Excellence programs, Research Foundations
13. Societies

After classifying the Swedish data, the Netherlands data were processed in the same way.

Delineating climate change research

We used the three WoS databases SCI expanded, SSCI and AHCI. In order to delineate climate change research, we started with the search ts=climat* and checked for a random set of papers the precision. Clearly quite some papers were retrieved that do not focus on climate change. Then we used a more restricted search, using ts="climat* change*" which led to a much smaller set of papers. Checking the difference between the two sets, we found quite some relevant papers that were not in the second search. Therefore we designed a query that was in between the two tests. A test indicated that the precision and recall were OK. We used the following query:

ts=climat* and (ts=change* or ts=variabilit* or ts=anthropogenic* or ts=model* or ts=strategy* or ts=policy* or ts=regime* or ts=scenario* or ts=carbon* or ts=”integrated assessment” or ts=environment* or ts=reforestati* or ts=deforestati* or ts=desertificati* or ts=”greenhouse gas”* or ts=GHG or ts=ecolog* or ts=environment* or ts=biodiversity or ts=”global change” or ts=”water stress”) or ts=climate-driven or ts=”global warming” or ts="sea level*" and (ts=change* or ts=rising)

We tested whether e.g., papers on climate change mitigation and adaptation were included, even without using the latter two search terms, and this was the case for more than 90%.[61]
The set was refined for publication years (PY=2009-2010), for document type (DT=article or proceeding paper or letter or review), and for country (CU=Sweden or Netherlands). This resulted in 954 Swedish papers and 1293 Netherlands' papers that were used in the analysis.

Analysis

After having classified all mentioned funders, we used a dedicated Swedish tool to estimate the impact of the publications funded by the different sources. We calculate the average field normalized citation impact for each of the funding modes in the two countries, for publications in the field of climate change. We also calculated for each of the funding modes the percentage of papers in the top 1%, the top 5%, and the top 10% in the relevant journal environments [12].
Relative indicators or rebased citation counts, as an index of research impact, are widely used by the scientometrics community. We calculated a weighted NCSf (Field Normalized Citation Score), based on fractional counts based on the number of funders per paper. This gives a weight for the contribution of the funder to the impact of papers. Fractional counting is a way of controlling the effect of collaboration (here between funders) when measuring output and impact. Consequently, figures based on fractional counting show the extent to which the set of papers receives many citations for the collaborative funded papers only, or if the papers that were funded by a single funding agency are cited in the same manner.

Some restrictions

Having FU details does not imply that we have the full information of all funding sources. In some cases universities and university departments are mentioned as one funding source, especially if there is a specific program at the university e.g.

[61] We did not further investigate recall and precision of this search string, as we do not aim to cover climate research completely, but only need a representative sample from climate change research in Sweden and the Netherlands, in order to compare the funding modes. We assume here that the sample is good enough for this.

for climate research, but in the normal case the contributions from the university in the form of faculty funding is not acknowledged by the authors of papers.
We do not have data about the amount of funding per project by funding organizations. One of the organizations might contribute with 1 million Euros and another organization with less than 50,000 Euros. In the same way, it is impossible to know the extent to which different sources have been used for the specific article published. It might be the case that a researcher develops ideas and produces results in a project, but when the article is finally published, he/she may be already involved in a new and completely different project with new funding sources – and consequently acknowledges the *new* funder. All these problems exist, but we have to consider that on the *micro* scale, the systems of input and output are always disconnected (to some extent). However, in the long run there will be a tendency for people to acknowledge funding streams and many of these will rely on sources for several years. In that way there is always a connection established between funding and output.
Climate Research is a growing area, attracting different types of funding. When an area grows, it also attracts interest from researchers relabeling their work in order to fit in to the new funding opportunities. In such arenas there might be a signaling value for the researcher as well as for the funding agency to point out that the respective partners are active within the area of this specific type of research.

Findings

Structure and growth of the field

Clearly, the field is young and grows very fast (fig 2). Is it covered by old journals, changing to climate change research, or new journals focusing on climate change? We list here the 11 most frequent journals (table 1). As the table indicates, the journals are relatively young as seven were founded after 1980, and two more in the 1970s. Apart from the general journal PlosOne, most journals are on climate and global change (6) or on (atmospheric) geophysics (3).

