Research Evaluation, 19(3), September 2010, pages 000–000
DOI: 10.3152/095820210X503465; http://www.ingentaconnect.com/content/beech/rev

Life cycles of research groups: the case of CWTS

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By combining concepts from scientometrics and organisation studies, we hypothesise a basic 'life cycle' of organisational research units (institutes, laboratories or groups), if internal and external conditions are stable. Three output indicators enable a comparison of historical patterns with the life-cycle pattern, to reveal basic dynamics and changing conditions. We tested the model for a specific case: the Centre for Science and Technology Studies (CWTS) at Leiden University. The 'standard' life cycle was found from the start of CWTS in the early 1980s until the beginning of this century. Then, a boost of activities indicates the start of a second life cycle, explained by increased demand for performance studies and increased ability of CWTS to deliver standardised products. Recent changes in funding and key membership are expected to start a third cycle with reorientation of CWTS's activity profile.

RESEARCH GROUPS ARE important organisational elements of the science system. Studying the development of research groups may improve our understanding of the functioning of the science system, but also inform research management and science policy. Evaluation of research performance is often focused on research groups that function within universities, public research laboratories or institutes. However, we know little about long-term development patterns of such organisational research groups.

- To what extent are groups able to steer themselves?
- What kind of measures taken by research management and policy-makers may be effective in influencing the development of a research group? And
- To what extent may such measures have unintended effects on group development and performance?

To answer these questions, better understanding of group dynamics is needed. Exploring patterns in the life history of a number of selected research groups may help in clarifying the dynamics of group development, and show the influence of specific events and processes, and possible implications for effective management.

Theoretical framework

The evaluation of research performance of organisational units can be legitimised by their ability to learn and to steer their own activities to a considerable extent. Research groups are seen as the smallest appropriate units for performance analysis via advanced citation studies (Van Raan, 2000; Moed, 2005), if the units are not too small for statistical reasons and there are no problems of attribution (Gläser, 2000). Every organisational research unit, at any level of aggregation, faces internal and external conditions that set boundaries to what it can achieve. One of these boundaries is the amount of resources a research group can extract from its environment. As resources generally are limited, the *size* of activities of a group will grow to a certain ceiling defined by the maximum of resources available. According to Price (1963), the growth pattern of activities in such cases will have the shape of an S-curve.

Apart from the size of activities, a research group is also characterised by its *scope* of activities.

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 0958-2029/10/03000-00 US$12.00

Research groups are often active in several domains, ranging from academic science to public debate. Each of the domains consists of different target groups (audiences) and requires different types of activities and products. As pointed out by Larédo and Mustar (2000), research groups[1] cannot do everything and have to *focus* on types of activities that are undertaken within the various domains. This leads to different *activity profiles* of labs and groups.

The activity profile is a strategic translation of the mission of a group (Larédo and Mustar, 2000). This is because every group has to find a combination of activities in one or more domains that is fit for both the realisation of the mission and the survival of the group. For example, within a university context, a combination of research and teaching is required to survive, and in a public research organisation, a different combination is required for the vitality of a research group.

Following organisational ecology, a research group, and in fact any research organisation, must find a viable profile in its given environment (Hannan *et al*, 2007). If the process of searching such a profile is successful, this will lead to a *stabilising set of activities* over time within specific domains[2] of knowledge production and information transfer. Comparing the activity profiles over consecutive years, their similarity will increase, probably in the form of an S-curve as well, if conditions are stable. Environmental conditions, however, may change, and research organisations will have react on this. As shown by Sanz-Menéndez and Cruz-Castro (2003), public research organisations may react to declining public funding resources in diverse ways (active or compliant), depending on the degree and type of autonomy. In any case, changing conditions will lead to a deviation from an earlier stabilised pattern until a research group, or research organisation at a higher aggregation level, finds a new balance.

Furthermore, within each domain of activity a research group and its products will have to be accepted and utilised by the target groups (audiences) as legitimate and valuable, otherwise a group cannot produce any results. Legitimacy of a group and its products increases to the extent that the product's features are favoured by the audiences in the domains (Hannan *et al*, 2007). For example, a manuscript submitted for publication in a scientific journal will be accepted only if it fits the features required by the journal editorial board and its reviewers (colleagues within the field).

For two reasons a group will produce products within a focused set of domains and for a limited number of target groups (market segments). First, its own capacity is limited: one cannot be an expert in everything. Second, the wider the range of features of a group and/or its products the less it will be seen as expert by any specific audience. Thus, groups will focus their activities to some extent, and the scope of specialist groups will be smaller than that of generalist groups. We define the focus level by the percentage of output in segments not already used earlier, which, after an initial search period, will gradually tend to decrease and converge into a stable level for each type of output.

The above limitations imply that for any group functioning within stable internal conditions (mission; strategic staff) and stable external conditions (organisation; resources; domains) we expect specific patterns in the development of activities and in the development of performance. Before we introduce these patterns, we introduce some relevant concepts drawn from organisation theory.

First, organisation theory distinguishes between four types of 'change motors' that influence processes of organisational development (Poole *et al*, 2000; Poole and Hollingshead, 2005):

- Teleological motor (processes driven by goal orientation, e.g. by the mission of a group);[3]
- Life-cycle motor (processes of unfolding stages of a prefigured program, e.g. ageing);
- Evolutionary motor (processes of variation, selection and retention, e.g. competition);
- Dialectical motor (processes of conflict resolution, e.g. resulting in reorganisation).

Second, one can distinguish between primary forces that work from within groups and other forces that work external to the group (Arrow *et al*, 2005: 324–330). This results in several models of change:

- The 'robust equilibrium model' emphasises internal evolutionary change in the early phase of self-organisation of groups establishing a stable state, after which change requires external intervention.
- The 'punctuated equilibrium model' focuses on the response of groups to periodic change in external circumstances resulting in stable periods punctuated by change.
- The 'adaptive response model' focuses on (external) environmental opportunities for groups, the mix and change of which leads to idiosyncratic paths of development of groups thriving to reach their goals (teleological motor).
- 'Sequential stage models' identify a series of stages a group goes through as part of its natural unfolding life cycle, from an endogenous process, that is, originating in the group.
- Finally, dialectical processes within groups may lead to cyclic changes shorter than the lifetime of a group.

