

Indicators for comparative analysis of public project funding: concepts, implementation and evaluation

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

Despite its relevance for research funding, few comparable data are available in official R&D statistics on the amount and composition of project funding. This paper discusses in detail the methodology developed in the European Network of Excellence on Research and Innovation Policies PRIME for systematically producing indicators on public project funding which allow for comparative analysis between different countries and across periods of time. We introduce the design of the methodology, and discuss delimitation problems and how to develop suitable classifications of project funding instruments, as well as data availability and limitations. We present examples of our quantitative results for six European countries and of the questions they raise for comparative policy analysis.

IT IS HARDLY POSSIBLE to undervalue the importance of project funding — broadly defined as money attributed to a group or an individual to perform a research activity limited in scope, budget and time — for research policy. It is considered as the second major stream of public research funds alongside general institutional funds (Millar and Senker, 2000) and, according to some estimations,

accounts for between a third and a quarter of total public funding in most European countries (Geuna, 2001; Lepori *et al.*, 2006).

The relevance of project funding for research policy stems also from some features of this instrument as most project funding instruments allocate money directly to individual groups according to criteria and selection processes decided by the managing agency. This means that, in principle, project funding could allow for a more selective distribution of money, for example targeting the best research groups, promoting some subjects or supporting structural change such as the creation of cooperation networks and structures (Braun, 2003). Hence, the increase of the share of project funding in total public funding of research over the last 20 to 30 years has been linked to the attempt from the state to steer research activities more actively (Geuna, 2001; Braun, 2003).

Despite its importance, project funding as such has rarely been examined in research policy studies. The subject has been touched upon in some general studies of national research policies (Larédo and Mustar, 2001) and funding systems (Braun, 2003; Millar and Senker, 2000). At the same time there have been a number of studies concerning individual funding agencies, focusing essentially on their

Dr Benedetto Lepori is at the Università della Svizzera italiana and Observatoire des Sciences et Techniques, via Lambertenghi 10a, CH-6904 Lugano, Switzerland; Email: blepori@unis.ch; Tel: +41 58 666 46 14; Fax: +41 58 666 46 19. Prof. Dr Peter van den Besselaar is Head of Department, Science System Assessment, Rathenau Institute, PO Box 95366, 2509 CJ The Hague, The Netherlands. Dr Michael Dinges is at Joanneum Research – Institute of Technology and Regional Policy, Haus der Forschung, Sensengasse 1, 1090 Vienna, Austria. Dr Barend van der Meulen is at the Centre for Studies of Science, Technology and Society, School of Business, Public Administration and Technology, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands. Bianca Potì and Dr Emanuela Reale are at CNR-CERIS, Via dei Taurini, 19, 00185 Rome, Italy. Dr Stig Slipersaeter is at NIFU STEP, Wergelandsv. 7, N-0167 Oslo, Norway. Dr Jean Theves is at the Observatoire des Sciences et Techniques, 93 rue de Vaugirard, 75006 Paris, France.

intermediation role between the state and the scientific community (Braun, 1998; Van der Meulen, 1998) or on the evolution of individual agencies (Benner and Sandström, 2000; Van der Meulen, 2003). Some studies have also examined specific research programs, such as the European Framework programs and, actually, most studies trying to develop some generalizations concerning funding models have been based on the extension of case studies (as for example Benner and Sandström, 2000). Finally, data on repartition of project funding are routinely elaborated as a part of the evaluation of funding agencies and of research programs, as in the case of European programs (Siune, 2004); however, exactly because of their objective, these studies cover normally a single funding instrument and funding period.

However, there has been a notable lack of analysis considering the *whole organization and portfolio of project funding instruments* in a country, comparing it with other countries and assessing its evolution over time. The issue is of high relevance since, in today's differentiated funding systems for policy-makers and for research performers, the palette of project funding instruments — as well as their share in funding volume — is more important than individual instruments and agencies. This portfolio analysis becomes even more important with the development of European funding instruments, whose impact on research activities is likely to depend also on their interaction with (different) national contexts of research funding (Dinges and Lepori, 2006).

This situation is also due to the lack of indicators allowing comparison quantitatively of project funding portfolios between countries. To overcome this limitation, the authors developed and implemented in the last years — in the framework of a project inside the PRIME Network of Excellence on research and innovation policy — a methodology for producing indicators based on the collection of data directly from the funding agencies and, on this basis, producing a set of in-depth comparative analyses of public systems in European countries (Lepori, 2006b; Lepori *et al.*, 2007; Theves *et al.*, 2007; Potì and Reale, 2007).

The focus of this paper is on methodology and empirical evidence. We present in detail the main concepts behind the development of project funding indicators and discuss carefully methodological issues, including definitions, delimitation problems, comparability and data availability and limitations; moreover, we introduce some categories and classifications useful for comparative analysis. Finally, we show how some of the quantitative results obtained until now display the applicability of the methodology and the type of science policy questions for which these indicators can provide useful insights. As our focus is the exploration of new methodological approaches, the reader should refer to the cited papers for more in-depth policy analysis.

Designing a methodology to measure project funding

In this section, we review the existing information on project funding in the R&D statistics and the reasons for its limitations; then we introduce the methodology we have developed and we discuss a number of issues concerning delimitation of project funding, data sources and comparative classification.

Project funding and R&D statistics

Despite its importance for research policy, project funding plays a limited role in the R&D statistics based on the *Frascati Manual* (OECD, 2002; for a general presentation and discussion see Luwel, 2004; Godin, 2005). R&D statistics are basically concerned with a detailed measure of R&D expenditure and its breakdown by performers and sectors. Performers are then requested in the R&D survey to provide a breakdown by source of funds, but limited only to the five sectors used by the manual (business; government; higher education; private non-profit; abroad; OECD, 2002: 118–120). This lack of interest for distinguishing between *modes of allocation* of funding is probably explained by the historical context in which the *Frascati Manual* was born in the 1960s, when the main issue was to compare the national effort in R&D (Lepori, 2006a).

The interest in allocation modes emerged later in the 1970s and 1980s for two main reasons: first, the stagnation of the volume of public research funding — measured as percentage of GDP — and second, a new policy rationale for an efficient use of public funding through competitive allocation mechanisms (Geuna, 2001). However, R&D statistics have not been adapted to provide indicators concerning project funding; in a project on steering and funding of public research institutions, the OECD tried to collect some data from national statistical offices, but only five countries provided answers covering at best the period between 1996 and 2000 (OECD, 2003).