The two countries we focus on both have a faster growth than world average, where we took the year 2000 as 100 (figure 2). The growth of climate change research in the Netherlands has been faster than average since about the year 2000, with growth acceleration around 2003 with the start of the *Klimaat voor Ruimte* program and a second impulse with the *Kennis voor Klimaat* program around 2008. These two programs are (in the classification deployed here) in the "large programs" category.
Sweden has invested heavily in climate research [13] and followed the world growth until 2009, but is strongly speeding up since. We also include two other countries in the graph, for comparison. Switzerland follows a similar fast growth path as the Netherlands, and Germany is following about the world growth rate.

Table 1: Main journals in the field of climate change research

Name or journal	*first volume*	*nr of papers in the set (2009/10)*
Journal of Geophysical Research Atmospheres	1900	1782
Journal of Climate	1988	1724
Geophysical Research Letters	1973	1670
Global Change Biology	1996	1009
Climatic Change	1978	992
Climate Dynamics	1986	940
Atmospheric Chemistry and Physics	2000	927
Palaeogeography Palaeoclimatology Palaeoecology	1965	893
Quaternary Science Reviews	1982	854
PlosOne	2006	852
International Journal of Climatology	1981	698

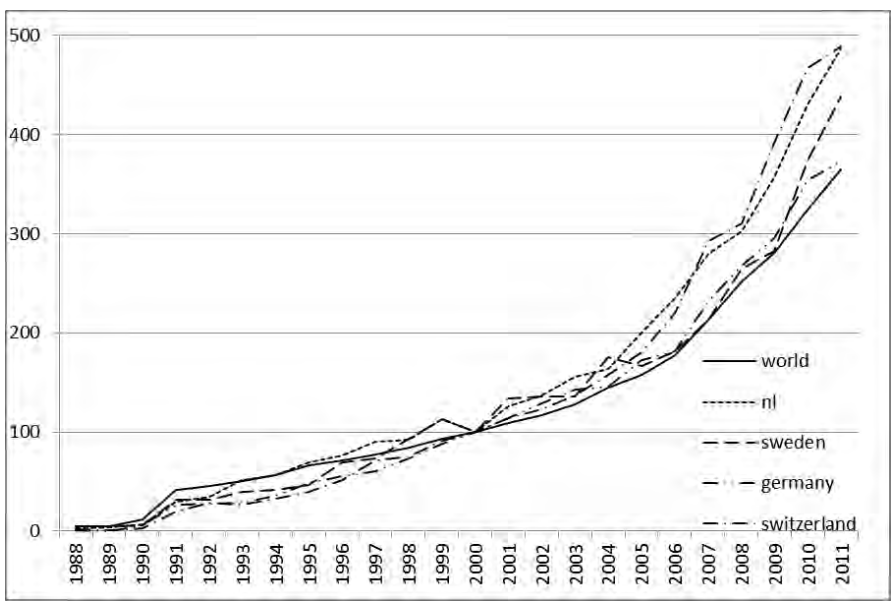

Figure 2: Growth in climate change research 1988-2011 (2000=100)

Funders and impact

First of all, many papers mention more than one funder, and Table 2 shows the number of funders by papers. The table also shows the average field normalized impact (NCSf) for each of the sets. The table suggests that many (more than four) funders are good for the citation rate.

Table 2: Impact by number of funders

Nr FA	Papers	NCSf
1	495	1,84
2	181	1,60
3	114	1,72
4	59	1,64
5	40	2,80
>=6	65	4,09

Sweden, Climate Science, 2009-2010

At the same time, it is not the case that all papers refer to all funders, and therefore we may be able to study the effect of the mode of funding on the impact of papers. Tables 3 (Sweden) and 4 (Netherlands) present the basic findings about the impact of the climate change papers within the several funding modes in the two countries. We report for each of the funding modes the nr of (integer counted) publications, the field normalized citation scores, and the share of papers in the set of top-cited papers.