Based on this, we hypothesise a basic life-cycle pattern of evolutionary development to be expected for groups in stable conditions. In such conditions, groups are expected to go through a life cycle of three stages. In the first stage, the group will formulate and/or internalise its mission and it will find a strategic pattern of activities in domains that are suitable for realising its mission; the strategic pattern

of activities will help to sustain its survival. If a group succeeds in this, it will reach the next phase of robust equilibrium, and will remain functioning in a stable way until its mission is fulfilled and/or its members retire while key-members are not (adequately) replaced — thus reaching the third phase: (relative) decline.

We use three bibliometric indicators[4] to map the development paths of groups, and Figure 1 shows the hypothesised basic evolutionary patterns:

1. Growth of outputs corresponding with strategic activities, aggregated over activity domains;
2. Similarity of the pattern of activities (profile) over time, from each year to its preceding one;
3. Percentage of output in new categories and/or market segments of target audiences.

In the (second) stable phase, change comes only if it is forced upon the group. This might stem from conflicts within or around a group about its functioning, or from changes in relevant environments. This may result in, for instance, a change of a group's mission or strategy, in its organisational embedding or it may even lead to an end of its existence. Moreover, in each domain of activity a group will have to compete with other groups for scarce resources. Changes within domains require a response from a group, for example, more specialisation. Changes in one domain may influence activities in other domains: if resources become scarcer in one domain, a group may have to intensify or diversify activities in other domains to replenish lost resources. All these changes are reflected in 'deviations' from the basic development pattern as hypothesised.

This case study is a first test: can we use the model meaningfully here? The approach is heuristic in the sense that it guides the analysis of the life history of a group by comparing the actual group development to the hypothesised basic patterns.

- To what extent does the group follow a basic life-cycle pattern?
- Can we distinguish between the three phases expected in this?
- Where is the group now in its trajectory on the life-cycle path?
- Moreover, can we explain deviations from the basic pattern by crucial events and/or processes within the groups or in its environment that have influenced the development path of the group?

We will search for evidence about changing conditions at specific moments or periods, by inspecting relevant documentation (e.g. annual reports), by interviewing group members, and by a review of literature about the research field in which the group is active. The analytical model is here applied to the Centre for Science and Technology Studies (CWTS) at Leiden University, The Netherlands. The validity of the life-cycle model will be further tested in other cases (Braam and Van den Besselaar, paper in preparation).

The case of CWTS

In 1980 the board of the University of Leiden struggled with the question of how to (re)distribute resources among groups within a number of its faculties. One of its staff members came up with the idea of basing this on a publication and citation performance analysis. Thus, an indicators project was born that led to the formation of a science indicators

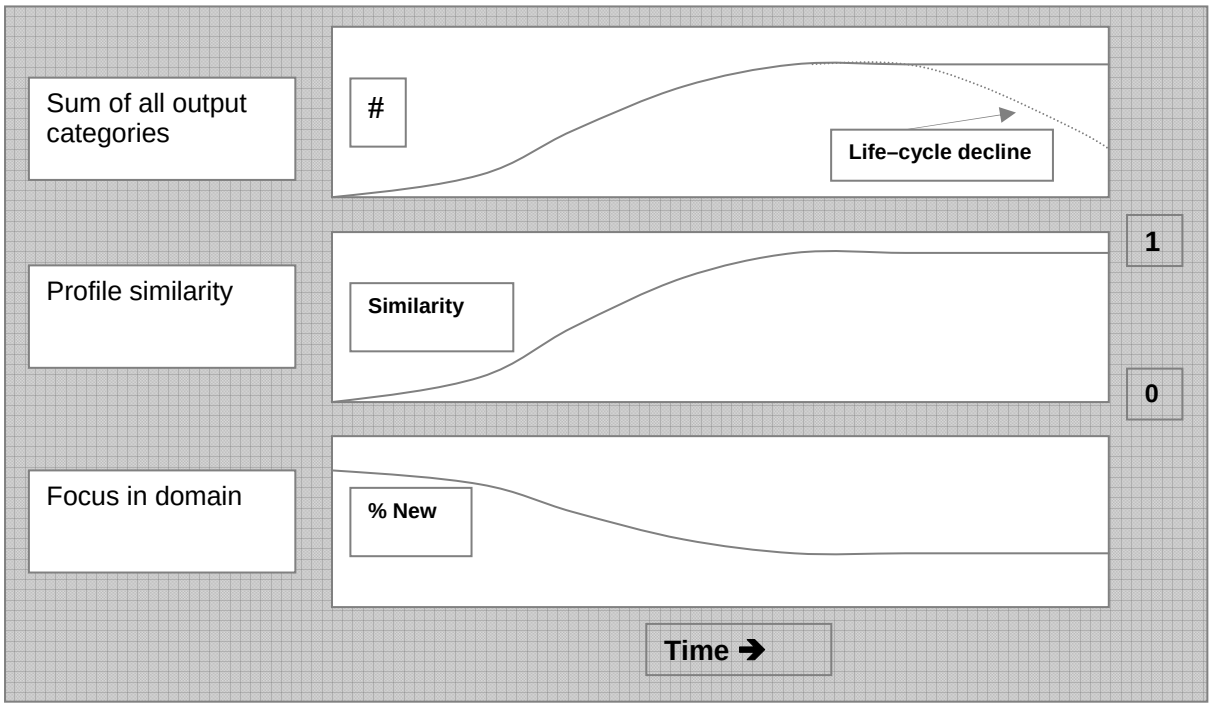

Figure 1. Group development in stable internal and external conditions

unit, one branch of which was first housed at the National Advisory Council for Science and Technology (RAWB) in The Hague. Shortly after, this branch was relocated, moving in with the Leiden branch, as part of the Science Studies Unit of the Leiden Institute for Social Policy Research (LISBON) at Leiden University. A few years later the unit was nominally grouped with the Department of Data Theory at the Faculty of Psychology. In the early 1990s, the group was embedded in the faculty of Social and Behavioural Sciences, where it remains to this day as the Centre for Science and Technology Studies (Centrum voor Wetenschaps- en Technologie Studies — CWTS).

The staff of the group gradually increased from a few staff members to a temporary high of 15 full-time equivalents (FTEs) at the end of the 1980s, after which it remained at a stable level of around 10 FTEs research staff. Currently a new growth of personnel is foreseen from increased commissioned work and additional basic funding from the Netherlands Government. But at the start of the second decade in the 21st century, some key staff members are leaving, while the added funding poses new questions to the group concerning strategic positioning of its activities, particularly within the educational domain.