Only for higher education institutions are some data available broadly comparable to what we define as project funding. The *Frascati Manual* provides a detailed annex on the measurement of R&D in higher education, where it distinguishes between “general university funds” (GUFs) — the share of the general state contribution to the university budget devoted to R&D — and direct government funds in forms of grants and contracts (OECD, 2002, annex 2). The calculation of R&D expenditures differs accordingly: GUFs are calculated through the share of time of personnel devoted to R&D, while direct funds should be identified as such.

Accordingly, OECD databases provide series on direct R&D funding to the higher education sector for most countries since the 1980s with the exception of Italy and Germany (data available only from 1995). These data have been used by Geuna (2001)

to support the thesis of an increasing share of project funding in funding of universities. However, they have a number of limitations. First, there is no such distinction for the other performing sectors and, especially, for public research laboratories and it is thus impossible to compute the share of project funding of total public funding. Second, there is no breakdown by funding instruments and agencies and thus it is impossible to analyze the composition of project funding. Finally, the quality of data is rather problematic since the coverage of direct R&D funding might differ between countries for a number of reasons: different definitions of what are to be considered as “direct government funds”, different accounting systems and, finally, different levels of coverage in central accounts of universities (see for instance OECD, 2000; Godin, 2005). At best, these data can be used as a rough benchmark to check the results presented in this paper. Recent work on higher education funding has confirmed the existence of wide variations in the coverage of sources of funds between countries, but also between individual institutions (Bonaccorsi *et al.*, 2007).

We notice that at least in some countries national statistical offices are making an effort to overcome these limitations by matching data from the performers with data from funding agencies, thus providing detailed figures on flows of funds in the public sector. This is the case in Switzerland, where contracts and projects funds are systematically recorded by the Swiss Federal Statistical Office and figures are provided including the Swiss National Science Foundation as intermediary (Lepori, 2006b).

From a performer-based to an agency-based approach

Beyond the technical aspects concerning data collection and quality discussed in the previous section, the whole design of R&D statistics is not well adapted to produce indicators on the volume and composition of project funding. Figure 1 displays a simple structural diagram of the main flows of public research funding in developed countries (Millar and Senker, 2000). Thus, funding can be divided between general funds — normally attributed as a block grant to whole

universities or research institutes — and project funds; the latter are normally distributed by a number of agencies — intermediaries, ministries, international organizations — directly to individual research laboratories or individuals.

R&D statistics have been purposefully designed to record R&D expenditures at the level of performers, since their main aim is to measure the national research effort and to provide detailed data on expenditure of different performers. However, if the aim is to analyze and compare the composition of project funding — the share of instruments, agencies and performers groups — this approach is impractical since data have to be collected where funds are disaggregated, namely at the level of individual grants and contracts. Now, the number of grants is typically in the range between some hundreds to tens of thousands for the largest agencies and programs such as the European Framework programs. This raises issues of data collection (if data are not collected through other reporting mechanisms) and of coverage, especially between different institutions and countries, which cannot be solved easily. Moreover, even if the performer-based approach is worth being pursued for the future, it is unlikely that it will be usable for the past, since breaks in series in higher education and R&D statistics occurred in most countries during the 1990s (Esterle and Theves, 2005; Lepori, 2006a).

For these reasons, we have chosen an approach where data are collected at the level of funding agencies, where flows are aggregated, thus drastically reducing the size of data to be collected (typically, between 10 and 15 significant project funding instruments in each country). Since these are public agencies, we could assume that most of the data are available on public documents or on request and that, in principle, also data referring to the past could be retrieved with a reasonable effort.

Of course, this simplification comes at the price of a loss of information in the repartition of funding flows between beneficiaries, since normally only the breakdown between main sectors can be provided, and thus the methodology discussed here is not necessarily well suited for very detailed analysis of the distribution of project funds. This remark underscores

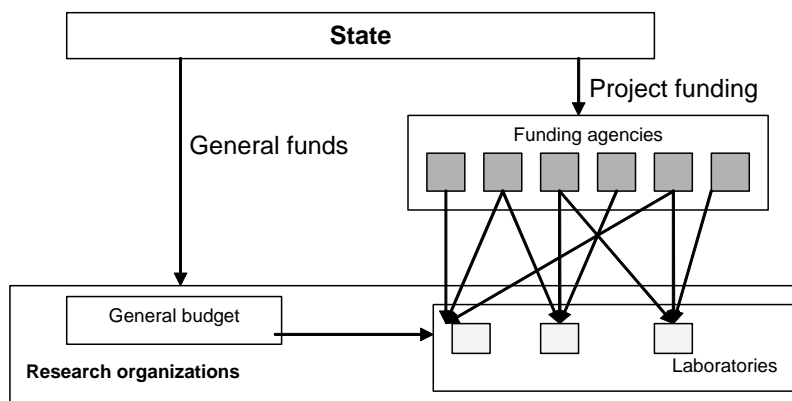


Figure 1. Structure of public funding of research

that the design of the indicators and of their production methodology has to be closely linked to the underlying policy or research questions, and to the intended use of indicators.

Basic choices

Our approach is based on the definition of a (country-specific) *list of project funding instruments* for research and on the collection for each of them of data on the funding volume, its repartition between beneficiaries and changes over time. Data were then aggregated to produce national totals and breakdowns by categories of agencies, type of instrument and beneficiary groups. Data were collected first for the baseline year 2002 and then backwards with the aim of producing series for the period 1970 to 2002.

The main difficulty with this methodology is to define the instruments to be included in project funding (vs. general funding) and for research activities (vs. for other activities). This selection was based on four main criteria:

1. Funds are intended to serve for research activities and there are some indications that most of them are used for activities classified as R&D according to the definitions of the *Frascati Manual*.
2. Funds are attributed for a research activity limited in time, scope and budget (distinguishing them from recurrent funding).
3. Funds are allocated by an agency external to the research organization and, normally, are attributed directly to the institutional subunits.
4. The total amount is significant for the total volume of project funding. Thus, the aim was to limit the analysis to quantitatively significant

instruments. This criterion was applied for the overall volume of project funding, but could be in finer analyses applied to subsectors (leading to a different list of instruments).

This work was performed by each national participant based on their expert knowledge of the national systems and led to the design of project funding charts as in Figure 2; these charts — produced for the years 1970, 1980, 1990 and 2002 — are essential for the methodology since they provide a guide on the data to be collected.