In both countries, the largest categories are Foreign, EU and the national research council. Also the group of papers without funder is among the largest. Of course, one should take into account that the category "foreign" includes a large number of different funders (and funder types), most of them only funding a few papers. So the high impact of this category is not related to a specific funding mode, but probably to the fact that if a researcher collaborates with foreign researchers that have obtained funding, he/she has a good international team resulting in high impact results.

Table 3: impact of funding types – Sweden, Climate change research, 2009-2010

	# papers	Field normalized citation score	Share in top cited papers 1%	5%	10%
EU	175	2.46	***6.0%**	**19.8%**	**36.5%**
Foreign	322	2.21	**6.2%**	**15.0%**	**26.8%**
No funder mentioned	290	1.92	4.8%	13.1%	24.1%
Mission-oriented Council	98	1.89	**6.1%**	**17.1%**	25.6%
Research Council	142	1.75	3.0%	9.8%	22.0%
Charities, Organizations	70	1.69	**7.8%**	10.5%	17.0%
Corporations	31	1.67	2.6%	4.5%	**29.7%**
Large programs	32	1.59	2.6%	4.8%	10.6%
Societies	35	1.57	3.3%	9.7%	**26.2%**
Universities	107	1.53	3.3%	8.1%	13.0%
Applied Research Institute	21	1.53	0.0%	**13.2%**	25.2%
Applied funder	122	1.48	0.5%	7.6%	17.3%
Total	954	1.96	4.8%	13.1%	24.6%

* bold: belonging to the top 4 performing types in this indicator

Table 4: impact of funding types – Netherlands, Climate change research, 2009-2010

	# papers	Field normalized citation score	Share in top cited papers 1%	5%	10%
Foreign	491	2.56	***6.7%**	**19.9%**	**30.2%**
Large programs (Bsik / FES)	31	2.52	1.2%	**24.8%**	**37.0%**
Corporations	22	2.50	1.7%	10.3%	27.5%
EU	221	2.22	**5.6%**	**19.4%**	**30.1%**
Applied Research Institute	28	2.16	**5.2%**	16.3%	26.7%
Societies	15	2.05	0.0%	18.6%	26.1%
Mission-oriented Council	23	1.96	2.6%	**22.0%**	**36.4%**
Universities	74	1.93	4.7%	17.1%	25.8%
No funder mentioned	486	1.90	**5.1%**	12.6%	22.4%
Research Council (NWO)	208	1.74	2.4%	12.5%	21.8%
Applied funder	56	1.49	3.4%	10.8%	18.9%
Charities, Organizations	8	1.23	0.0%	0.0%	5.2%
Basic research Institute	8	0.91	0.0%	11.4%	11.4%
Total	1293	2.09	5.0%	15.6%	25.7%

* bold: belonging to the top 4 performing types in this indicator

Figure 3 and 4 show the distributions of the normalized citation impact for the main categories of funders in each of the countries. The figures should be read in the following way: We distinguish nine impact classes.[62] For each of the funder types, we calculated the share of papers in each of these nine impact classes. The share of non-cited papers (class 1) is placed to the left in the graph. Then we have the sum of the two lowest scoring classes (1-2), the sum of the three lowest classes (1-3), and so on.

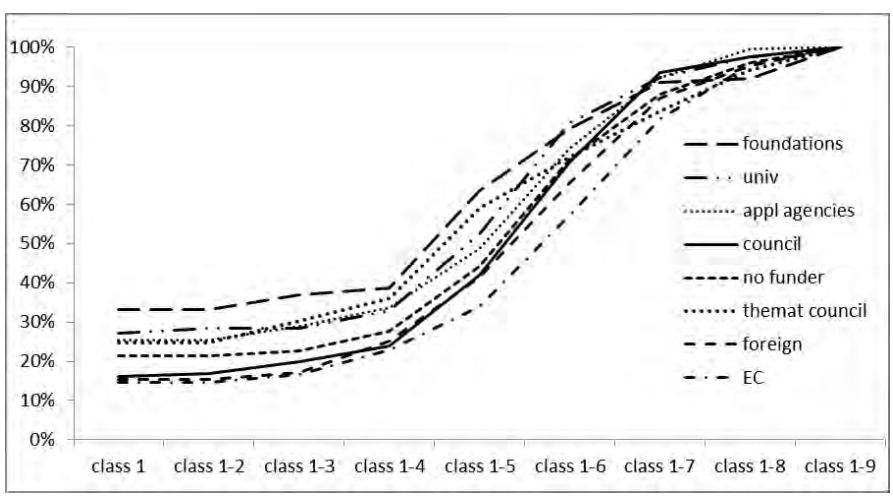

Figure 3: Cumulative distribution of impact by funder type, Sweden (class 1= non-cited, class 1-2 = non-cited plus lowest cited, etc),