Data and analysis

We gathered bibliometric data on output activities over the whole nearly 30-year life history of the group (1980–2009). These were taken from the website of the institute, where it publishes lists of output of activities. Additionally, we gathered data from the annual reports of the group, on other activities listed there, such as presentations, lectures and reports. For the latter we were granted access by CWTS to inspect their project database, as an extra source of information on their commissioned work. We inspected the annual reports for explicit statements on internal and or external changes that influenced the group during its lifetime. Finally, we gathered publication and citation data from the Web of Science on the scientific field wherein CWTS is active, by looking at the records of the four journals that were and are used by CWTS staff most frequently as an outlet for its research publications.

Findings

Table 1 summarises the domains of activity and the output categories we found for CWTS. CWTS delivers scientific contributions, reports and presentations to governmental agencies and private firms, publications in local media and lectures to professionals and the general public, and some educational activities. This overview depicts the *compass card* of CWTS, as Larédo and Mustar (2000) would call it.

In Figure 2 we present results on the growth of CWTS' compass activities over time. The graph displays all figures on output categories together, indicating total activity of the group.

Visual inspection of the activity output pattern clearly shows the first two phases of a standard life-cycle pattern from 1980 until the early 2000s. After this, however, instead of an expected stable continuity or decline phase, a new growth phase starts. Statistical analysis of the output data confirms a three-phase development (Figure 3), by significant changes of the average output level at two points in time: 1987 and 2005 (confidence above 99%). The boost of activities as from 2005 is not in line with a standard life-cycle pattern, as this would imply stable continuity, or a decline phase to start (for both of which no statistical evidence is present). Therefore, this third phase can be interpreted as the start of a novel (second) life cycle. The boost of activities is presented by increased output of research reports[5] and of international presentations (Figure 4).

CWTS staff members confirmed that the number of commissioned projects had indeed risen rapidly since CWTS started its company in 2002 — CWTS bv — for delivering routine products, such as citation analysis for research evaluation.[6] Thus, this new phase seems to be of an application-oriented nature.

The aggregated output analysis points to a development of CWTS in three-phases (Figure 2):

Table 1. Domains of activity and output categories of CWTS

	Domains of activity			
Output categories	**Science**	**Private/government**	**Public info/debate**	**Education**
International journal articles	■			
Reports (national and international)		■	■	
Presentations – international	■	■		
Books and book chapters	■	■		
Professional media – national			■	
Presentations – national			■	
Teaching lectures and courses				■

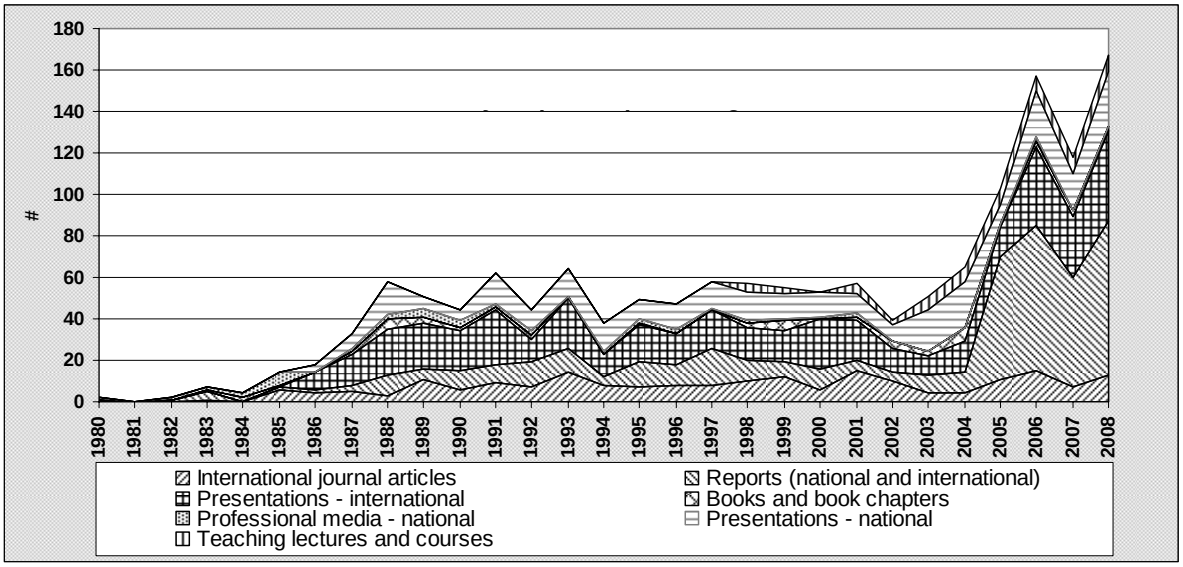

Figure 2. Activity output growth of CWTS, 1980–2008

1. A period of starting-up activities, from 1980 to the end of the 1980s, taking some eight years;
2. A stable period of 'saturated growth', with a ceiling of available resources, from the end of the 1980s to the beginning of the 2000s, enduring over 15 years;
3. A boost of activities from 2005 until the present day, in particular from increased activities in presentation and application of research, probably related to the starting of CWTS bv.

This long-term pattern looks like a repeating life-cycle pattern, where the stable period of a first cycle is interrupted by the start of a second cycle. The pattern could also be interpreted as an instance of the 'punctuated equilibrium model' where stable periods are punctuated by short periods of radical change in which a group attempts to improve its fit with the demands of its context (Arrow *et al*, 2005: 329). The context, in this case, has changed as the demand for bibliometric products has increased substantially in this decade. At the same time, CWTS' internal situation changed; in 2002 it set up a company to commercialise standardised basic and advanced indicators deliverable from its data-system (CWTS, *Annual Research Report*, '04–'06).

We now turn to the second indicator, the stability of the activity profile (Figure 5). We measure this with an *activity profile similarity indicator*. This indicator reveals change in the mix of output.