Delimitation issues

These criteria give rise to delimitation problems concerning specific instruments that were discussed in project meetings to ensure comparable choices in different countries, leading to the definition of categories of instruments to be included or excluded. Normally included are:

- Funds from research councils and agencies for technological R&D, except funding to own laboratories.
- Long-term schemes such as centers of excellence are also included (for example in Austria and Switzerland) since the allocation is basically competitive and they are granted for a limited period of time (even if longer than for projects).
- European Framework programs and other international programs and agencies, including Eureka and contracts from the European Space Agency.
- Contracts and programs of the ministries and from regional authorities which are clearly defined as research funding.

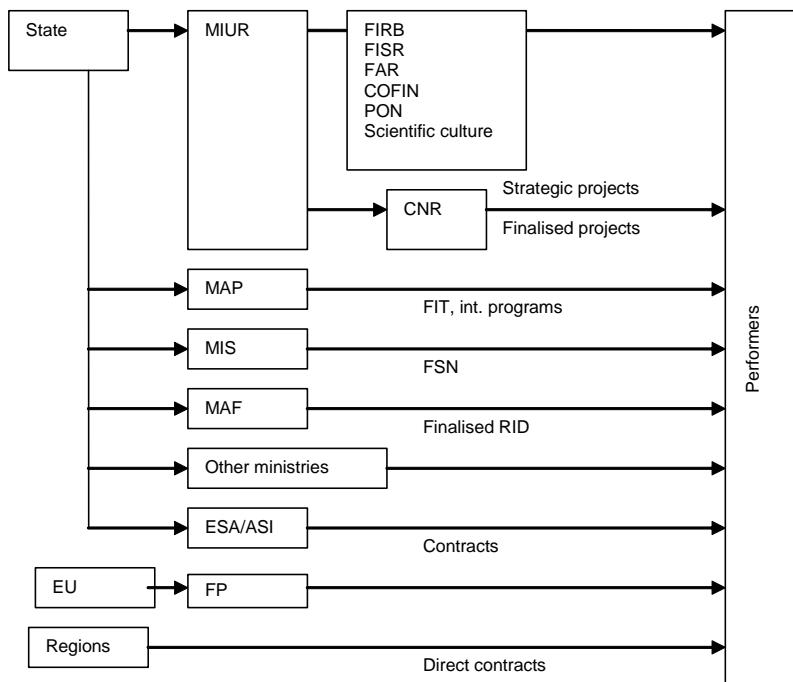


Figure 2. Chart of project funding instruments, Italy, 2002

- Individual grants (for example for PhD students) if they are attributed competitively through national schemes for research (thus excluding scholarships).
- Charities where they are significant, for example in medicine in The Netherlands since, even if the origin of funds is from the private sector or from individuals, the type of instrument is rather similar to public project funding.
- The research part of the European Structural funds has been included under national funding since the project allocation is decided on the national (or regional) level. However, these funds are considered only in countries where we know that they are significant, such as Italy (see European Commission, 1999, 2003, for overall statistics on R&D funding in structural programs).

Internal funds to research organizations, even if allocated competitively, have been excluded, as well as funds targeted only to economic promotion and support to industry, such as start-up programs or tax reductions for new companies. Finally, we excluded private contracts to public research organizations, since these cannot be measured with this methodology; however, we used data on total private funding to the public sector from the R&D statistics for comparisons.

In fact, most delimitation problems occurred at the borderline between development and industrial production, especially in high-tech sectors where this delimitation is more difficult to be drawn (the typical case being European Space Agency contracts). In general, our choice was rather extensive to include all instruments that have at least some R&D funding, even if a part of the funds could be devoted to innovation and economic production.

A useful check is to compare project funding data with the total amount of public funds to the private sector in the R&D statistics (which we expect to be essentially composed by project funds). As shown by Table 1, for all countries there is a reasonable good correspondence, with the exception of Norway where the difference is due to a different classification of a number research institutes (included in the public sector in our data rather than in the private sector in the OECD data). For Italy our value is significantly higher (probably owing to the inclusion of some innovation funds which do not fund R&D

activities only), while Dutch data are underestimated since it was not possible to divide among beneficiaries a number of instruments devoted to innovation.

Finally, a very specific case is France where a large part of public funding is distributed to the joint laboratories between CNRS and universities through the allocation of human resources paid by CNRS; this modality presents some features of project funding, even if resources are allocated through people rather than money. Thus, for France we developed two sets of indicators, one considering only “traditional” project funding, the other also including CNRS allocations to joint laboratories (Theves *et al.*, 2007).

These remarks show that the clear-cut distinction between project funds and general funds leaves room for a number of intermediary cases, where a structural component is present even if funds are allocated competitively and for a limited period of time (network of excellence schemes being a typical case). The development of a more refined classification of funding schemes is thus an area of further work.

Sources and data availability

In all the considered countries, there is no systematic collection of data on project funds, except for some periods (for example in Switzerland data have been collected by the Swiss Science Council for the years 1988–1999). Thus, data had to be collected from a variety of sources, including reports of research ministries and of funding agencies or state accounts. As a consequence, availability and quality of data varied and getting some uniformity was a major task.

Data from autonomous agencies such as research councils were the least problematic, since most of them produce detailed yearly reports; also for the past data availability was quite good except in case of mergers (in Norway at the beginning of the 1990s). In a number of countries (including Austria and Switzerland) complete lists of funded projects including amounts are available, which could be exploited in the future for detailed analyses.

Programs and contracts managed from ministries gave much greater data problems, since normally there is no uniform reporting across all programs (a notable exception being Switzerland where these data are collected in the R&D survey). In some

Table 1. Project funds and total project funding for the private sector, 2002, national currency (2000 for Netherlands)

	Austria	France	Italy	Netherlands	Norway	Switzerland
Project funding	189	2,210	1,120	156	347	161
Total public funding	175	2,249	861	231	1,568*	163
%	108%	98%	130%	68%	22%	99%

Notes: Project funding as calculated in the project.
Total public funding to the private sector from the MSTI database
* average between 2001 and 2003

countries a few summary reports are available (for example BMBWK, 1977–2002, for Austria), while in the other cases data had to be compiled from state budgets or requested directly to the concerned ministries. In no country were complete data available on contracts and programs funded by the regional authorities, but all participants shared the view that their overall volume was not large.

