MODALITIES OF R&D FUNDING:

A COMPARISON OF EU MEMBER STATES

FINAL REPORT

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Jonathan Cave
Erik Frinking
Kerry Malone
Wouter van Rossum
Robbin te Velde

with the assistance of
Paul Stoneman

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GLOSSARY

Table 1: Terms and acronyms[1]

Term/acronym	Definition
Funders:	Sources of support for research and development:
Government (G)	Government ministries, etc.
Higher education (HE)	Own funds of the University sector[2].
University funds (UF)	General government allocations for University teaching and research.
Private not-for-profit (PNP)	Private non-profit (foundation) supporters.
Private (P)	Private (for-profit) enterprises.
Other (O)	Other (usually foreign) sources – may include foreign for-profit, NGO or supranational (e.g. EU) funding sources.
Performers:	Those who conduct research and development:
Government laboratories (GL)	Research facilities under direct control of government ministries, and/or that conduct the overwhelming majority of their work for ministerial clients. (Frascati *Government* sector)
Universities (UL)	Institutions of higher education combining teaching and research functions. (Frascati *Higher Education* sector)
Research Institutes (RI)	Private not-for-profit research institutions with (typically) a mix of government and non-government clients. (Frascati *Private Non-Profit* sector)
Private laboratories (PL)	Privately owned research establishments operating for profit and/or predominantly for private enterprise clients. (Frascati *Business Enterprise* sector)
GBAORD	Total government budget appropriations or outlays for research and development.
GERD	Gross domestic expenditure on research and development.
NIS	National innovation system.
General University Funds	That part of University research financed by the general grant from ministries of education, used for both teaching and research.
Institutional funding	Former[3] OECD term for block grants to universities. Also refers to block grant funding of research institutes1.
Non-oriented funding	Funding outside the (OECD) defined focus areas (economics, health & environment, space) – may be administered as (non-higher education) institutional funding, as in Germany.
Oriented funding	Funding within (OECD) defined focus areas (economics, health & environment, space) – typically project-based funding allocated through calls for proposal or tender.
Publicly research support (PRS)	Research support provided by public sources (G, HE[4], UF).
Non-private research support (NPRS)	Research support provided from public and non-profit sources (G, HE, UF, PNP)[5].
Publicly supported research (PSR)	Research conducted by performers receiving the majority of their support from public sources – GL, UL and sometimes RI[6].
PSR institutions (PSRI)	Establishments where PSR is performed.
Non-privately supported research (NPSR)	Research conducted by performers receiving the majority of their support from non-private sources – GL, UL and usually RI.
NPSR institutions (NPSRI)	Establishments where NPSR is performed.

[1] For detailed descriptions of the Frascati equivalents, please see Section A.1.
[2] Includes endowments, gifts, revenues from sales of non-research goods and services, etc.
[3] Discontinued in favour of General University Funds due to classification difficulties and reporting variations.
[4] Most Higher Education own funds are publicly administered.
[5] "Other" or "Abroad" funding is excluded due to classification difficulties.
[6] This funding is commingled with (typically) 'non-oriented funding' in GBAORD figures. Cf. page 10.

1. SUMMARY

The European Commission wished to obtain an overview of the different sources of public R&D support in the EU, mechanisms used to channel this support and the contexts of their use. This study looks at differences and trends in R&D funding modalities at publicly supported research institutions. Here, 'modalities' refers both to channels by which support flows to research performers and details of mechanisms used to select researchers and contracts that guide their work.

1.1. EXECUTIVE SUMMARY

1.1.1. Scope and information sources

Our analysis differentiated among participants in the R&D system and among different flows of funds. Participants were divided by proximity to research performance (funders, intermediaries and research performers) and objectives (public or private interests). Funding arrangements were distinguished along the dimensions of *control* (research scope, focus and conduct) and *competition* (use of market-like mechanisms to allocate funds and select and/or motivate research performance).

We attempted to collect data that would provide a basis for comparing changes in modality across countries and over time. Direct data that were consistent over time and comparable across countries were not available due to difficulties in definition and measurement of institutional vs. contract-mediated funding and evolution of hybrid public and private RTD support systems[7]. Examples include competitive allocation of institutional funding and transformation of funding modalities by intermediary organisations – e.g. contracts paid from institutional funds or *vice versa*. These difficulties led to inconsistent reporting and series breaks that reduce the utility of available data for trend analysis. For this reason, nationwide aggregate figures on the proportion of institutional funding are difficult to compare, and are no longer routinely reported by international organisations such as the OECD. We also note that it is difficult to aggregate data collected at different levels (e.g. funder, intermediary and performer).

As a result, these dimensions provide a primarily conceptual framework for studying evolution of funding modalities and identifying interesting practices. Existing data can shed light on underlying trends. The main text examines trends in specific countries and particular types of research performers. Our analysis was based on OECD and related international data, national and organisation-level data, interviews with players, and other secondary analyses.

There may be advantages to creating common definitions and a corresponding data collection effort. Institutional aspects could be clarified by classification into *incremental* (past levels plus additional funding for new activities), *formula-based* or *contractual* funding. Control can be indicated by division into *client-specified* (tender-based), *performer-controlled* (proposal and block grant) or *mixed-mode* funding. Competition can be classified by *funding selection criteria* - scientific excellence, relevance and/or financial attractiveness. Time-series data should be supplemented by measures of indirect effects: productivity (stratified along the same lines as funding); distribution of resources across performing institutions; flows through intermediaries; the degree to which performers are privately-owned or work for private-sector clients; control of intellectual property rights; continuity of research staff and orientation; etc.

1.1.2. Main findings

- **Nominal gross expenditures on R&D continue to increase, but at a decreasing rate.** They also make up a (recently) falling proportion of GDP. This may be due to increased efficiency or a shift from publicly funded, fundamental research towards private, near-market research.

- **Nominal Government expenditure on research and development has stagnated, and forms a diminishing proportion of gross expenditure.** This reflects increasing pressure on government R&D budgets and pressure on performers to find other sources of support.

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[7] Others have noted these problems: cf. OECD 1981, and National Science Foundation 1998.

- **Choices as to research direction, priorities and conduct are increasingly left to research performers.** Budget data suggest[8] that research orientation is increasingly left to performers – aggregate non-oriented and general university funds are rising while oriented research is falling. Individual countries show similar patterns with significant variations due to e.g. realignment between public and private parties.

- **Despite this apparent increase in latitude, funders are demanding greater accountability[9].** This reflects budget pressures and strategic R&D policy, but does not necessarily bias topic selection or the balance between contract and institutional funds.

- **Recent reductions in government spending have increased the *relative* importance of University performers of publicly supported R&D.** This is partially due to the difficulty of reducing the relatively institutional General University Funds.

- **Defence R&D has seen a shift from institutional funding to sole-source (non-competitive) contracts.**

- **Competitive fund allocation, whether conscious policy or a by-product of realignments in the performing sector, seems to be on the increase.** Variations and trends were observed in the motives, mechanisms and effects of competition.

- **Common motivations for using competition include resource rationing (e.g. value for money) and (secondarily) candidate selection.** Performance incentives, separation of performers and funders and risk transfer seemed less common.

- **Competitive mechanisms cover a wide range.** They include: peer review screening of individual project proposals; selection based on criteria that include some mix of scientific merit, social benefit, nationality, seniority, disciplinary balance, cost and other economic factors; Higher Education institutional funding based past performance; head-to-head institutional or regional competitions for research infrastructure funding; and extended mechanisms in which a subset of bidders are provided limited support for concept development, preliminary work and proposals.

- **Effects of competition vary with mechanism and context.** Efforts to link research priorities and funding modalities to economic goals have increased in selectivity and competitiveness. Research strategies of some major intermediaries and performers have adjusted to the new environment. This is particularly striking in Germany, where changed priorities (since 1996) envisage a future where all publicly supported research institutions will compete for a large proportion of their funding[10]. Preliminary research indicates a variety of effects of competitive higher education funding including: concentration of research resources and agendas; attention to intellectual property rights; co-operation between public and private entities; research labour mobility; higher proportions of contract researchers among University personnel; and spill-over effects on teaching and knowledge diffusion. One particular consequence is pressure on institutional infrastructure - as the contract proportion rises, so do claims on shared resources. This would occur even if contracts were additional money - downward pressures on public institutional funding exacerbate it.