Visual inspection of similarity change gives a similar three-phased picture as the one for activity growth. In the 1980s, the activity profile fluctuated and went upwards, after which it remained very stable until the early years of the 2000s, when the activity profile became less stable, fluctuating until 2006. Statistical analysis (change point analysis) confirms a change of the similarity level, as of 1988, towards a stable very high level, indicating stability of activities. The fluctuation of the similarity around 2004 is

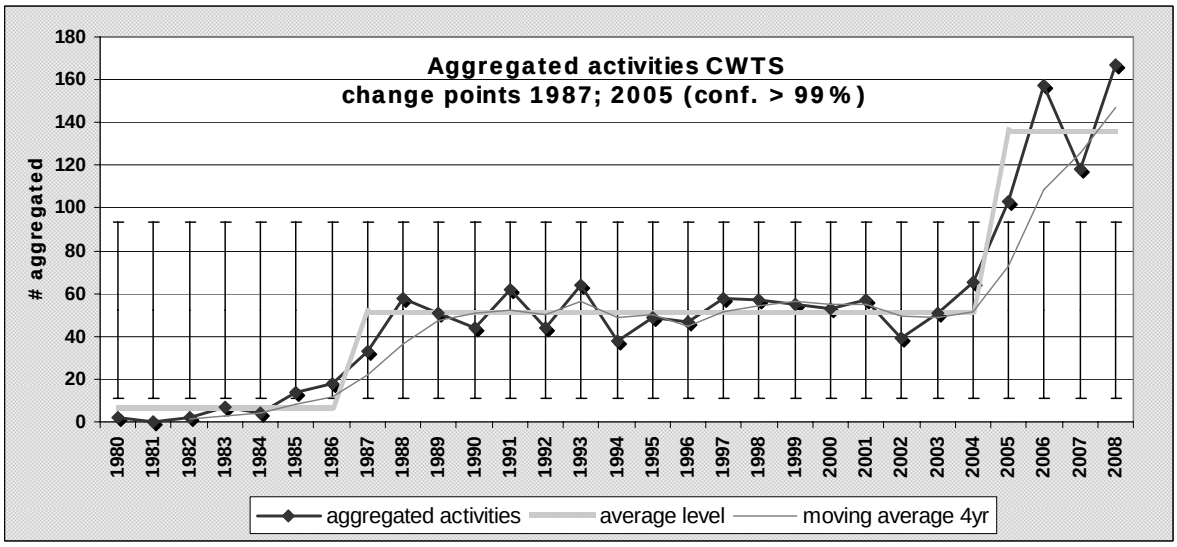

Figure 3. Analysis of aggregated output: time plot+std; moving average, and level changes.
Note: For analysis of level changes we used Change-Point Analyzer Software, by Taylor (2008)

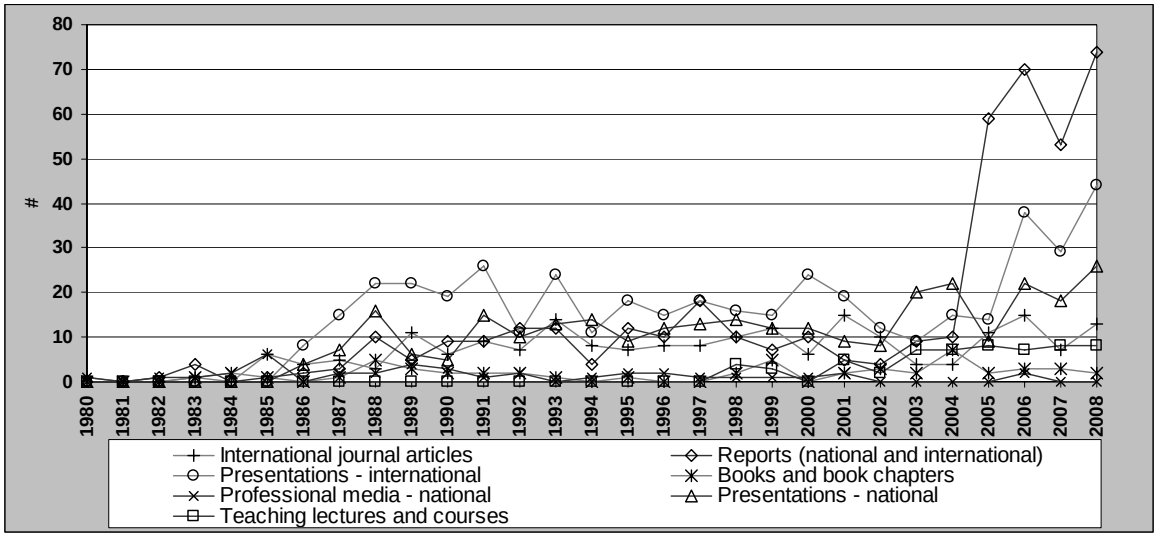

Figure 4. Activity output growth per category, CWTS, 1980–2008

not significantly deviant (90% confidence level), and the low values of 2003 and in particular of 2005 are statistically detected as outliers.

On the other hand, the moving average line reveals a gradual downward trend in these years. Thus, the profile similarity development indicates a two-, and possibly three-, phased development. After an initial period of searching for a fit mix of activities, until 1988, CWTS found a very stable mix of activities, consisting of a combination of scientific output, presentations, both local and abroad, and a steady output of reports from commissioned work. In the annual reports it is stated repeatedly that CWTS 'lives' mostly on commissioned work, acquiring 80–90% of its resources from this. In the onset of the recent boost of activities, since 2005, there was some fluctuation in stability of the profile, but it stabilised, and values are very high again in the most recent years (since 2006).

The combination of activities in the stable second phase (Figure 6 upper) points to the dual strategy of realising academic goals as well as providing interesting information (products) for professional and governmental target groups. The large number of (inter)national presentations, presumably, was required to attract the attention of relevant audiences to its competences and products. The activity profile (Figure 6 lower) over the last period, from