[62] The classes of citation impact (NCSf) are defined as follows: 1=0, 2=>0-0,125; 3=>0,125-0,25; 4=>0,25-0,5; 5=>0,5-1,0; 6=1.0-2.0; 7=>2-4; 8=>4-8; 9=>8.

For each of the seven (Netherlands) or eight (Sweden) main funder types, we display the cumulative distribution of impact, and the lower the line in the figure, the larger the share of high impact papers this funder has. E.g., in Sweden, EC funded climate research has the highest (mean and median) impact, whereas the foundations have the lowest.

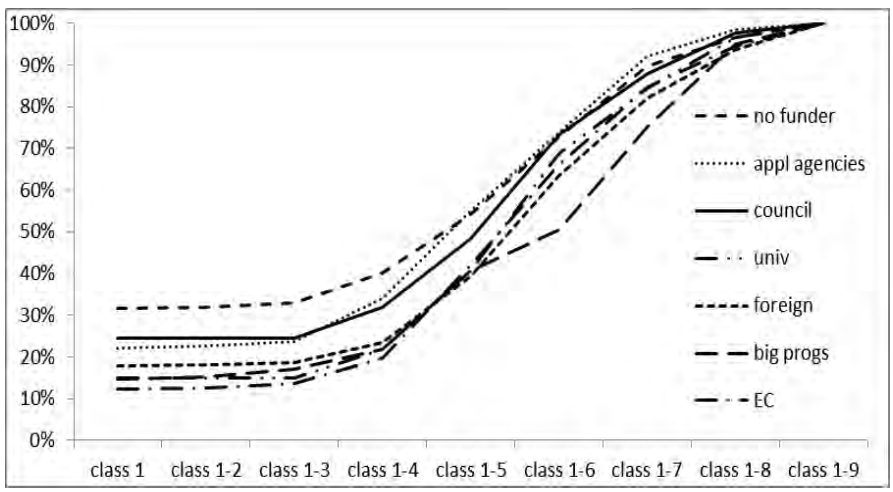

Figure 4: Cumulative distribution of impact by funder type, Netherlands (class 1= non-cited, class 1-2 = non-cited plus lowest cited, etc),

Comparing the tables 3 and 4 shows the following results, consisting of similarities (1-6) and differences (7-9) between the two countries – for the case of climate change research in the recent period.

1. Climate change research started in the early 1980s, and showed a fast growth
2. Dutch and Swedish climate change research has grown fast in the recent period, faster than world average.
3. On average, Swedish and Dutch climate research score about the same, both countries have impact scores 100% above international average.
4. Research councils only perform at an average level, not very strongly contributing to the top output.
5. Output generated together with (funded and therefore high level) international co-authors scores the best in the Netherlands, and almost the best in Sweden. Here we do not see so much an effect of a funding mode, but more a characteristic of researchers: collaborating with foreign researchers that obtain funding for their research seems creating good consortia for high impact research.
6. EU funded work scores very well in both countries, above 100% better than the international average. Here, also the international collaboration effect may play a role.

7. The distribution of papers over types of funding organizations is different in the two countries. E.g., it seems that the charities and other organizations that fund research (such as NGOs) play a much bigger role in Sweden than they do in the Netherlands.
8. The opposite holds for the large programs that score low in Sweden but high in the Netherlands. These are funded out of a specific source and meant for excellent and societal relevant research in targeted fields, such as climate change.
9. Applied research institutes located in the Netherlands score much higher than their Swedish counterparts.