Funding organisations are also evolving. Fiscal authorities are modifying 'frame budgeting' to reduce duplication and increase efficiency of mission- and knowledge-oriented R&D. Competition, tight contractual arrangements and potential public returns are cited to help justify public support. In practice, there are many approaches to implementing competitive mechanisms and there is little consensus about their classification, let alone ways to evaluate them and identify effects on the composition and organisation of research, best practice, etc[11]. Intellectual property rights are generously assigned to performers, but not yet pursued with great vigour. Their central retention, co-ordination and exploitation are often suggested, though others fear biased project selection (particularly in

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[8] This pattern may overstate the transfer of control, as GUF (typically) includes a fixed proportion allocated to teaching, so much of the increase may be attributable to rising student numbers. In addition, institutional funding is increasingly allocated via "hybrid" mechanisms involving greater funder control (cf discussion in Sec. 2.3.).

[9] cf Geuna (1999), Massy (1996) and discussion at Sec. 3.2.

[10] Contract and other (non-institutional) funding is often referred to as the "third way" or *Drittmittel*.

[11] The Logical Framework Methodology (see Sec. A.4) would seem to be an ideal candidate for supporting such an impact evaluation.

academically oriented institutions) and increased pressures on academic and contract research staff to the detriment of higher education *per se*.

Intermediaries are important players in many countries. The widely copied Research Council system is changing in response to budget pressures and public demands for greater focus and accountability. These modifications increase the importance of competitive mechanisms, economic and social selection criteria and scientific and human resource considerations. Other intermediaries facilitate co-operation among R&D entities, particularly to link publicly supported research to the industrial base without jeopardising their separate 'cultures.'

Hybrids like funder-performers are 'spinning off' their performer roles to the private non-profit or private sectors. Funder-intermediaries are increasing and intermediary-performers continue to thrive. Finally, attention is beginning to be paid to competition among funders as well as among performers.

On balance, public funding modalities continue to evolve in response to scientific, policy and market pressures. There is little clear trend in the institutional/contract dimension, but there is a general tendency towards reduced agenda control by public funders but increased competition among performers.

1.2. EXECUTIVE SUMMARY [IN GERMAN]

Die Europäische Kommission hatte den Wunsch, einen Überblick über die verschiedenen Quellen öffentlicher F&E-Förderungen in der EU, die zur Kanalisierung dieser Förderungen verwendeten Mechanismen sowie die Inhalte ihrer Verwendung zu erhalten. Die vorliegende Studie untersucht Unterschiede und Trends bei F&E-Finanzierungsmodalitäten in öffentlich geförderten Forschungsinstitutionen. Der Begriff „Modalitäten" bezieht sich hier sowohl auf Kanäle, über die Förderungen an FTE-Durchführenden fließen, als auch auf die genaueren Mechanismen zur Auswahl von Forschern und deren Arbeit bestimmenden Verträgen.

1.2.1 Umfang und Informationsquellen

Unsere Analyse differenzierte zwischen Teilnehmern am F&E-System und verschiedenen Geldströmen. Die Teilnehmer wurden durch Annäherung den Bereichen Forschungsdienstleistung (Geldgeber, Mittler und FTE-Durchführenden) und Ziele (öffentliche und private Interessen) zugeordnet. Finanzierungsarrangements wurden auf der Grundlage der Dimensionen *Kontrolle* (Forschungsumfang, -mittelpunkt und -durchführung) und *Wettbewerb* (Einsatz von marktähnlichen Mechanismen für die Vergabe von Mitteln und die Wahl bzw. Motivation der Forschungsdienstleistung) unterschieden.

Wir versuchten, Daten als Grundlage für einen länderbezogenen und zeitlichen Vergleich der Modalitätsänderungen zu sammeln. Direkte Daten, die zeitlich konstant blieben und einen Vergleich zwischen einzelnen Ländern gestatteten, waren aufgrund von Problemen bei der Definition und Messung institutioneller bzw. vertragsgekoppelter Finanzierungsmodalitäten und der Entwicklung hybrider öffentlicher und privater FTE-Förderungssysteme nicht verfügbar (vgl. Anmerkung 7). Zu den Beispiele zählen die wettbewerbsorientierte institutionelle Finanzierung sowie die Umwandlung von Finanzierungsmodalitäten durch Mittlerorganisationen – z.B. aus institutionellen Mitteln bezahlte Verträge oder umgekehrt. Diese Schwierigkeiten führten zu einer widersprüchlichen Berichterstattung und zu Reihenbrüchen, welche den Nutzen der verfügbaren Daten für eine Trendanalyse reduzieren. Aus diesem Grunde ist es schwierig, landesweite globale Zahlen über den Anteil einer institutionellen Finanzierung zu vergleichen, und werden derartige Zahlen nicht mehr routinemäßig von internationalen Organisationen wie der OECD gemeldet. Wir möchten auch anmerken, daß es schwierig ist, auf verschiedenen Ebenen (z.B. Geldgeber, Mittler und FTE-Durchführenden) gesammelte Daten auf einen globalen Nenner zu bringen.

Diese Dimensionen bilden daher in erster Linie einen konzeptuellen Rahmen für die Untersuchung der Finanzierungsmodalitäten und für die Bestimmung interessanter Praktiken. Bestehende Daten können Licht auf zugrundeliegende Trends werfen. Der Haupttext untersucht Trends in bestimmten Ländern und bei speziellen Typen von FTE-Durchführenden. Unsere Analyse stützte sich auf OECD-Daten und damit in Zusammenhang stehende internationale Daten, Daten auf nationaler und Organisationsebene, Interviews mit Akteuren sowie andere sekundäre Analysen.

Es mag von Vorteil sein, sich um gemeinsame Definitionen und um eine entsprechende Datensammlung zu bemühen. Institutionelle Aspekte könnten durch eine Einteilung in eine *Zusatzfinanzierung* (vorherige Höhe plus zusätzliche Finanzierung neuer Aktivitäten), eine Finanzierung *auf Formelbasis* oder eine *vertraglich vereinbarte* Finanzierung geklärt werden. Der Kontrollaspekt kann durch eine Unterteilung in eine *vom Kunden bestimmte* (auf Ausschreibungen beruhende), *vom FTE-Durchführenden gesteuerte* (Vorschlag und Globalzuschuß) Finanzierung oder einen *Finanzierungsmischmodus* aufgezeigt werden. Eine Klassifizierung des Wettbewerbsaspekts kann über *Finanzierungsauswahlkriterien* - wissenschaftliche Qualität, Relevanz bzw. finanzielle Attraktivität - erfolgen. Zeitreihendaten sollten durch eine Beurteilung indirekter Auswirkungen ergänzt werden: Produktivität (gleiche Schichtung wie bei der Finanzierung); Verteilung von Ressourcen auf Dienstleistungsinstitutionen, Geldflüsse über Mittler, das Ausmaß, in dem FTE-Durchführenden im Privateigentum stehen oder für Kunden des Privatsektors tätig sind; Kontrolle von Rechten an geistigem Eigentum; Kontinuität bei Forschungspersonal und -ausrichtung usw.

1.2.2. Hauptergebnisse

- **Die nominellen Bruttoausgaben für F&E steigen weiterhin, jedoch in einem immer geringeren Tempo**. Sie bilden weiters einen (neuerdings) sinkenden Anteil am BIP. Dies ist möglicherweise auf eine erhöhte Rentabilität oder einen Wechsel von einer öffentlich finanzierten Grundlagenforschung zu einer privaten marktnahen Forschung zurückzuführen.

- **Die nominellen Staatsausgaben für Forschung und Entwicklung stagnieren und bilden einen sinkenden Anteil an den Bruttoausgaben.** Dies spiegelt den steigenden Druck auf staatliche F&E-Budgets sowie den Druck auf FTE-Durchführenden, andere Förderungsquellen zu erschließen, wider.

- **Die Wahl der Forschungsausrichtung, Forschungsprioritäten und Forschungsdurchführung wird immer mehr den FTE-Durchführenden überlassen.** Budgetdaten deuten darauf hin, daß die Forschungsausrichtung immer mehr den Dienstleistern überlassen wird - die Gesamtsumme der nicht zielgerichteten, allgemeinen universitären Mittel nimmt zu, während die zielgerichtete Forschung abnimmt. Einzelne Länder zeigen ähnliche Muster mit signifikanten Variationen z.B. aufgrund einer Neuorientierung zwischen öffentlichen und privaten Parteien.