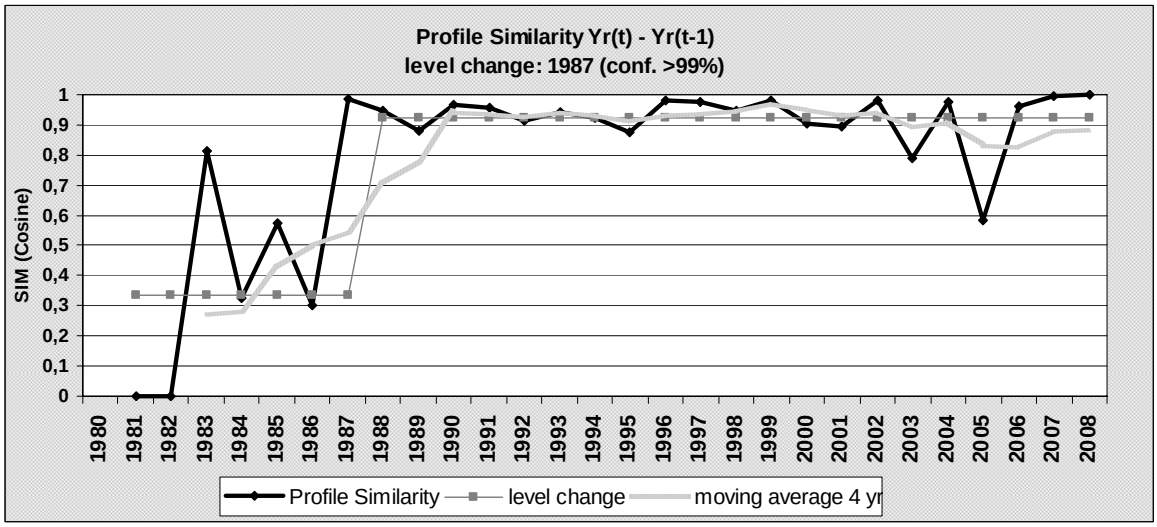

Figure 5. Activity profile similarity (t_n to t_{n-1}), for CWTS, 1980–2008
Note:

$$\mathrm{Sim}(APyr_t, APyr_{t-1}) = \frac{\sum_{i=1}^{n}(Ai_{yrt})(Ai_{yrt-1})}{\sqrt{\sum_{i=1}^{n}(Ai_{yrt})^2}\sqrt{\sum_{i=1}^{n}Ai_{yrt-1})^2}} = (0,1)$$

where

$APyr_t$ = activity profile: items on activities of category *i*–n, in year *t*
Ai_{yrt} = output items in activity category *i* (e.g. journal publication) in year *t*

Sources of this 'cosine' formula are G Salton and M J McGill (1983), and W P Jones and G W Furnas (1987); the approach is the same as applied elsewhere to compare term profiles of document clusters (Braam, 1991)

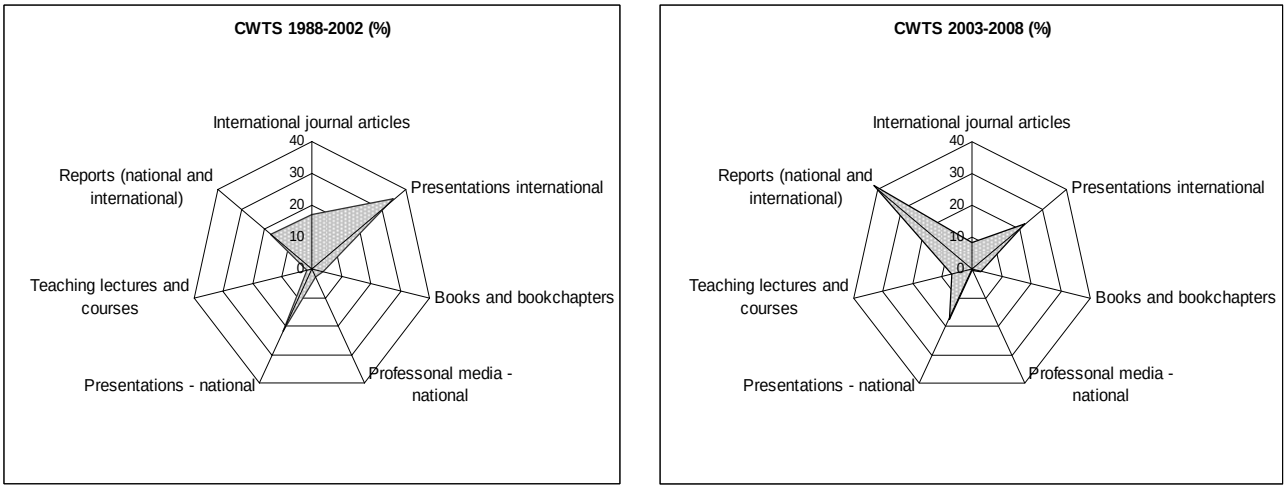

Figure 6. Activity profiles of CWTS in its most recent periods, 1988–2002 and 2003–2008

2003–2008, mainly shows intensification of report outputs, and reflects increased demand for this product category. This illustrates that the impact of added basic funding (since February 2008) is yet to come.

The third indicator of dynamics that we use measures the focus of activities in domains (Figure 7).[7] Focus levels are calculated as the relative amount of output in new market segments of CWTS.

First, for the scientific domain we measured the percentage of articles in journals not used earlier as outlets by CWTS staff. Second, we measured the percentage of presentations given at institutes in countries that had not been attended by CWTS before. Third, we measured commissioned work for agencies in countries not involved earlier. Finally, we measured the percentage of new contributing authors to CWTS scientific publications, and plotted a four-year moving average for this, to inspect trend.

The pattern of focal change is (as partly for the other indicators), typical for a life-cycle pattern of development: an unstable first period, until the beginning of the 1990s, followed by a long period of stable focus at a low level of change, apart from incidental fluctuations in some of the output types. The low level of focal change indicates a specialisation strategy of CWTS. In recent years a remarkable upward shift occurs in the amount of newly contributing authors (as revealed by the four-year average trend line). The new co-authors are mainly incorporated in commissioned reports.

Crucial events and the life cycle

Can we explain the life cycle of CWTS in terms of crucial events and processes? To what extent were conditions indeed stable for CWTS, and what happened in recent years that caused a new life cycle to start? To find answers to these questions we inspected two sources of information.