Conclusions

This is a preliminary and first attempt to determine the relation between funding mode and impact of research. The findings suggest that international collaborative and funded research leads to high impact. In the Netherlands, we also find some other high impact funding modes: companies, applied research institutes, and special programs. As these funding modes score lower in Sweden, this poses the question as to whether the organization of funding (next to the type of funding) has an own and independent effect. So special programs can be organized better or poorer, influencing the impact of the funded research. Finally, the impact of papers funded by the national councils is in both countries relatively low. The far majority of these papers do not mention international funding or EC funding, which may be related to this finding.

Further work

In a follow up project, we will apply the approach or a variety of other fields, in different disciplines, and in different stages of development. Not only 'hot' fields as climate change research, but also fields that are less in the focus of science policy makers, and of the general public. We also plan to study different modalities of research funding types, in order to find out how the organization of a type of funding may affect the selection and through this, the impact of the funded research. Thirdly, we intend to compare funding patterns of top-researchers, compared to the average researcher (Verbree et al 2013).

Acknowledgments

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References

[1] Lepori, Benedetto, Peter van den Besselaar, Michael Dinges, Bianca Potì, Emanuela Reale, Stig Slipersaeter, Jean Theves, Barend van der Meulen,

Indicators for Comparative Analysis of Public Project Funding. Concepts, Implementation and Evaluation. *Research Evaluation* **16** (2007) 4
[2] Lepori, Benedetto, Peter van den Besselaar, Michael Dinges, Barend van der Meulen, Bianca Potì, Emanuela Reale, Stig Slipersaeter, Jean Theves, Comparing the evolution of national research policies: what patterns of change? *Science & Public Policy* **34** (2007) 5
[3] Versleijen, Anouschka, Barend van der Meulen, Jan van Steen, Penny Kloprogge, Robert Braam, Ruth Mamphuis, Peter van den Besselaar, *Thirty year of public research funding – trends, policy and implications* (in Dutch). Den Haag: Rathenau Instituut 2007.
[4] Van Steen, Jan, *Modes of public funding of R&D: towards internationally comparable indicators*. STI working paper (version 13 January 2012).
[5] Pastor, Elisabeth; van Steen, Jan, C.G. (2012), *Draft guidelines for data collection on modes of public funding of R&D based on GBAORD, OECD, DSTI/EAS/STP/NESTI* (2012)12.
[6] Wang, J. & Shapira, P. (2011). Funding Acknowledgement Analysis: An Enhanced Tool to Investigate Research Sponsorship Impacts: The Case Of Nanotechnology. *Scientometrics*, 87 (3), 563-586.
[7] Van den Besselaar, Peter, Annamaria Inzelt, Emanuela Reale, Measuring internationalization of funding agencies? E. Archambault, Y. Gingras, V. Lariviere (eds.) *Proceedings Science & Technology Indicators 2012*. Montreal, OST & Science Metrix, 2012, 121-130
[8] Cronin, B & D Show, Citation, funding acknowledgement and author nationality relationships in four information science journals. *Journal of Documentation* **55** (1999) 402-408
[9] Costas, R. & van Leeuwen, T.N. (2012). Approaching the 'Reward Triangle: General Analysis of the Presence of Funding Acknowledgements and 'Peer Interactive Communication' in Scientific Publications. *Journal of the American Society for Information Science and Technology* 63 (8), 1647–1661.
[10] Rigby, J. (2011). Systematic Grant and Funding Body Acknowledgment Data for Publications: New Dimensions and New Controversies for Research Policy and Evaluation. *Research Evaluation*, 20 (5), 365-375.
[11] Van den Besselaar, Peter, Annamaria Inzelt, Emanuela Reale, Elisabeth de Turckheim, Valerio Vercesi, *Indicators for internationalization of research institutions*. Strasbourg: European Science Foundation ESF (2012)
[12] Leydesdorff L, and L. Bornmann, Percentile Ranks and the Integrated Impact Indicator (I3), *Journal of the American Society for Information Science and Technology* **63** (9), 1901-1902.
[13] *Svensk klimatforskning – vad kostar den och vad har den gett?* (RiR 2012:2)
[14] Verbree M, Van der Weijden V, Van den Besselaar P, Academic leadership of high performing research groups. In: Hamlin, C.M. Allwood, B. Martin, M.M. Mumford (eds.), *Creativity and leadership in science, technology and innovation*. London: Routledge 2013, pp 113-148.