- **Trotz dieser offensichtlichen Erweiterung des Spielraums verlangen Geldgeber eine größere Rechenschaftspflicht.** Dies spiegelt den Budgetdruck und eine strategische F&E-Politik wieder, verzerrt jedoch nicht notwendigerweise die Auswahl der Forschungsthemen oder das Gleichgewicht zwischen vertraglich vereinbarten und institutionellen Mitteln.

- **Kürzlich erfolgte Kürzungen bei den Staatsausgaben haben die *relative* Bedeutung von universitären Dienstleistern einer öffentlich geförderten F&E erhöht.** Dies ist teilweise darauf zurückzuführen, daß es schwierig ist, die relativ institutionellen allgemeinen universitären Mittel zu reduzieren.

- **Bei der F&E im Verteidigungsbereich hat sich ein Wandel von einer institutionellen Finanzierung hin zu (nicht wettbewerblichen) Alleinverträgen vollzogen.**

- **Die wettbewerbsorientierte Mittelvergabe - ob als bewußte Politik oder als Nebenprodukt einer Neuorientierung auf dem FTE-Dienstleistungssektor - scheint immer mehr zuzunehmen.** Es wurden Unterschiede und Trends bei Wettbewerbsmotiven, -mechanismen und -auswirkungen beobachtet.

- **Zu den üblichen Motiven für den Einsatz von Wettbewerbmechanismen zählen die Rationierung finanzieller Mittel (z.B. optimale Mittelverwendung) und (in zweiter Linie) die Kandidatenauswahl.** Leistungsanreize, die Trennung von Dienstleistern und Geldgebern und die Risikoverlagerung scheinen weniger üblich zu sein.

- **Es gibt eine breite Palette von Wettbewerbsmechanismen.** Dazu zählen: die Beurteilung von einzelnen Projektvorschlägen durch eine Peer-Gruppe; die Auswahl auf der Grundlage von Kriterien, die eine gewisse Mischung aus wissenschaftlicher Leistung, sozialem Nutzen, Länderzugehörigkeit, Rang, fachlicher Ausgewogenheit, Kosten und anderen wirtschaftlichen Faktoren umfassen; institutionelle Finanzierung im Bereich der höheren Bildung auf der Grundlage von in der Vergangenheit erbrachten Leistungen; Wettbewerb zwischen Institutionen und Regionen

um die Finanzierung einer Forschungsinfrastruktur; sowie erweiterte Mechanismen, in dem eine Untergruppe von Anbietern begrenzte Unterstützung für die Konzeptentwicklung, Vorarbeiten und Vorschläge erhält.

- **Die Auswirkungen des Wettbewerbs variieren je nach Mechanismus und Kontext.** Bemühungen, Forschungsprioritäten und Finanzierungsmodalitäten mit wirtschaftlichen Zielen zu verbinden, haben zu einer Erhöhung der Selektivität und der Wettbewerbsfähigkeit geführt. Die Forschungsstrategien mancher Hauptmittler und -dienstleister haben sich an die veränderten Gegebenheiten angepaßt. Besonders auffällig ist diese Entwicklung in Deutschland, wo (seit 1996) veränderte Prioritäten auf eine Zukunft hindeuten, in der alle öffentlich unterstützten Forschungsinstitutionen miteinander um einen Großteil ihrer Finanzmittel konkurrieren werden. Voruntersuchungen weisen auf verschiedenste Auswirkungen einer wettbewerbsorientierten Finanzierung der höheren Bildung einschließlich einer Konzentration von Forschungsmitteln und -agenden; der Beachtung von Rechten an geistigem Eigentum; einer Zusammenarbeit zwischen öffentlichen und privaten Unternehmen; einer höheren Mobilität der in der Forschung beschäftigten Personen; eines höheren Anteils an Vertragsforschern beim Hochschulpersonal; sowie Ausstrahlungseffekte auf die Lehre und die Wissensverbreitung hin. Eine besondere Folge ist der Druck auf die institutionelle Infrastruktur - in dem Maße, in dem der Anteil einer vertragsgekoppelten Finanzierung steigt, steigen auch die Ansprüche auf gemeinsam genutzte Mittel. Dies würde sogar dann passieren, wenn Verträge zusätzliches Geld wären - der Druck auf die öffentliche institutionelle Finanzierung verschärft diese Entwicklung.

Es entwickeln sich auch Finanzierungsorganisationen. Steuerbehörden ändern ihre "Rahmenbudgetierung", um eine Doppelerfassung zu verringern und die Effizienz einer aufgaben- und wissensorientierten F&E zu erhöhen. Wettbewerb, enge vertragliche Vereinbarungen und potentielle öffentliche Erträge werden als Argumente angeführt, um eine öffentliche Unterstützung zu rechtfertigen. In der Praxis gibt es viele Ansätze, wie Wettbewerbsmechanismen umgesetzt werden können, und es herrscht nur ein geringer Konsens über ihre Klassifikation, ganz zu schweigen von den Möglichkeiten einer Bewertung dieser Mechanismen oder einer Bestimmung der Auswirkungen auf die Zusammensetzung und Organisation der Forschung, optimaler Verfahren etc. Rechte an geistigem Eigentum werden FTE-Durchführenden zwar großzügig übertragen, jedoch noch nicht sehr tatkräftig durchgesetzt. Eine zentrale Beibehaltung, Koordinierung und Nutzung dieser Rechte wird häufig vorgeschlagen, obwohl andere wiederum eine einseitige Projektauswahl (insbesondere in akademisch ausgerichteten Institutionen) und einen erhöhten Druck auf akademisches und Forschungspersonal zum Schaden der höheren Bildung *an sich* befürchten.

Mittler sind in manchen Ländern wichtige Akteure. Das weithin kopierte System des Forschungemeinschaftes verändert sich als Reaktion auf Budgeterfordernisse und öffentliche Forderungen nach einer größeren Zielgerichtetheit und Rechenschaftspflicht. Diese Veränderungen erhöhen die Bedeutung von Wettbewerbsmechanismen, wirtschaftlichen und sozialen Auswahlkriterien und wissenschaftlichen und personellen Überlegungen. Andere Mittler ermöglichen eine Zusammenarbeit zwischen F&E-Unternehmen, insbesondere um die öffentlich geförderte Forschung an die industrielle Basis anzubinden, ohne deren verschiedene "Kulturen" zu gefährden.

Hybridartige Geldgeber-Dienstleister "gliedern" ihre aktive Rolle auf den privaten nicht-erwerbswirtschaftlichen Sektor oder den Privatsektor "aus". Es gibt immer mehr Geldgeber-Mittler, und auch Mittler-Dienstleister erleben weiterhin eine Blüte. Und schließlich beginnt man auch damit, dem Wettbewerb unter Geldgebern sowie unter FTE-Durchführenden Beachtung zu schenken.

Alles in allem entwickeln sich öffentliche Finanzierungsmodalitäten weiterhin als Reaktion auf wissenschaftlichen, politischen und wirtschaftlichen Druck. Obwohl es kein sehr eindeutiger Trend in Hinblick auf die institutionelle/vertragliche Dimension vorliegt, gibt es jedoch eine allgemeine Tendenz hin zu einer verringerten Kontrolle der Forschungsagenden durch öffentliche Geldgeber und zu einem erhöhten Wettbewerb zwischen FTE-Durchführenden.

1.3. EXECUTIVE SUMMARY [IN FRENCH]

La Commission européenne souhaitait obtenir un aperçu des diverses sources de subventions publiques en matière de R&D dans l'Union européenne, des mécanismes utilisés pour acheminer ces subventions et du contexte dans lequel elles sont utilisées. Cette étude se penche sur les différences et les tendances existant dans les modalités de financement en matière de R&D au sein des instituts de recherche financés par des fonds publics. Le terme de 'modalités' englobe ici à la fois les canaux par

lesquels les subventions sont acheminées vers les exécutants de la recherche, les détails des mécanismes utilisés pour sélectionner ces chercheurs et les contrats qui régissent leurs travaux.

1.3.1. Cadre et sources d'information

Notre analyse a fait une différentiation entre les divers participants au système de R&D et les divers flux de ressources financières. Les participants ont été classifiés en fonction de leur proximité vis-à-vis des activités de recherche (bailleurs de fonds, intermédiaires et exécutants) et des objectifs (intérêts publics ou privés). Les accords de financement ont été classifiés selon les critères de *contrôle* (cadre de la recherche, focalisation et gestion) et de *concurrence* (utilisation de mécanismes assimilables à des mécanismes commerciaux pour l'attribution des fonds et pour la sélection et/ou la motivation de la recherche).