First, we looked at developments in the scientific area wherein CWTS is active. As we showed elsewhere, scientometrics and science policy studies emerged as research fields in the 1970s and 1980s, and this formed a fertile environment for CWTS development (Van den Besselaar, 2000, 2001). Are

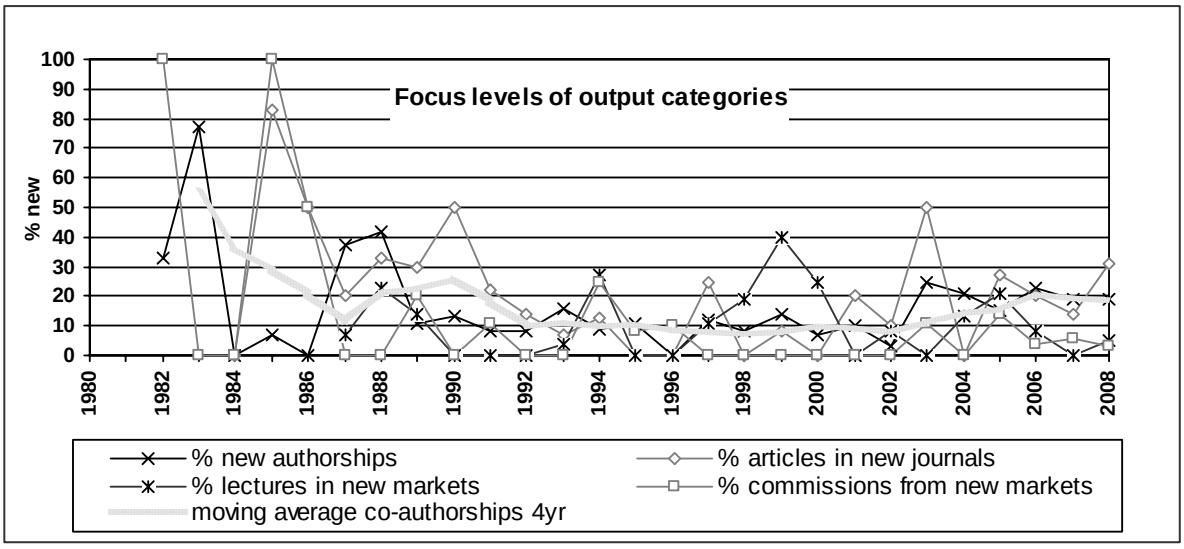

Figure 7. Focal change in CWTS activity categories, 1980–2008

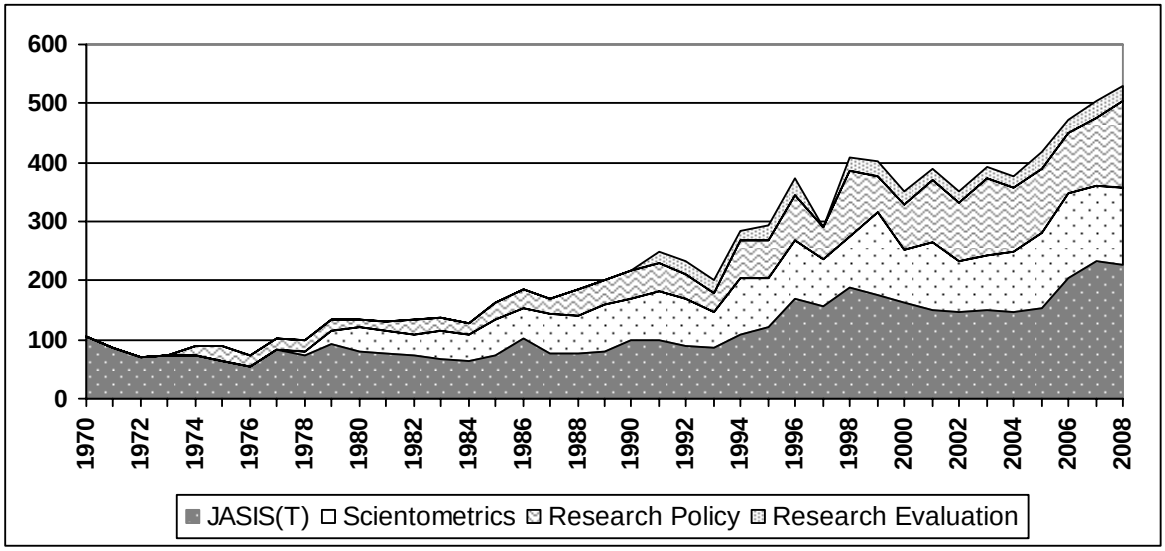

Figure 8. Size of the four main journals in scientometrics and science policy studies
Source: Web of Science, Thomson Reuters; except Research Evaluation 1991–1999, from journal editorial board
Note: The four journals are also the main journals CWTS staff publishes in.

developments of CWTS in line with those of the field? To inspect this, we gathered publication and citation data on the four main journals for CWTS: *Research Evaluation*, *Research Policy*, *Scientometrics*, and the *Journal of the American Society for Information Science and Technology, JASIS(T)*. Results of analysing the development of the number of publications in and citations to these journals give no obvious answer (Figures 8 and 9).

The results show a continued increase of publication activities in the field (Figure 8), indicating steady growth of the field. The articles in these four journals received a total amount of 96.304 citations, in an accelerating fashion since the late 1990s, nearly 85% of the citing documents (30.275 out of 35.943) stemming from other journals (Figure 9).

Closer inspection learns that these other journals, for a large part, relate to research areas such as management (20%), business (12%), economics (9%), and operations research and management science (8%). For Netherlands citing publications (1,252 in total; and also accelerating since the 1990s) these percentages are high as well (respectively: 25%; 18%; 17%; and 6%). It is thus clear that the accelerated citations since the late 1990s not only reflect the growth of the field itself, but also indicate increased interest as well from external areas, in particular from areas related to management and business, that we take to reflect a wider policy interest in indicators.

Whereas the observed external citation increase coincides with increased attention to CWTS routine products, the scholarly output of CWTS remained stable and did not catch up with the growth of the field. This may be explained by a lack of recognition of the field by local funding bodies, and as a result basic funding for CWTS remained minimal. The recent steep rise of citations to the four field journals may be taken to reflect an increased interest in the use of citation analysis in research performance studies and a related policy interest in performance assessment and/or ranking. The basic funding