The most problematic part of data collection concerned international programs. For European Framework programs, data on national repartition are scarce: in a number of countries (including Italy and France) only estimates for whole programs and with a limited breakdown by beneficiaries are available (some general data are also available in the annual report of RTD activities of the European Commission [2004]). For the contracts of the European Space Agency the situation is even more difficult since only in some countries sparse data on recent years are available (for example Austria and Switzerland); for time series, we used as a proxy 85% of the national contribution to ESA, since this return is on average granted to member countries. For EU structural funds in Italy a careful analysis based on national data was needed to separate the project funding component (excluding infrastructure).

Calculation of the amounts and time series

Calculation of the amounts also raised also some difficulties. First, different sources do not always adopt the same rules: in some cases the total amount of the grant is reported, in other cases only the funds paid in the current year. This does not give rise to problems if the amount granted each year is reasonably stable, but can lead to strong variations from year to year for programs with irregular calls (for example EU FP). In these cases, some kind of averaging was needed (see the national reports for details).

Projects funded through repayable loans to private industry were also a source of concern, since one should calculate the effective cash value of the grant. This issue is mentioned but not dealt with in detail in the *Frascati Manual*. As a matter of fact, these cases were quite limited in the studied countries and we could rely on national estimates. For Italy the two main funds for business (FAR and FIT) include repayable loans (low interest loans) and the Italian Association for Industrial Research (AIRI) has made an estimation of the effective benefit to business firms, that is, the amount effectively received by industrial firms after having deducted refunding. For FIT the estimates show on average only 25% of the amount is the real benefit to industrial firms and thus FIT values have been reduced correspondingly. For FAR, on average only 50 % of the total amount is the real benefit to industrial firms.

With these adjustments, it was possible to collect complete data for the baseline year 2002. The construction of time series was also possible, since

typically in the past the number of instruments was smaller, going back to 1970 for Austria, Norway and Switzerland and 1971 for Italy. A major problem is, however, that for the past it is nearly impossible to check for data specificities and reporting mistakes, as is the case for the strong oscillations of project funding volume in Italy in the second half of the 1970s. Moreover, it was generally impossible to provide a breakdown of project funding by beneficiaries. Finally, some incoherency can be generated by the need to use different sources across time and by varying detail of information (for example in Norway very detailed data are available for the 1970s and 1980s, but this series ends at the mid-1980s).

A major difficulty was normalization to compare funding volumes across countries. We resorted to two indicators, project funding as percentage of total public funding (GERD GOV) and as percentage of GDP. The first one should be more significant, but data quality is not very high since a large part of GERD GOV is composed of the general university funds, whose measure is problematic (OECD, 2000; Lepori, 2006a); the second one is more robust, but less significant (even if we know that in most developed countries the share of public research funding on GDP did not change dramatically in the last decades). Typically, we used the first indicator for recent years and the second one for more long-time series.

Country reports and data integration

On the basis of the definitions and categories described, the work has involved two main steps: first, the collection of qualitative information and of quantitative data on amounts allocated for each instrument (if possible divided by beneficiary groups) for each involved country; second, the integration of these data in a joint dataset and comparative analysis across countries either considering the whole project funding or some specific aspects.

National analyses are summarized in country reports (Dinges, 2005; Lepori, 2005; Potì and Reale, 2005), which provide a detailed description of national systems of project funding and of their evolution over time. Besides providing information for comparative work, these reports are useful results on their own for national research policies.

Further, the quantitative data have been integrated in a joint database, which can be used for producing comparative figures. The database is constructed around a table containing the amount allocated for each year by each funding instrument per beneficiary group. It has been purposefully designed to keep national specificities: thus, the list of instruments, agencies and beneficiaries are *country-specific*, while separate tables aggregate them to the common categories (type of agency, type of instrument, performer sector).

This allows keeping track of national systems characteristics and details: for example, in the Swiss

case, the higher education sector is divided between cantonal universities, federal institutes of technology and universities of applied sciences. Moreover, this structure makes it easy to reclassify national information (for example project funding instruments). Given the limited number of data, the database has been realized in Microsoft Access. A master copy is kept by the project coordinator to whom any modifications of the data have to be transmitted, while project partners receive the whole database for the purposes of analysis. Data can be made available to other research groups on some conditions, including a contribution to the data themselves and the involvement of the national partners in the analysis; a corresponding framework agreement has been drafted.

The database now covers six countries (Austria, France, Italy, Netherlands, Norway, Switzerland); the integration of UK data is foreseen by the end of 2007, while an extension of the project to four Eastern European countries is ongoing, with a slightly different approach given their specificities.

Comparative analysis

The development of indicators was mainly aiming at comparative analysis of public project funding between countries, as well as of their evolution over time. This is also to better understand similarities and differences between national research policies and to assess to what extent these policies tended to converge in the last decades, an issue debated in science policy studies (Lemola, 2002, Senker *et al*, 1999). Besides this academic interest, we believe that these indicators can be quite useful for policy discussion and for the evaluation of national research policies and research programs. They provide a characterization of whole national systems of public research funding which is far more detailed than OECD data and fully considers the diversity of allocation mechanisms, and allows at the same time analysis of the whole system and international comparisons, which is normally not possible using data from single programs and agencies. Evaluations of funding agencies are for example often hampered by lack of comparative data, and our approach could be a step towards better indicators for the role of such agencies in national systems as well as for international comparisons.

In this section, we present some examples of the quantitative results we obtained and of some questions they raise for policy analysis. The reader should be aware that these examples are introduced essentially to illustrate the potential of the methodology, while a full understanding of the displayed patterns would require in-depth analysis of the figures combined with more qualitative information on the organization of national research policies and funding systems (see Lepori *et al*, 2006 for an in-depth comparative analysis in this direction).

Funding volumes and evolution over time

The simplest application concerns the comparison of the volumes of public project funding across countries and of its evolution over time. We perform this by computing the share of project funding on total public R&D funding (GERD GOV), respectively as a share of GDP for time series. Data for 2002 show a rather similar aggregate role of project funding in the six considered countries (Table 2). Of course, it will be seen to what extent this result is still valid when we include other countries such as the UK.

This methodology allows production, with a reasonable effort time, of series beginning in the 1970s (Figure 3). This is important since we know that in most Western European countries series over two or three decades are normally needed to detect structural changes in funding systems (Lepori, 2006b). These data show different timescales in the development of project funding, with Switzerland and Norway as forerunners, where today's level was already reached at the end of the 1960s, and Austria, Italy and Netherlands coming later. These data, alongside the more qualitative information on the evolution of agencies and instruments, open a considerable space for the analysis of historical development of public funding and its effects on national research systems.