Nous avons tenté de rassembler des données pouvant fournir une base à la comparaison des changements de modalités dans les divers pays et dans le temps. Aucune donnée directe cohérente dans le temps et comparable entre les divers pays n'était disponible en raison des difficultés rencontrées pour définir et mesurer les financements institutionnels par rapport aux financements 'contractuels' et l'évolution des systèmes de subventions R&DT mixtes privées et publiques (voir note 7). On peut citer comme exemple l'attribution concurrentielle de fonds institutionnels et la transformation des modalités de financement par des organisations intermédiaires, c'est-à-dire les contrats payés à l'aide de fonds institutionnels et vice versa. Ces difficultés ont conduit à des rapports incohérents et des discontinuités ayant réduit l'utilité des données disponibles pour une analyse des tendances. Pour cette raison, les chiffres globaux au niveau du pays en matière de proportion de financement public sont difficilement comparables et ne font plus l'objet d'un rapport routinier de la part des organisations internationales telles que l'OCDE. Nous notons également qu'il est difficile d'assimiler les données collectées à différents niveaux (par exemple le bailleur de fonds, l'intermédiaire et l'exécutant).

En conséquence, ces critères fournissent un cadre conceptuel primaire pour l'étude de l'évolution des modalités de financement et l'identification de pratiques intéressantes. Les données existantes peuvent faire la lumière sur les tendances sous-jacentes. Le texte principal examine les tendances dans les pays spécifiques et les types particuliers d'acteurs en matière de recherche. Notre analyse a été basée sur des données de l'OCDE et des données internationales y étant liées, des données au niveau du pays et de l'organisation, des interviews avec les acteurs et d'autres analyses secondaires.

La création de définitions communes et un effort correspondant de collecte de données peuvent présenter des avantages. Les aspects institutionnels pourraient être clarifiés par une classification en financement *par addition* (niveaux précédents plus financement supplémentaire pour de nouvelles activités), financement *basé sur une formule* ou financement *contractuel*. Le contrôle peut être indiqué par division en financement *spécifié par client* (basé sur une offre), *contrôlé par exécutant* (proposition et subvention par tranches) ou *mixte*. La concurrence peut être classifiée par *critères de sélection du financement* – mérite scientifique, pertinence et/ou attrait financier. Les données périodiques devraient être complétées par la mesure des effets indirects : productivité (stratifiée de la même façon que le financement) ; distribution de ressources parmi les institutions exécutantes ; flux passant par les intermédiaires ; degré de privatisation des exécutants ou mesure dans laquelle ils travaillent pour des clients du secteur privé ; contrôle des droits de propriété intellectuelle ; continuité dans l'équipe de chercheurs et orientation de la recherche ; etc.

1.3.2. Principaux résultats

- **Les dépenses nominales brutes en matière de R&D continuent d'augmenter, mais à un rythme qui faiblit.** Elles forment (jusque récemmment) une part décroissante du PIB. Cela peut être dû à une rentabilité accrue ou à un glissement d'une recherche fondamentale financée par des fonds publics à une recherche privée quasi-commerciale.

- **Les dépenses gouvernementales nominales sur la recherche et le développement ont stagné et représentent un part en diminution des dépenses brutes.** Cela reflète la pression croissante exercée sur les budgets publics de R&D et sur les exécutants pour trouver d'autres sources de subvention.

- **Les choix en matière de direction, de priorités et de gestion de la recherche sont de plus en plus abandonnés aux exécutants.** Les données budgétaires suggèrent que l'orientation de la

recherche est de plus en plus laissée à l'appréciation des exécutants – les fonds globaux non orientés et les fonds universitaires généraux sont en augmentation tandis que la recherche orientée est en régression. Les pays individuels montrent des modèles similaires avec de sérieuses variations dues par exemple à l'alignement entre les parties publiques et privées.

- **En dépit de cette apparente augmentation de la liberté d'action, les bailleurs de fonds exigent une responsabilité accrue.** Cela reflète les pressions budgétaires et la politique en matière de R&D mais ne rend pas nécessairement partiale la sélection des sujets ni l'équilibre entre le financement contractuel et le financement institutionnel.

- **De récentes réductions des dépenses publiques ont fait augmenter l'importance *relative* des exécutants universitaires de la R&D subventionnée par l'État.** Cela est en partie dû aux difficultés rencontrées pour réduire les fonds universitaires généraux relativement institutionnels.

- **La recherche et le développement militaires ont connu un passage des financements institutionnels aux contrats (non concurrentiels) à source unique.**

- **L'attribution concurrentielle de fonds, qu'il s'agisse d'une politique délibérée ou d'un produit dérivé de l'alignement dans le secteur de l'exécution, semble être en augmentation.** Des variations et tendances ont été observées dans les motifs, les mécanismes et les effets de la concurrence.

- **Les motivations communes pour l'usage de la concurrence comprennent le rationnement des ressources (par exemple le rapport qualité/prix) et (indirectement) la sélection du candidat.** Les primes de performances, la séparation entre exécutants et bailleurs de fonds et le transfert des risques semblent être moins répandus.

- **Les mécanismes concurrentiels couvrent un domaine étendu.** Ils comprennent : l'examen comparatif des propositions individuelles de projets ; la sélection basée sur des critères comprenant des éléments de mérite scientifique, d'avantage social, de nationalité, d'ancienneté, d'équilibre disciplinaire, de coûts et d'autres facteurs économiques ; une performance passée basée sur le financement institutionnel de l'enseignement supérieur ; des compétitions directes institutionnelles ou régionales pour le financement de l'infrastructure de la recherche ; et des mécanismes étendus dans lesquels un groupe secondaire d'offreurs reçoit des subventions limitées pour le développement de concepts, les travaux préliminaires et les propositions.

- **Les effets de la concurrence varient avec le mécanisme et le contexte.** Les efforts déployés pour établir des liens entre les priorités de la recherche et les modalités de financement d'une part et les objectifs économiques d'autre part ont gagné en sélectivité et en compétitivité. Les stratégies de recherche de certains intermédiaires et exécutants importants ont été adaptées au nouvel environnement. Cela est particulièrement frappant en Allemagne, où les nouvelles priorités (depuis 1996) envisagent un avenir où tous les instituts de recherche subventionnés par l'État seront en concurrence pour une grande partie de leur financement. Les recherches préliminaires indiquent une variété d'effets du financement concurrentiel de l'enseignement supérieur comprenant : la concentration des ressources et des agendas de la recherche ; l'attention portée aux droits de propriété intellectuelle ; la coopération entre les entités publiques et privées ; la mobilité de l'emploi dans la recherche ; de plus grandes proportions de chercheurs sous contrat dans le personnel universitaire et des effets de débordement sur l'enseignement et la divulgation des connaissances. Une des conséquences particulières réside dans la pression exercée sur l'infrastructure institutionnelle – l'augmentation du nombre des contrats s'accompagne d'une augmentation des revendications sur les ressources partagées. Cela se produit même lorsque les contrats portent sur des fonds supplémentaires – phénomène aggravé par les pressions en aval sur le financement institutionnel public.

Les organisations de financement évoluent également. Les autorités fiscales modifient la 'budgétisation compartimentée' pour réduire les doubles financements et améliorer l'efficacité de la R&D orientée sur la mission et sur les connaissances. La concurrence, des contrats serrés et de potentiels revenus publics sont cités pour justifier la subvention publique. Dans la pratique, il existe de nombreuses approches pour la mise en œuvre de mécanismes concurrentiels et leur classification est loin de faire l'unanimité, sans parler des moyens de les évaluer et d'identifier les effets sur la composition et l'organisation de la recherche, des meilleures pratiques, etc. Les droits de propriété intellectuelle sont généreusement attribués aux exécutants, mais ne sont pas encore exercés avec grande

vigueur. Leur maintien, leur coordination et leur exploitation sont souvent suggérés, bien que d'autres craignent une sélection partiale des projets (en particulier dans les institutions à orientation académique) et une augmentation des pressions exercées sur le personnel de recherche académique et contracté au détriment de l'enseignement supérieur en lui-même.

Les intermédiaires sont des acteurs importants dans de nombreux pays. Le système du Institut ou Centre National de la Recherche, largement copié, change en réponse aux pressions budgétaires et aux exigences gouvernementales de meilleure focalisation et de plus grande responsabilité. Ces modifications augmentent l'importance des mécanismes concurrentiels, des critères de sélection économiques et sociaux et des considérations en matière de ressources scientifiques et humaines. D'autres intermédiaires facilitent la coopération entre les entités de la R&D, en particulier pour lier la recherche subventionnée par l'État à la base industrielle sans porter préjudice à leurs 'cultures' respectives.