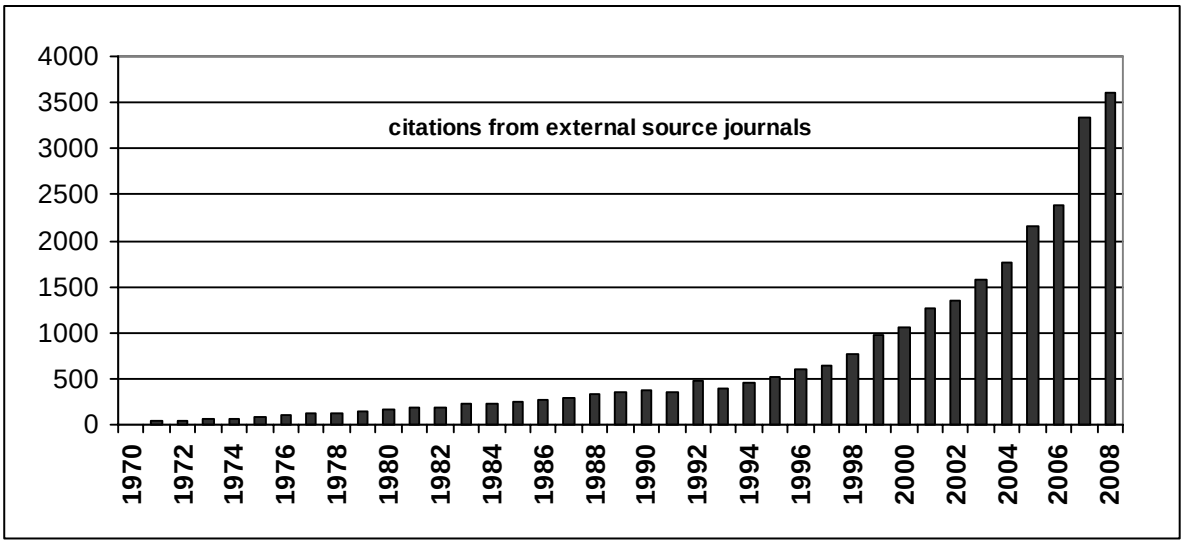

Figure 9. Documents citing main journals in scientometrics and science policy studies

recently obtained by CWTS from the Science Ministry is in line with such interest, but also brings with it more academic challenges.

Second, we looked at the CWTS annual reports (available for the years 1986 to 2008), and the most recent review report, for evidence of any changing circumstances mentioned by the group. In Table 2 we list a number of events taken from the annual reports of CWTS.

One obvious thing to look at is the mission formulation. At the programme level of CWTS the formulation has remained quite constant over the years: quantitative science and technology studies with a focus on indicators, cognitive processes, information systems and interaction between science and society. Another aspect is the organisational embedding of the group. In the early years, the growing Science Studies Unit was repositioned a

Table 2. Important events in CWTS history taken from annual reports, and a review report

Year	Noteworthy events
1980	First article: Van Raan, A F J and J G Frankfort 1980. An approach to university policy: a new research funding system. *Int. J. of Inst. Manag. in Higher Education*, **4**, 155
1981	First grant for the Leiden Science Indicators Project, from Ministry of Education and Science
1983	First book: Moed, H F, W J M Burger, J G Frankfort and A F J van Raan. 1980. *On the Measurement of Research Performance: the Use of Bibliometric Indicators.* University of Leiden
"	Science Indicators Unit located at Research Council RAWB (3 FTEs)
1985	First article in *Scientometrics*: Nederhof, A J 1985. Evaluating research output through life work citation counts. *Scientometrics*, **7**, 23–28.
"	First article in *Research Policy*: Moed, H F, W J M Burger, J G Frankfort and A F J van Raan 1985. The use of bibliometric data for the measurement of university research performance. *Research Policy*, **14**, 131–149.
"	First NWO Grants for projects on publication and citation characteristics, and citation statistics
1986	Located at Leiden University, within the LISBON Institute, Faculty of Social Science
"	First report: *On the Potentialities of Bibliometrics Indicators*, for Elsevier Science Publishers
"	Long-term programme on science and technology indicators, Ministry of Science contract
1987	First annual report (1986), Science Studies Unit
"	First International Conference on Bibliometrics and Informetrics, Diepenbeek, 8 papers by CWTS
1988	First annual report in English, with mission statement and programme focus
"	First *Handbook of Quantitative Studies of Science and Technology*, edited by Ton van Raan
"	13th Annual Meeting of Society for Social Studies of Science (4S), with eight papers by CWTS
1989	First thesis on Science Indicators (Henk Moed)
"	Move to new building, with new name CWTS, as autonomous organisational unit in Faculty of Social Sciences
1991	First theses on mapping of science (Braam, 1991; Tijssen, 1992)
"	First professorship at CWTS: Anthony van Raan
1994	First bi-annual NOWT report on S&T Indicators for the Netherlands (coordinated by Tijssen)
1995	Derek de Solla Price Award for CWTS member, Ton van Raan
1996	Prolongation of national indicators programme and European Community supported work
"	Member of Netherlands Graduate School for Science and Technology in Modern Society
1998	CWTS formal status of research institute within Faculty of Social and Behavioural Sciences
1999	Derek de Solla Price Award for second CWTS member, Henk Moed
2001	Research review of CWTS (assessment score: 'excellent')
2002	CWTS bv started to commercialise products and services, formally apart from the Institute
"	First CWTS annual (one-week) course on science indicators for students and policy-makers
2004	*Handbook of Quantitative Science and Technology Research* (co-edited by CWTS)
2005	Textbook: *Citation Analysis in Research Evaluation*, Springer (by Henk Moed)
2007	Move to Willem Einthoven Building, on the Leiden University Campus
2008	Basic funding CWTS Institute from the Ministry of Science, Culture and Education
"	Additional professorship appointed (in science policy)
"	CHERPA: European Consortium for Higher Education and Research Performance Assessment
"	Research review of CWTS (assessment score: 'excellent')
2009–2010	Core staff members leaving or retiring; New professor appointed (in science and innovation studies)

number of times within Leiden University, but from the early 1990s onwards CWTS has had a stable place in the Faculty of Social and Behavioural Sciences. The more commercial activities have always been part of the CWTS program, but became more explicit from the year 2002, when CWTS started a separate company for this, which is tightly linked to CWTS institute, through a personal union of CWTS staff members. Apart from the growth of the market for bibliometric analysis already mentioned above, the most striking change in local circumstances is the substantial increase of basic funding for CWTS by the Ministry of Education, Culture and Science.

These events (Table 2) are for a large part in line with the life cycle of CWTS, as visualised in the graphs (Figures 2, 3, 5 and 7) presented above. The editorship of the first *Handbook*, and the organisation of the First International Conference on Science and Technology Indicators, followed by the first PhD thesis, mark the end of the start-up period. The events from 2002 on mark the shift to a new phase, ending the stable second part of the life cycle of CWTS, based on the foundation of the CWTS company for research evaluation products. The second *Handbook,* and even a textbook on citation analysis in research evaluation, as well as the start of the annual teaching course on indicators, all point to partial mission completion regarding the development of performance indicators. This is in line with the onset of increased applied activities in this area (Figures 4 and 6). Finally, the basic funding obtained from the Ministry of Science, the recent addition of new professorship positions, and the upcoming changes in the core staff may mark the onset of a — qualitatively different — new life cycle, but this is not yet visible in the indicators.