Portfolio of funding instruments

A more detailed analysis concerns the composition of project funding, since we have some anecdotal evidence that countries might differ in this respect and a large part of the debate in science policy studies has concerned shifts in funding portfolios (Braun, 2003). Of course, to fulfil this aim, a comparable classification of funding instruments across countries is needed and this has proved the most difficult part of the project.

We followed a pragmatic approach starting with a broad definition of the policy objectives of

Table 2. Public project funding basic data. 2002

	Total project funding (mio current PPP \$)	Total project funding as % of GERD GOV	Total project funding as % of GDP
Austria	495	29	0.20
France	3,113	24	0.20
France (with CNRS)	4,736	36	0.31
Italy	2,467	24	0.16
Netherlands	951	36	0.24
Norway	530	46	0.32
Switzerland	461	32	0.19

Note: Netherlands: data for the year 2000

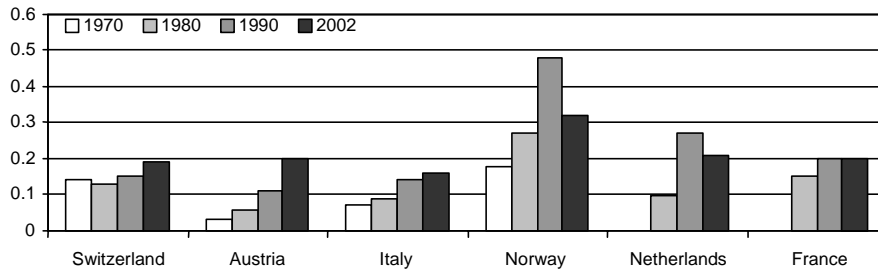


Figure 3. Project funding as percentage of GDP

Notes: Italy: 1970 value refers to 1971
 France: 1980 value refers to 1982
 Netherlands: 2002 value refers to 2000

instruments and matching it with the bottom-up aggregation of the instruments found in the involved countries:

- *Academic instruments* oriented to the production of scientific results such as publications and PhDs. The main allocation criterion is scientific reputation, and beneficiaries are essentially higher education institutions; in many cases there are no preferential research themes, otherwise the budget is divided among scientific disciplines.
- *Thematic instruments* either on priority subjects for policy reasons (for example social needs) or for economic development (technological programs). Thematic instruments can be divided by subject; but for the time being we limit ourselves to separate space programs only.
- *Innovation instruments* that are directly oriented to innovation and economic development in companies, normally with a bottom-up approach (or, if a priority is defined, based on economic sectors).

This classification refers to the aims of the instrument and to the allocation criteria, but not necessarily to the type of research performed, since we are considering here only the level of the funding instruments and not the actual use of the money. Moreover, given the high level of aggregation, in a number of cases the instrument considered is far from being homogeneous; for instance European Framework programs are mainly theme-oriented but include also specific instruments for innovation (such as CRAFT). The attribution of an instrument to a single category should then be considered as a rough approximation, which could be made more precise in the future. Future analysis should also compare the actual use of instruments for a better understanding of national variations, as even if instruments show some similarities, their actual implementation can vary considerably.

Despite these caveats, this classification proved to be usable for most instruments and provides a first comparative view of the national portfolios (Table 3).

Table 3. Classification of instruments by country

	Academic	Innovation	Thematic	
			General	Space
International	European Research Council (from 2007)		EU FP	ESA
Austria	Austrian Science Funds, some grant programs of the Federal Ministry	General programs of the Austria Research Promotion Agency	Programs of ministries Thematic programs of the Austria Research Promotion Agency	Aerospace program (Austria Research Promotion Agency)
France	FNS; doctoral grants from research ministry; FRT (RRIT); CNRS (if included)	ANVAR	Programs from Ministries of Industry /Defense	CNES
Italy	COFIN, FIRB, CNR	FAR, FIT, L488	Mismez, Fizr, Pus, Maf, Mis, Pon, Cnr finalized projects	ASI
Netherlands	Most National research Council NOW programs	A variety of programs, mainly through the Ministry of Economic Affairs (Bsik/Fes program, IOP, innovation program)	NWO thematic programs; policy-oriented research funds of ministries	Several national programs for space research
Norway	RCN free projects, grants, basic research programmes and centers of excellence	RCN user-directed innovation programs and centers for research-based innovation	RCN large-scale programs and targeted programs National administration contracts	
Switzerland	SNF free research projects; grants; national centers of excellence	Swiss Innovation Agency (including Eureka)	National research programs Priority programs National and regional administration contracts	

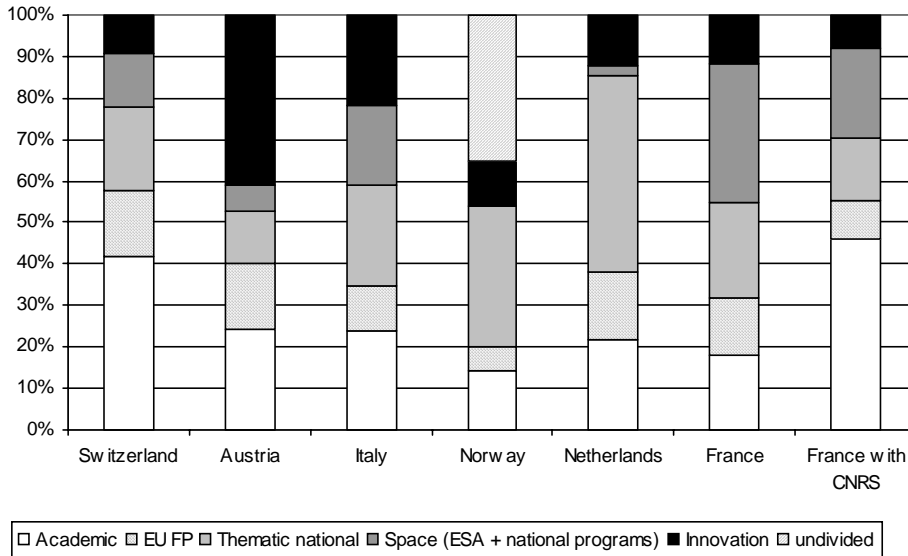


Figure 4. Share of instrument types, 2002
 Note: Netherlands: data for 2000

This bottom-up approach opens a very interesting field for finer comparisons considering some sub-categories.