Les organisations hybrides telles que bailleurs de fonds-exécutants abandonnent progressivement leur rôle d'exécutant au secteur privé à but non lucratif ou au secteur privé. Les intermédiaires bailleurs de fonds sont en augmentation et les intermédiaires exécutants continuent de prospérer. Enfin, l'attention commence à se porter sur la concurrence, aussi bien entre bailleurs de fonds qu'entre exécutants.

En fin de compte, les modalités du financement public continuent d'évoluer sous les pressions scientifiques, politiques et commerciales. Il n'y pas de tendance vraiment définie dans la proportion institutionnel/contractuel, mais une tendance générale vers une réduction du contrôle des agendas par les bailleurs de fonds publics et une augmentation de la concurrence entre les exécutants.

1.4. EXAMPLES OF TRENDS AND ALTERNATIVE APPROACHES

Data from four specific countries (Denmark, Germany, the Netherlands and the United Kingdom) were used to examine the i) the forces promoting competition; ii) specific competitive mechanisms and iii) the pattern of prevalence of competitive and/or contract-mediated R&D support in more detail than was possible from the international data.

With regard to the first point, the overt commitment of the German government to open competition between all types of performers has produced many changes. While the German Fraunhofer institutes (FHG) have always been intended to work predominantly for private industry, they long enjoyed substantial public institutional funding. This has remained strong but not overwhelming, while public project-based financing has fallen dramatically. The FHG was thus led to increasing competition for private contracts with private entities on one side and public performers with higher levels of institutional finance (e.g. the Helmholtz centres) on the other, changing their mix of basic and near-market research. By contrast, the analogous Netherlands organisation (TNO) had lower and stagnant institutional financing and slower overall growth. As with the FHG, they were led to compete for contract funding, with private contracts growing faster than government contracts (though overall public funding remains just over 50%). The 'large technological institutes' with whom they compete are far more dependent on contract revenues than their German analogues, making the competition that much sharper.

In terms of specific competitive mechanisms operated by government funding sources, The Danish Research Foundation was established in 1991 to provide basic research funding along similar lines to the Max Planck Gesellschaft in Germany. As part of the 'second tier' of non-institutional funding sources, its resources were from the start committed competitively, However, in order to provide stability and enhance the sustainability of the efforts it supported, the monies allocated were: relatively free of substantive preconditions; fairly substantial; and allocated for a 3-5 year period. The budget pressures and increasing demands for funding faced by the Deutsche Forschungsgemeinschaft have led to specific changes in funding allocation. For *project-based funding*, this has meant the expansion of evaluation criteria beyond scientific merit, the use of adaptive mechanisms such as large-scale project comparisons, and open competitions in specific areas[12]. The burden of these mechanisms has produced an emphasis on longer grants with greater control by research performers. At the *programme* level, institutional funds are increasingly allocated via open calls for proposals and head-to-

[12] e.g. the "Spearhead projects" (*Leitprojekte*).

head competitions[13]. Finally, competitive review is increasingly used to allocate *infrastructure* (e.g. equipment) support, with mandatory availability to several research groups. In the U.K. research support has been reorganised to increase accountability and client focus. The Research Assessment Exercise has made much of the *institutional* funding of Universities overtly competitive, profoundly affecting the location and orientation of R&D. *Infrastructure* funding is also being provided through a growing series of competitions based on peer review, with certainty and continuity protected through longer-term funding commitments.

The UK was the only country in our sample to collect data on the overall prevalence of competition and contracting across a wide range of different types of public support organisation. These data show different patterns among four principals. First, Research Council funding of R&D in Higher Education and dedicated Institutes and Centres comprises 54% contract research, of which 92% is competitively allocated. Second, the Higher Education Budget provides support for a mix of purposes, of which about 57% flows through competitive contracts, though the recent trend is a shift from non-competitive contracts to institutional funding. The third group, Civil R&D support from other government sources, is shifting from institutional to competitive contract funding. Finally, military R&D funding is shifting to non-competitive contracts, partially as a result of privatisation of military research facilities.

[13] e.g. The *BioRegio* and *BioFuture* biotechnology competitions and a parallel effort in nanotechnology.

2. METHODOLOGY AND APPROACH

2.1. A SIMPLIFIED REPRESENTATION OF R&D FUNDING SUPPORT

We divided participants according to their proximity to research performance and objectives (public or private interest). This leads to the stylised view shown in Figure 1.

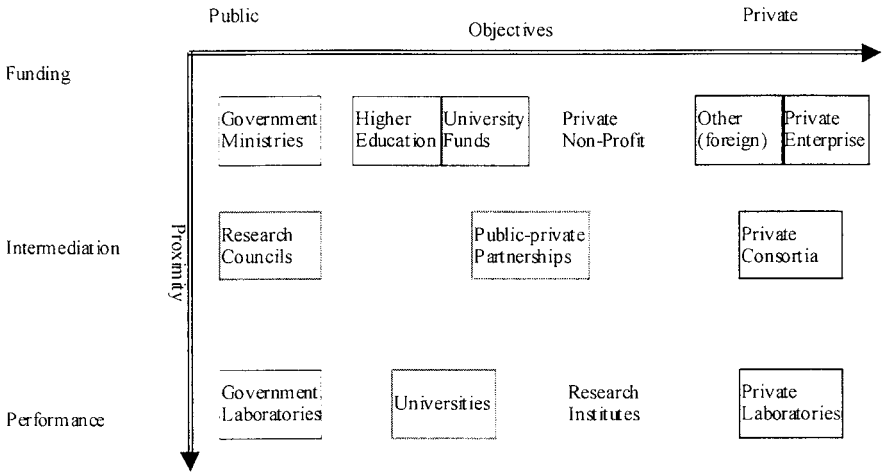

Figure 1: Players in the R&D system

Some entities occupy multiple vertical levels (e.g. research councils combining intermediation and research performance) or migrate horizontally (e.g. privatised government laboratories). Funding entities described here are equivalent to the standard OECD classification. OECD data do not distinguish intermediaries. Names of performing entities have been changed to reflect the nature of the organisations contacted and clearly distinguish performers from similarly named funding entities:

Table 2: Research performer categories

OECD name	Name used in this study	Publicly supported[14]?
Government	Government laboratories	Yes
Higher education	Universities	Yes
Private non-profit (PNP)	Research institutes	Sometimes
Private	Private laboratories	No

In this report, a research institute is *publicly supported* if it receives the majority of its funding from government and higher education[15] sources and *non-privately supported* if the majority of its funding comes from government, higher education[15] and private non-profit sources. Table 3 shows the number of years for which 'Research Institutes' are: i) present in OECD data; ii) publicly supported; and iii) non-privately supported. These classifications were used to construct figures for publicly (non-privately) supported research institutions later in the report.

[14] Exceptions, e.g. private universities and privatising government labs cannot be measured at the aggregate level.
[15] It makes no difference for this classification whether or not University Funds are included.

Table 3: Public and non-private support for research institutes

Country	*Years of data*	*Publicly supported years*	*Non-privately supported years*
Austria	2	Pre-1993	Pre-1993
Belgium	5	None	None
Denmark	6	None	All
Finland	4	None	All
France	7	None	All
Germany	3	All	All
Greece	1	None	All
Ireland	7	None	Pre-1993
Italy	0	N/A	N/A
Netherlands	7	All	All
Portugal	3	Post-1992	All
Spain	7	None	None
Sweden	4	All	All
United Kingdom	7	Pre-1994	All
European Union	7	Pre-1992	All

2.2. CONTROL AND COMPETITION

The funding arrangements are distinguished along the dimensions of control and competition.

Control (or orientation) is the extent to which funders or performers determine research scope, focus and conduct. Available OECD data distinguish three levels of orientation. In *general university funds*[16] research content and conduct are left to the performing institution. *Non-oriented research funds* entail client approval or performer-specified projects. *Oriented research funds* involve the highest degree of client control[17]. Figure 2 uses different terms that more closely reflect research control.