Facing a new life cycle?

Given the present situation, what can be expected of the future activity development of CWTS? Will its application-oriented activity profile stabilise at the current level or change qualitatively? As stated in its *Annual Report* (CWTS, 2008: 3), CWTS sees its mission as 'conducting cutting-edge basic and applied research in the field of quantitative science and technology studies', and 'to develop advanced applications on the basis of its research'. Its competitive edge, it states in the same annual report, lies in the strength of its bibliometric data system enabling its staff to create and apply high-value bibliometric indicators and maps. With this core capability it sees itself as well positioned to be one of the major players worldwide in the science and technology indicators and mapping arena, competing in a growing research field and growing market for applications (CWTS, 2008: 3). Thus, it sees its future as a continuation of what it has been doing so well over the last decades.

At the basis of this lies an ongoing activity of CWTS from the early start of its existence: the development and improvement of a database (licensed from Thomson Reuters/Thomson Scientific/ISI) that combines data from different sources. The resulting information system is suited for application in rather standardised research evaluation studies, and for delivering standardised basic and advanced indicators (CWTS *Annual Report*, 2004–2006).

However, two of the recent events — the start of the company, and the newly obtained basic funding — may create potentially conflicting incentives. The company, on one hand, drawing on CWTS data system and information products to sustain and boost commercial and applied activities, has been an important driving force and defining characteristic of CWTS during the last seven or eight years. On the other hand, the new influx of basic funding constitutes a novel input and 'environmental factor' as it triggers a broadening scope of research activities, from evaluative bibliometrics to a wider field including science policy studies and science and innovation studies. Moreover, CWTS is expected to become more active in regular teaching activities at Leiden University.

In the period to come, the institute faces the challenge to adjust its successful strategy to fit a broader research scope and to include extended activities in the educational domain. Its competitive edge, as mentioned in the 2008 *Annual Report*, may turn out to be too narrowly formulated for the future. Starting a next (third) life cycle asks for reflection on the mission and adaptation of its strategy. And this is precisely what the proposed life-cycle theory predicts for the early phase. We expect that within five years from now, CWTS will be involved in a rather different mix of activities from what it is today, reflecting the changed internal and external conditions.

Conclusions and discussions

In this paper we analysed the history of a research institute, in terms of long-term patterns in output and activities. The analysis provides interesting results that help the understanding of the dynamics of research groups. In the case of CWTS a life-cycle pattern has been found that correlates with stable internal conditions. External conditions in the field were not stable, in the sense that the fields of

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scientometrics and science policy studies were growing fast. CWTS could not benefit from these because local basic funding was small and constant. However, at the end of its first life cycle, an important event triggered new growth: the fast-increasing demand for the standardised products of CWTS. This resulted in a second life cycle, which will be affected by a more recent external change: newly obtained substantial basic funding. Both these events, in combination, ask for a reorientation of the mission and strategy of CWTS. The bibliometric, life-history indicators clearly reflect this transition phase.

Of course, in this paper we analysed only one case for the study of research group life cycles. However, we plan to publish other studies to show whether or not the case-study analysis in this paper can be generalised to a wider range of research groups (Braam and Van den Besselaar, in preparation). If that is correct, one may theorise about the implications of the life-cycle theory for managing the science system, for example, through research evaluation. If the long-term development pattern of research groups and institutes is mainly driven by internal conditions, as reflected in the group mission and strategy, and external circumstances, such as available resources and competition, we could ask what implications this has for research performance evaluation exercises.

A first issue following from our theory is the phase-dependency of performance, implying that groups in the start-up phase of their development will perform less then stabilised groups, if circumstances are the same. This point is not regularly taken into account in evaluation exercises.

Another issue implied by the theory, concerning saturated growth, is the question whether providing the right conditions may be sufficient, and may lead to more efficient and effective ways of influencing the productive development of research groups, rather than frequent in-depth evaluations.

Lastly, an issue to address is the question to what extent forced changes of activities and missions may turn out to be disruptive 'shocks', as the choice of activity domains and realised output profiles of research groups reflect the specific (accumulated) missions and adaptive strategies that are vital fits of groups to their environment. In case of CWTS, this point is made by the recent review panel evaluating CWTS (2002–2007), in relation to the added funding and foreseen transition of leadership: 'there are potential threats to the long-term vitality of the centre that now need to be addressed with vigour' (Leiden University, 2008: 8). The results of our life-cycle analysis of CWTS are in line with this conclusion of the review.

Acknowledgements

We thank Ton van Raan for providing the opportunity to inspect data on the history of CWTS from its Annual Reports, and its project database, and Thed van Leeuwen for assisting in the use of this and checking consistency and validity of our interpretations of these data. We also thank William Page, from Beech Tree Publishing, for providing us with data on the 1991–2000 issues of *Research Evaluation* not covered by the WoS, and Thomas Gurney for proofreading. We acknowledge the useful comments of several reviewers on an earlier version of this text. We profited from earlier draft presentations and discussions of this paper at the PRIME-ENID STI-Indicators Conference, Oslo, Norway, May 2008, and at a CWTS staff meeting, November 2009.

Notes

1. Larédo and Mustar (2000) focus on laboratories.
2. A domain is a relatively secluded social context wherein a research group performs activities. Larédo and Mustar (2000) distinguish five such domains (or 'dimensions'): the scientific arena; the education system; the economic system; the government; and public media (debate, public understanding of science); and typify laboratories by their involvement in these five domains.
3. Teleological: related to an ultimate purpose. Dialectical: related to contradiction (thesis, antithesis) and solution (synthesis).
4. Integer counts of items per year were used as weights for all output categories. At the item level, possible differences in time and efforts to produce them, both between and within categories, may exist, but data to correct for this are lacking. As we analyse long-term patterns in output production this does not produce a large problem, and data for each output category can be followed. Local fluctuations in the series, due to the production of 'rare' items consuming much time and effort, will be captured if other output then decreases as a result. For performance analysis, however, such data problems may be more sensitive (Moed, 2005).
5. The data about commissioned research reports for recent years are taken from the CWTS project database.
6. CWTS bv is wholly owned by the Leiden University Holding (LURIS).
7. This indicator was introduced earlier, in a study of genomics research (Braam, 2009: 69–72).

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