The quantitative data show what we named a ‘composite’ policy model, where some instruments in each category are found in almost all countries considered, but their share in the funding volume differs significantly (Figure 4), a result which would have not been possible without quantitative indicators.

A further question concerns the changes in the portfolio of instruments across time. There is a wide body of literature discussing a shift in project funding instruments from ‘reactive’ academic-oriented instruments such as grants and free projects where the choice of research themes and the selection of the projects is left to the academic community, towards more policy or innovation-oriented instruments where the state take a more active role in defining goals and program contents (Braun, 2003). To assess these developments, we computed the shares of instrument categories over time (see Figure 5). This shows a general replacement of academic instruments with thematic instruments, but at the same time that differences between countries stay very large. This confirms

quantitatively the hypothesis of policy shifts, but displays at the same time that national specificities are not disappearing.

Beneficiaries

A further element of interest is the repartition of project funding between beneficiaries (Figure 6). This is relevant not only to understand its impacts, but also to some extent the policy rationales behind these measures. Given the level of aggregation of the data, comparative analysis was limited to the main research performing sectors defined in the *Frascati Manual*, namely business enterprise, government, higher education, private non-profit and abroad (OECD, 2002). As a matter of fact, only the first three are significant for the analysis of public funding. However, since the use of these categories in the R&D statistics is somewhat different according to the country, national experts were free to provide their own definitions, departing if necessary from official statistics. For example, in Switzerland, the four research institutes belonging to the domain of the Federal Institute of Technology have been included in the government instead of in the higher education

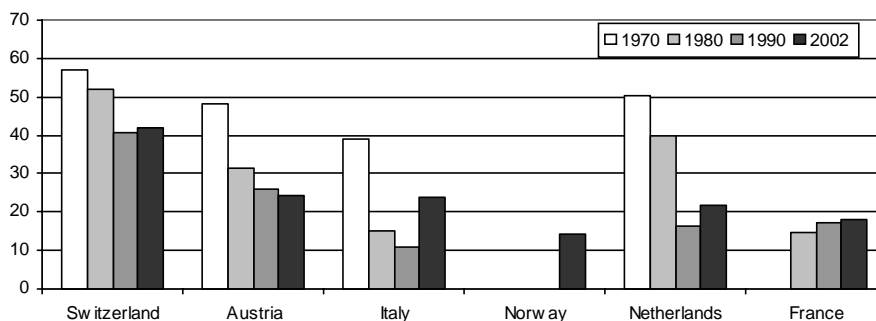


Figure 5. Share of academic-oriented instruments by country, 1970–2002

Notes: Netherlands: 1970 refers to 1975, 2002 to 2000
 Italy: 1970 refers to 1971
 France: 1980 refers to 1982

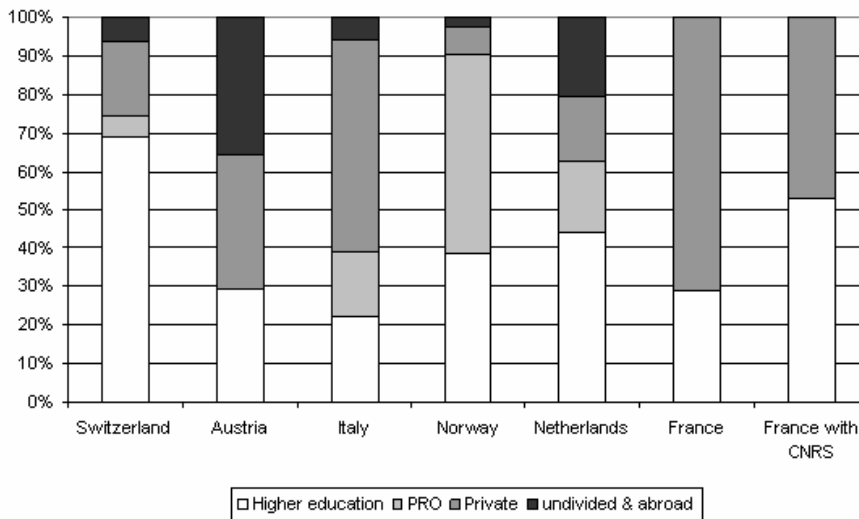


Figure 6. Shares of beneficiaries, 2002

Notes: France and Austria: higher education also includes public research organizations since no separation was possible
 Netherlands: data refer to 2002

sector, as for CNRS own laboratories in France (which in French R&D statistics are included in higher education). Another special case are research laboratories in Norway, which in R&D statistics are divided between the government and the private sector according to the main sectors they serve, while in national statistics are normally considered as sector on their own. In our analysis, we followed this practice, which better reflects national specificities.

Quantitative data display very strong differences between countries in this respect, with the extreme cases of Switzerland where three-quarters of public project funding benefits to higher education institutions and of Italy where more than half of the total funding volume goes to private companies. Probably there are different national organizational models for the research systems, but also different policies towards sectors, here in effect (see Lepori *et al*, 2007 for a more in-depth discussion).

Role of funding agencies

A final application concerns the nature of the funding agencies and their relationships with the state; to this aim, we devised a very simple classification in four groups:

1. *National government* Agencies which are directly part of the national state administration, such as ministries, offices and other similar bodies.
2. *Intermediary agencies* Agencies enjoying strong autonomy in respect to the state in their management and decision-making process, the typical case being research councils managed by the scientists themselves (corresponding largely to the notion of ‘intermediary agencies’ in science policy).
3. *Regional government* Agencies that are part of the regional and local state administration.

4. *International agencies* International organizations and bodies, including the European Commission and intergovernmental agencies such as the European Space Agency.

By our definition, the funding agency is the body that attributes the grants, irrespective of the origins of the funds. Thus, European structural funds if managed by regional agencies are considered regional and not international funds.

We notice that the distinction between the first two categories is not clear-cut, but there are a number of intermediary cases between the state administration (where a bureaucrat decides on the allocation of grants) and autonomous agencies with little interference from the state. As a rule, we adopted a rather restrictive definition of intermediary agencies including only cases with strong autonomy from the state (thus, we do not include in this category committees delegated by ministries, even if they enjoy large autonomy).

Both quantitative data (Figure 7) and documentary information in the national reports show that this is the dimension where the observed countries differ the most, ranging from a system dominated by a national council (Switzerland), to a dual system with a research council alongside with an innovation agency (Austria), to a country where project funding is targeted to research in private companies and managed by the research ministry (Italy). Our hypothesis of a strong path-dependency of organizational structure is here at work (Lepori *et al*, 2006).