1. *Institutional or basic* – funds allocated as a block grant to the performing institution, which is reallocated among projects, centres, expenditure categories, etc. without detailed consultation.
2. *Free proposals* – funds allocated in response to calls for proposals that do not specify research subjects or methods e.g. project-level funds allocated by science ministries.
3. *Programmes* – funds allocated to calls for proposals that specify an overarching theme e.g. project-level funding within the research remit of mission oriented ministries.
4. *Tenders* – funds allocated to calls for tender that specify in detail the problem to be studied and the methods used, usually in support of the funding agency's specific policy responsibilities.

Competition refers to use of market-like mechanisms to allocate research funds and select and/or motivate research performance. The conceptual framework distinguishes three levels.

1. *Non-competitive* – recipients are selected by an independent evaluation of the merits of the proposed research[18]. There is always implicit competition when resources are scarce – this category merely collects funding mechanisms that operate without explicit comparison of candidates.
2. *Heterogeneous* – competitive selection procedures that do not compare like with like. 'Free proposal' support typically falls under this heading. It is distinguished from non-competitive allocation in that odds of success depend on the number and strength of simultaneous contenders.
3. *Homogeneous* – head-to-head rivalry of proposals to conduct essentially identical research. Project selection is usually based on explicit scoring rules described in the Call for Tenders.

Figure 2 illustrates some of the more obvious possibilities.

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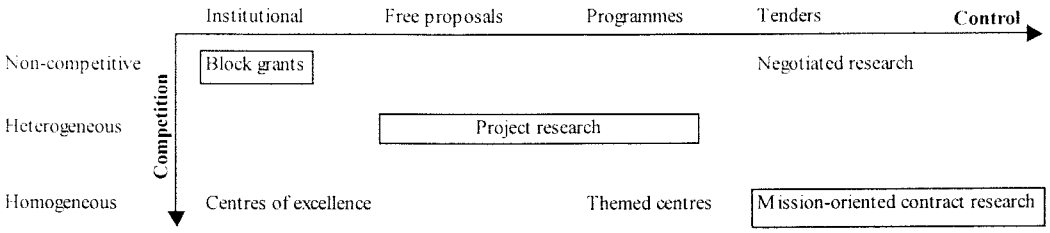
[16] Formerly called "institutional funding for higher education."

[17] The definitions are not exact, and their implementation varies across countries. In particular, the term 'oriented research' often refers to the specific research objectives defined in the NABS (Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets) developed by the EC. The data collection and classification methods are not entirely uniform over time and across countries.

[18] Other factors used in selection may include past performance and broader socio-economic objectives.



Note: "Themed centres" are research groups selected by competition to pursue a particular agenda with long-term financing.

Figure 2: Control and competition

In practice, most funding[19] falls along the "diagonal" (bordered text). Moving to the right, control of research shifts from the performer to the funder. Non-competitive mechanisms are used on the left because performers are relatively better informed about promising avenues for research or the public benefits flowing from it, or because discoveries may signal fundamental changes in direction, as in basic scientific research. By contrast, tender procedures are most useful when funders are relatively well informed and directly concerned with the fruits of research, e.g. applied research for private clients or mission-oriented research for ministries.

2.2.1. Competition

One strong conclusion from the interviews was the broad range of meanings attached to the term 'competition' and the very different activities represented as implementing it. From an analytic perspective, competition can serve to:

- ration scarce resources;
- select the best candidate to perform a given piece of research,
- improve performers' incentives for timeliness, relevance, quality, etc.
- ensure value for (public) money;
- separate funders from performers and prevent collusion; and
- transfer risk and responsibility to those best able to bear them.

Funders with a direct interest in research results are more interested in selectivity and incentives. By and large, competition is used primarily to allocate scarce resources, secondarily for candidate selection, and rarely as a means of providing incentives.

We encountered various competitive processes ranging from simple quality screens to intensive head-to-head ranking of proposals using pre-set criteria. Some ostensibly non-competitive allocation procedures were in fact competitive over a broad range of activities and a long sweep of time e.g. benchmarking and research assessment 'league tables' used to allocate institutional research funds.

Finally, expected and actual competition among research performers took different forms. Some proposal funding competitions were strongly oriented to scientific merit or social benefit, while others were more sensitive to nationality, seniority, disciplinary balance or cost and economic considerations. The nature of competition affects the balance between the effects listed above and influences 'unintended consequences.' This is why we did not produce aggregate figures or head-to-head comparisons of "competitiveness," even when data showing 'competition' were available.

2.2.2. Other dimensions of modality

This survey focused on funding modalities. The control and competition aspects of modality, while easy to grasp and relate to policy objectives, were difficult to measure. There are other dimensions about which more information is available. In particular, the system in Figure 1 can be proxied by performer-based data on flows of funds between different classes of funders and performers. The OECD standard classification of these entities bridges differences in national systems. Such data do not capture intermediaries, vertical integration or horizontal migration. However, comparison of 'snapshots' can give a useful overview of underlying trends.

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[19] Geuna (1999) develops a classification of government funding of the Higher Education sector into three classes: i) incremental funding (past levels plus additional funding for new activities); ii) formula funding; and iii) contractual funding. His first two categories correspond approximately to institutional funding in the present sense.

Competition and control are difficult to separate in practice, involving contractual relations formed in legal and social contexts that include long-term relationships among funders, intermediaries and performers. However, *control* can be approximated by multinational data on research orientation and (to a lesser extent) institutional vs. contract funding. These data (Sec. 3) are derived from funders' budgets, and cannot be directly compared with performer-based flow of funds data (Sec. 4), but do give an alternative perspective. They can also give an overall sense of *competition* assuming most funding falls along the diagonal of Figure 2. In specific countries, major participants were often able to characterise the control, competition and contractual aspects of funding flows. These data were neither universally available nor directly comparable so we avoided quantitative aggregation. Three specific 'cases' are described given in Sec. 3.3 below.

2.3. DEFINITIONS AND DATA AVAILABILITY

In this study, we attempted to collect data that would provide a basis for comparisons of changes in modality across countries and over time. These data were not consistently available, largely as a result of definitional problems.

2.3.1. Institutional and contract funding

In past years and specific settings, the distinction between institutional and contract funding was fairly clear. Recently, this distinction has been blurred by a large number of hybrid funding mechanisms. Some are modifications of existing categories.

i) Institutional grants conveyed by ever-more-tightly drawn contracts that specify research agendæ, commingle R&D project and equipment support with monies for other purposes, etc.

ii) Contracts that are explicitly tied to researchers' institutions and ongoing institutional funding arrangements (e.g. contracts that use "Centre" money) or continuation contracts that have the institutional characteristics of loose control.

Other modifications are new hybrids; especially the emergence of what Prof. Paul David of Oxford has termed "grantracts" - grants with many contractual features, including explicit review of past performance, mandated forms of competitive allocation and client intervention in the agenda-setting process. On the contract side, a range of "undertakings" of varying degrees of formality are used to commission or support research without the structure or controls of conventional contracts.

As a result it has become increasingly hard to characterise flows of money as purely institutional[20] or purely contract-based, and data that preserve this distinction are not routinely collected at higher levels of aggregation and not suitable for aggregation or comparison when they are collected. Thus, while this distinction may be conceptually useful for understanding the evolution of funding modalities and identifying candidate best practices, the data are not there. It might be worth creating common definitions and encouraging a corresponding data collection effort.

As a purely practical matter, it has become customary[21] to characterise OECD data on General University Funds as being predominantly institutional in character, whilst other government support for research in the Higher Education sector is regarded as contract-based.

2.3.2. Control

In terms of control, the above-described hybrid mechanisms make it hard to identify measurable flows of funding with discrete types of control mechanism. In such a fluid situation, a more fine-grained analysis of control by research area and funding/performing body might be more useful. This would involve a new survey rather than the technique we used of combining already-collected information with structured interviews of a few key personnel.

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[20] As indirect evidence, note that the OECD gave up on the term "Institutional" when referring to block grants to Universities, even leaving out the block grant characterisation.

[21] E.g. Geuna (1999), Kyvik (1997), OECD (1998).

2.3.3. Competition

There are serious difficulties in developing a practical definition of competition that can be related to funding flows. For any definition, the level, purposes and nature of competition change, especially as institutional identities shift (e.g. as performers are privatised, etc.). As far as we could determine, the UK is the only country that has tried to collect systematic data on aggregate competitive vs. non-competitive funding, and these efforts encountered major definitional issues involving "competition" and "contracts" that limit the statistics' comparability across agencies and over time.

2.3.4. Coverage

The data in the study refer to EU member states. Because suitable data on Luxembourg were not available in the OECD databases to which we had access, Luxembourg is not included in either the separate data or the EU totals.

3. CONTROL AND COMPETITION IN RESEARCH FUNDING

3.1. OVERVIEW

This section looks at evolving patterns in research control or orientation and the impact of competition. The emerging pattern is roughly as follows. As budgets tighten, there is increasing pressure to reduce funding and/or increase efficiency and accountability of publicly sponsored research. This leads to three effects.

- Use of modalities providing funder *control* of topic selection and research performance (though the control does not seem to be much exercised[22]).
- *Competition* amongst PSRIs and between PSRIs and PNP and for-profit performers.
- Incorporation of comparative and competitive *mechanisms* into selection and review procedures.

The debate over whether competition helps or hinders innovation continues unresolved. Indeed, the R&D sector continues to produce new forms of co-operation and competition (e.g. research joint ventures and other loose 'networks') that pose challenges for competition, antitrust and R&D policy that tries to advance both private and collective interests. This undermines the case for public support, especially of near-market R&D. Evidence of material budget pressures can be seen in the following observations:

- The growth of government budget *appropriations* for R&D (GBAORD) has been declining over the past fifteen years, particularly since 1990. There has also been convergence among the countries surveyed in this study. Appropriations have: dropped steeply among those spending the highest fraction of GDP on R&D (France, UK, Germany); stayed relatively flat among the 'catch-up' countries (Portugal and Spain); and remained high and stable among new EU Member States (Finland, Austria, Sweden).
- Government *expenditures* on R&D have fallen since 1985 for the EU as a whole (Figure 7). The largest drops were experienced in a mix of big spenders (France, UK, Germany) and 'catch-up' countries (Greece, Ireland). Recent increases have been registered in Belgium, Germany, Spain, Austria, Portugal and Finland. The proportion of business expenditure on R&D financed by governments has fallen much more steeply, especially in Germany, France and the UK.
- GBAORD have also fallen as a proportion of GDP to less than 0.9% on average.

The future can be inferred from indicative budgets. Sweden is planning substantial near-term reductions in ministerial R&D budgets, though largely through a shift of money to a more-accountable central research foundation. The UK also plans further reductions, driven by sectoral concerns - cessation of support for near-market and nuclear fusion research, general scaling-back and privatisation of defence research and 'Private Finance Initiative' measures that substitute private funding and/or transfer risk. Spain, Portugal and Greece plan increases up to European levels, but have a history of unsuccessful attempts. Ireland, following a 1996 White Paper[23] plan, has sustained recent growth in GERD/GDP and in particular in foreign R&D funding. Many other countries planning R&D expenditure increases have had difficulty with such targets in the past. This may worsen as a result of recent economic developments, particularly if R&D expenditure is seen as a relatively long-term and costly means of social support or job creation.

There are few consistent data sources capable of distinguishing the control, competition and mechanism effects described above. We therefore give a two-fold assessment. Subsection 3.2 considers patterns in GBAORD based on the distinction among general university funds[24], non-oriented funds and oriented funding. These data are consistently available and related to control of topic selection. They also support some inferences about competition - general university funding is only indirectly competitive while oriented research funding is often allocated by competitive proposal assessments. As these are relatively coarse and insensitive to national innovation system details, subsection 3.3 gives a more detailed view of three countries: Germany, the Netherlands and the United Kingdom.

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[22] 'Tight contracting' of research seems to be mostly oriented towards accountability by performers rather than direction by funders, in part because performers are deemed to be better able to select promising R&D avenues.
[23] Forfás 1996.
[24] In prior years this was referred to as "institutional funding for higher education."

3.2. CONTROL OF RESEARCH

The interviews suggested that research funders require increasing accountability[25]. This appears inconsistent with aggregate (EU) data in Figure 3[26], which show a steady trend toward GUF (with a recent interruption in 1994), together with erosion of oriented funding: a gradual transfer of control to performers. In practice[27], this is affected by the inclusion of private research, which tends to be client-controlled. At the same time, there is evidence that private R&D concentrates on near-market products and elimination of duplication: the two effects work in opposite directions as far as involvement of PSRIs and the degree of control are concerned[28]. The situation is complicated by multiple dimensions of control: project funding by the Italian Research Council (CNR), for instance, gives researchers great substantive latitude but imposes rigorous reporting and administrative requirements.

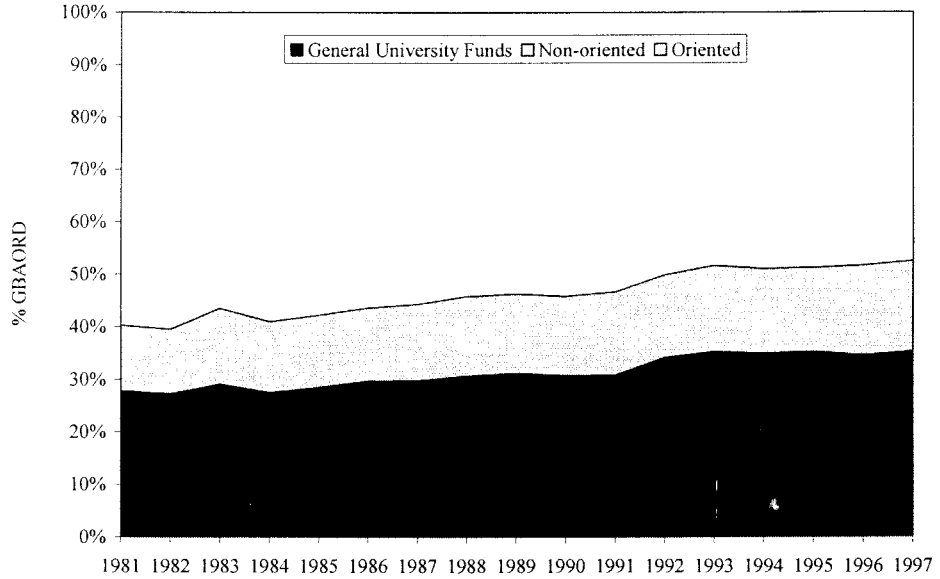

Figure 3: Orientation of research

Table 4 shows annual changes in the share of the three types of research, and indicates significant[29] trends at the country level. For instance the EU share of general university funding rose an estimated 0.64% per year over the indicated period[30].

Table 4: Significant trends in research orientation

Country	*Time-span*	*GUF*	*Non-oriented*	*Oriented*
Austria	1990-1998	0.01%	0.28%**	-0.29%*
Belgium	1990-1997	-0.17%	-0.10%	0.26%**
Denmark	1990-1996	0.58%**	-0.50%**	-0.08%
Finland	1990-1998	-0.14%	0.28%**	-0.15%
France	1990-1997	0.60%**	0.36%**	-0.96%**
Germany	1990-1997	0.67%**	0.24%**	-0.91%**
Greece	1990-1996	-0.01%	1.18%**	-1.16%*
Ireland	1990-1997	-0.94%	0.20%	0.74%
Italy	1990-1995	3.17%**	-0.63%**	-2.54%**
Netherlands	1990-1998	1.30%**	-0.08%	-1.22%**
Portugal	1990-1994	0.77%	-0.91%*	0.14%
Spain	1990-1997	2.16%**	-0.55%**	-1.61%**
Sweden	1990-1996	1.47%**	-0.68%**	-0.79%*
United Kingdom	1990-1997	-0.54%**	1.77%**	-1.22%**
European Union	1990-1997	0.64%**	0.25%**	-0.89%**

Source: OECD 1998

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[25] This is supported by other published sources (e.g. David, Foray and Steinmueller 1999) and government publications (e.g. BMBF 1996).
[26] Source: OECD data based on GBAORD
[27] The GBAORD data on orientation do not allow clear separation of public and private funds.
[28] Sec. 4 looks more closely at the public-private patterns.
[29] (*) denotes a significant (10%) trend; (**) denotes a highly significant (5%) trend, from regression estimates.
[30] Data for the period 1981-1998 are available, but we concentrate on more recent trends.

Data that fit the strict form of the increasing-control hypothesis would show:

- Significantly decreasing reliance on general university funds - UK;
- Significantly decreasing non-oriented research - Dk, It, Po, Sp and Sw; and/or
- Significantly increasing oriented research – Be and Sw.