Using our data, a finer analysis can be done on individual agencies. It is well known that in all countries research councils have been put increasingly under pressure since the 1970s to orient their funding portfolio towards policy needs and national priorities and to introduce structural funding

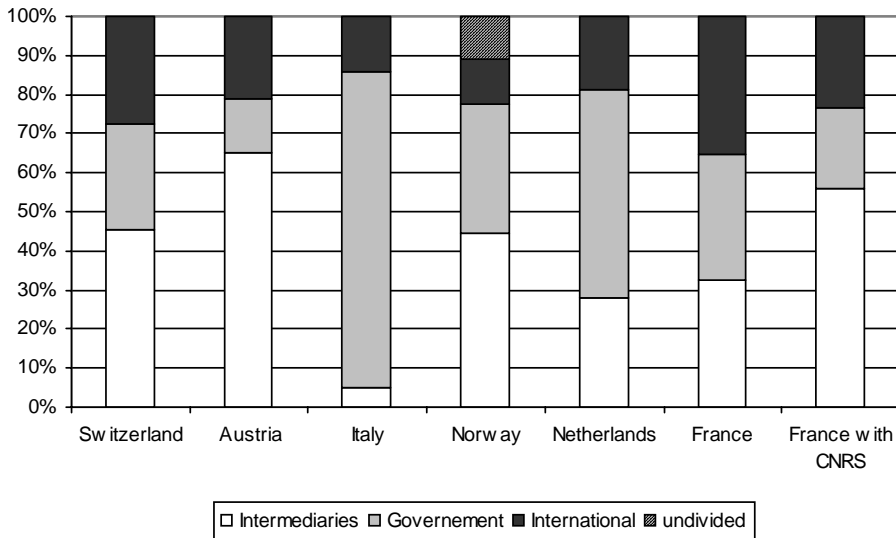


Figure 7. Role of managing agencies, 2002
 Note: Netherlands: data refer to 2000

instruments (for example long-term funding of centers of excellence instead of individual projects; Skoie, 2000; Van der Meulen, 2003).

Therefore to assess to which extent these pressures had an impact on their actual funding practices, we computed the share of instruments in their funding volume.

Figure 8 displays the quite different evolutions of the Swiss national Science Foundation, where change has been rather limited, and of the Norwegian Research Council where, by contrast, the portfolio of instruments has deeply changed over time. These differences need to be interpreted in respect to policies, institutional structures and actor constellations in the concerned countries (see Slipersaeter *et al*, 2007).

Concluding remarks

This study showed how using existing non-statistical sources made it possible to produce indicators for a domain of research funding which is not well covered by R&D statistics. These ‘positioning indicators’ are constructed *ad hoc* to answer specific questions and thus do not aim to the same degree of generality and coherency as R&D statistics (Barré, 2006), but still comply with some reproducible procedures, allowing use of them for comparative purposes and to maintain them over time. Moreover, the examples presented display the potential of these indicators for the comparative analysis of research policies, which will be fully developed in a set of companion papers (Lepori *et al*, 2007).

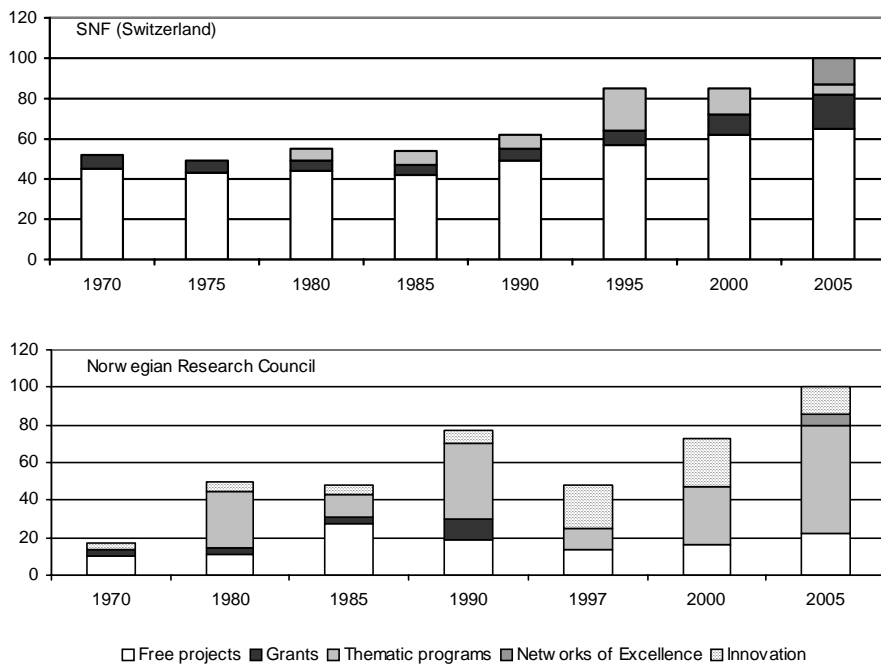


Figure 8. Funding instruments portfolio of the Swiss National Science Foundation and of the Norwegian research councils
 Note: Data real, with the total budget for 2005 = 100

We notice that the chosen approach would be amenable to other applications. With different parameters, categories and selection of countries; for example, it would be possible to consider separately and more in detail funding for specific research domains. An ongoing extension in the framework of PRIME concerns for example a more complete analysis of structural changes of public funding to research and higher education in Central and Eastern European countries, where it was felt necessary to broaden the scope of the analysis exactly because of the profound changes of the overall organization of funding in these countries.

In conclusion, it is useful to summarize some of the key receipts which made our approach feasible and which should be carefully considered for similar experiments in the future. First, the project was from the beginning clearly directed to answer to specific research questions that are discussed in depth in the literature. This theoretical and qualitative background largely ensured the relevance of the results, but was also essential to define the categories and methodological choices. Second, we followed a very pragmatic approach, devising reasonable simplifications based on expert knowledge of the national systems and accepting a number of estimations and even of incoherencies in the indicators where we could assume that they did not alter

fundamentally our results; this was of course essential in keeping the effort needed to an affordable level. Third, in the design of the methodology from the beginning we paid a lot of attention to the robustness of the produced indicators and to the (practical) feasibility of the chosen data collection methodology. Finally, even in a research setting without the ambition of building a coherent statistical system, we invested in the careful discussion of methodological problems and in documenting the choices we made and their effects on the results; this is of course essential to allow for the extension of the project to other countries and for the maintenance of the data.

Finally, an issue that needs to be addressed is to design an organizational form that allows the maintenance and further development of the database, an issue which emerged as critical also in other PRIME project concerned with experimental development of S&T indicators (Bonaccorsi *et al*, 2007). For indicators of this kind, which do not really fit into statistical systems because of their composite and largely *ad hoc* nature, open solutions such as those already developed in the open source software domain, leveraging on the benefits of collaboration for different purposes, would be more fruitful than the integration in official statistics, but this is an area for further work in the future (Lepori *et al*, 2008).

Acknowledgements

This paper is the result of a collective effort in the PRIME Network of Excellence and it was funded by the European Union through PRIME. The authors would like to thank the European Union through the PRIME network of excellence for funding this project. They would also thank other people contributing to this work, including Ghislaine Filiatreau, Philippe Larédo, Ruth Mampuy and Trude Røsdal.

References

Barré, R 2006 Towards a European STI Indicators Platform (ESTIP). Position paper presented at the 2nd PRIME annual conference, Paris, 6–10 February 2006.

Benner, M and U Sandström 2000 Institutionalizing the triple helix: research funding and norms in the academic system. *Research Policy*, **29**(2), 291–301.

BMBWK 1977–2002 Facts documentation of the federal offices, Vienna.

Bonaccorsi, A, C Daraio and B Lepori 2007 Indicators on individual higher education institutions: some methodological reflections. *Research Evaluation*, **16**(2), 66–78.

Braun, D 1998 The role of funding agencies in the cognitive development of science. *Research Policy*, **27**(8), 807–821.

Braun, D 2003 Lasting tensions in research policy-making — a delegation problem. *Science and Public Policy*, **30**(5), 309–321.

Dinges, M 2005 *Project Funding. Austria. Country Report*. Paris: European Network of Indicators Producers.

Dinges, M and B Lepori 2006 Public Project Funding of Research Activities. National Differences and Implications for the Establishment of a European Research Council. Paper presented at the New Frontiers in Evaluation conference, Vienna, 25–26 April 2006.

Esterle, L and J Theves 2005 Analysis of the Different European Systems for Producing Indicators. Paper presented at the

Workshop on S&T Indicators Production, Lisbon, 22–23 September 2005.

European Commission 1999 *Evaluation of Research, Technological Development and Innovation Related Actions under Structural Funds Objective 2*, Brussels.

European Commission 2003 *A New Partnership for Cohesion: Third Report on Economic and Social Cohesion*, Brussels.

European Commission 2004 *The Annual Report on Research and Technological Development Activities of the European Union in 2004*, Brussels.

Geuna, A 2001 The changing rationale for European university research funding: are there negative unintended consequences? *Journal of Economic Issues*, **35**(3), 607–632.

Godin, B 2005. *Measurement and Statistics on Science and Technology*, London: Routledge.

Larédo, P and P Mustar 2001 *Research and Innovation Policies in the New Global Economy: an International Comparative Analysis*. Cheltenham: Edward Elgar.

Lemola, T 2002 Convergence of national science and technology policies: the case of Finland. *Research Policy*, **31**(8–9), 1481–1490.

Lepori, B 2005 *Project Funding. Switzerland. Country Report*. Paris: European Network of Indicators Producers.

Lepori, B 2006a Methodologies for the analysis of research funding and expenditures: from input to positioning indicators. *Research Evaluation*, **15**(2), 133–144.

Lepori, B 2006b Public research funding and research policy: a long-term analysis for the Swiss case. *Science and Public Policy*, **33**(4).

Lepori, B, R Barré and G Filiatreau 2008 New Perspectives and Challenges for the Design and Production of S&T Indicators. *Research Evaluation*, **17**(1), forthcoming.

Lepori, B, M Dinges, R Mamphuis, B Poti, E Reale, S Slipersaeter, J Theves and B van der Meulen 2007 Comparing the evolution of national research policies: what patterns of change? *Science and Public Policy*, **34**(6), 372–388.

Luwel, M 2004 The use of input data in the performance analysis of R&D systems. In *Handbook of Quantitative Science and Technology Research*, eds. H Moed, W Glänzel and U Schmoch, pp. 315–338. Dordrecht: Kluwer.

Millar, J and J Senker 2000 *International Approaches to Research*

- Policy and Funding: University Research Policy in Different National Contexts*. Brighton: SPRU.
- OECD, Organization for Economic Co-operation and Development 2000 *Measuring R&D in the Higher Education Sector. Methods used in OECD/EU Member Countries*. Paris: OECD.
- OECD, Organization for Economic Co-operation and Development 2002 *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*. Paris: OECD.
- OECD, Organization for Economic Co-operation and Development 2003 *Public Funding of R&D: Trends and Changes, DSTI/STP(2003)9/ANN3*.
- Poti, B and E Reale 2005 *Project Funding. Italy. Country Report*. Paris: European Network of Indicators Producers.
- Poti, B and E Reale 2007 Changing allocation models for public research funding: an empirical exploration based on project funding data. *Science and Public Policy*, **34**(6), 417–430.
- Senker, J et al 1999 *European Comparison of Public Sector Research Systems*. Brighton.
- SFSO 2006 *Indikatoren Wissenschaft und Technologie. F+E der Schweiz 2004*. Neuchâtel.
- Siune, K 2004 *Implementation and Management of the Framework Programmes*. Brussels.
- Skoie, H 2000 Diversity and identity: the merger of five research councils in Norway. *Science and Public Policy*, **27**(2), 83–93.
- Slipersaeter, S 2006 *Project Funding. Norway. Country Report*. Paris: European Network of Indicators Producers.
- Slipersaeter, S, B Lepori and M Dinges 2007 Between policy and science: research councils' responsiveness in Austria, Norway and Switzerland. *Science and Public Policy*, **34**(6), 401–416.
- Theves, J, B Lepori and P Larédo 2007 Changing patterns of public research funding in France. *Science and Public Policy*, **34**(6), 389–400.
- Van der Meulen, B 1998 Science policy as principal-agent games: Institutionalization and path dependency in the relation between government and science. *Research Policy*, **27**, 397–414.
- Van der Meulen, B 2003 New roles and strategies of a research council: intermediation of the principal-agent relationship. *Science and Public Policy*, **30**(5), 323–336.