Closer inspection suggests this hypothesis is oversimplified. 9 of 14 Member States show an overall positive trend toward increased reliance on general university funds, which is highly significant in 7 countries. This may reflect the long-term commitment to education as well as R&D, while economic pressures reduce other funding types. Eleven of 14 Member States show falling proportions of oriented research; this trend is significant in 8 of them. One possible explanation is displacement of public by private support and 'devolution' of successful previous initiatives. Alternatively, many of those interviewed suggested that control and accountability increasingly focused on the way research was conducted rather than the subject. Finally, non-oriented research includes both contract-mediated and institutional funding, particularly in the large, non-academic publicly supported research establishments of nations like Germany (where it rose significantly) and the Netherlands (where it fell insignificantly). We take a closer look at these establishments in subsection 3.3.

3.3. COMPETITION

The investigation revealed interesting relations among the effects of economic forces, use of competitive mechanisms and 'market positioning' of research at PSRIs. These developments were connected to specific national systems of innovation, and substantive information was only available for a subset of the countries. This subsection describes four countries: Denmark, Germany, Netherlands and the United Kingdom. These cases were developed to shed light on two complementary phenomena: i) forces leading to the use of competitive mechanisms, and the changing mix of institutional and contract finance; and ii) specific instances of competitive mechanisms and the prevalence of competitive contracting. International comparisons are only possible with regard to the former.

3.3.1. Changes in funding of German and Dutch non-governmental research institutes

This subsection describes recent funding changes in two types of non-governmental research institution: i) the German Fraunhofer Gesellschaft (FHG) / Dutch Organization for Applied Research (TNO); and ii) the German Helmholtz Centres / Dutch Large Technological Institutes (LTI).

German data distinguish four funding types: (a) institutional basic funding; (b) project-based funding from government (Federal and Länder) sources; (c) contract research with business sources; and (d) other sources. Dutch statistics distinguish six types: (a) institutional basic funding; (b) contracts with Dutch public agencies; (c1) contracts with Dutch private firms; (c2) contracts with international private firms; (d1) goal-oriented funding (related to specific research programs); and (d2) contracts with international organizations (e.g. EU).

Recent challenges to the 'Fraunhofer model'

The Fraunhofer Society (FHG) performs long-term application-oriented contract research for public and private clients and also serves as an intermediary between science and industry. For many years it has maintained a stable balance among three principal funding sources (a-c above) and in terms of the research funding it in turn provides. This structure has allowed the FHG to provide a valuable mix of basic and application-oriented research serving public and private interests. Recent changes threaten this stability in ways that have interesting implications for the mix of funding of and by the FHG. Economic pressures slowed the growth of private sector contract research and greatly reduced the volume of public sector project funding. Indications of these changes can be found in the various ratios that characterise the 'Fraunhofer model.' Public project funding as a proportion of contract research revenue fell from 34% in 1991 to 18% in 1997[31]. Federal project revenue as a proportion of total earnings, long stable at around 28%, fell to 16% in 1996[32]. Finally, the 'earnings ratio' of contract research revenue to FHG expenditure on contract research has fallen to 60%. The first two shifts are shown[32] in Figure 4.

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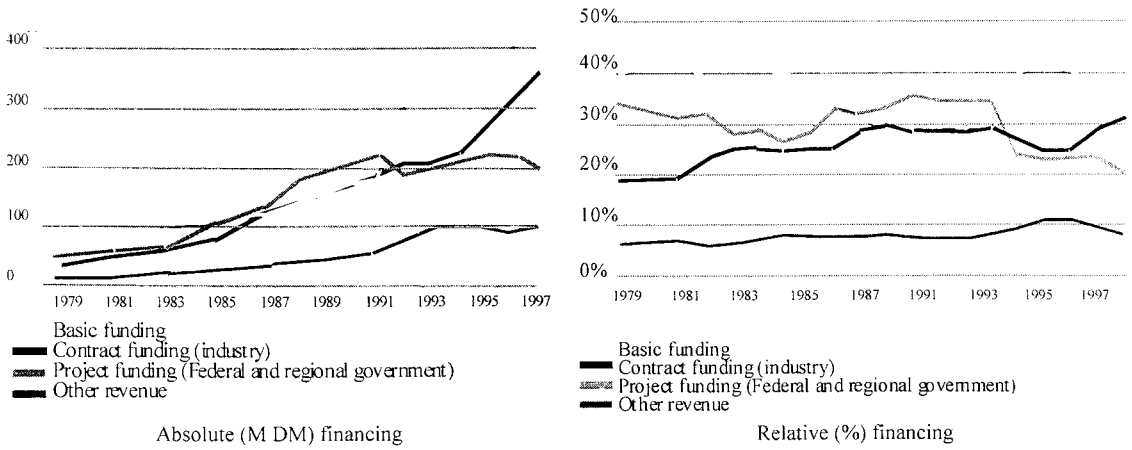
[31] 1997 Annual Report, Fraunhofer Gesellschaft.
[32] 1996 Annual Report, Fraunhofer Gesellschaft.



Absolute (M DM) financing

Relative (%) financing

Figure 4: Financing of Fraunhofer institutes

These changes caused the FHG and other publicly supported research institutes to seek more private support. The German contract research market has experienced stagnant demand and expanding supply as a result of falling levels of government project support and new restrictions on institutional support[33]. These institutions also compete with the research divisions of large private corporations. The ensuing competition involves many parts of the highly differentiated German R&D sector with very different degrees of flexibility, access to institutional funding and proximity to client interests. For the FHG at least this increased dependence on private clients and institutional funding to pay for the contract research it commissions. The FHG[31] views this as undermining its key flexibility. Increased dependence on core funding limits the ability to use results-related compensation for specialists and managers. On the other hand, increasing reliance on private contracts moves the FHG away from its traditional strengths towards a role as an 'extended workbench' for industry, where it faces considerable competition[34]. For German research as a whole, there is a danger that competitive pressures will either undermine the advantages of specialisation or produce unfair competition that imperils the viability of long-range application-oriented research. To counter these forces, the FHG has: i) increased co-operation where possible to eliminate duplication and increase flexibility (e.g. by lowering barriers between different categories of research establishment); ii) set up new innovation centres to provide an independent bridge between the research the FHG is best suited to performing and near-market applications of most value to private clients; and iii) phased out mature research areas.

TNO and the Fraunhofer Institutes

In the period 1984-1997 TNO's total research income gradually increased from 569 million to 780 million Dutch guilders (NlG). During the same period institutional funding fell from 27.2% to 14.2%. Although government policy increased program-related funds after 1984 their share fell from 37.5% in 1985 to 25.1% in 1997. Research financed via contracts with public and private organisations gradually increased from 276 million NlG (48.5%) to 473 million NlG (60.7%) over the period. Figure 5 shows the absolute (in PPP$ terms) and relative composition of TNO funding.

[33] E.g. Länder linkage of core financing to external finance.

[34] The 1997 Annual Report notes that private industry already 'co-determines' over half the FHG's research output, with 2/3 of this amount involving direct contracts to supply.

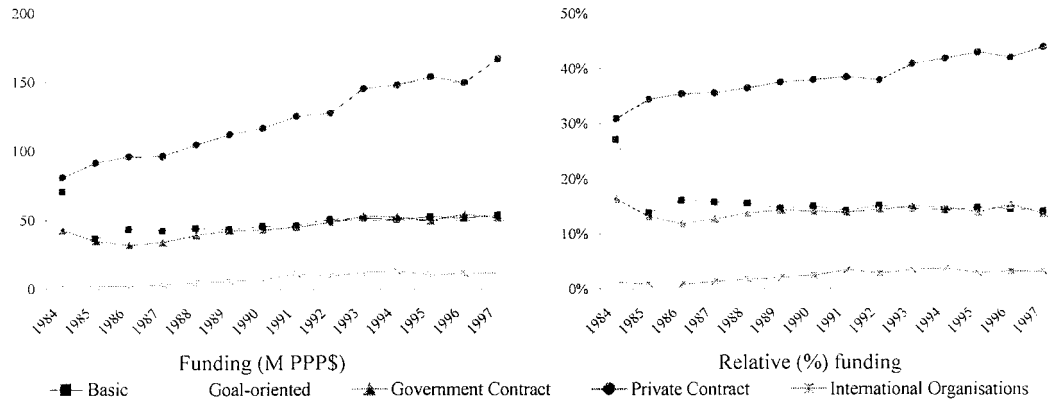


Figure 5: Financing of TNO research

Comparing TNO (Figure 5) with the structurally similar FHG (Figure 4) shows two significant differences. First, total funding for the FHG increased substantially more in the same period. Second, basic funding continues to play a strong role in the FHG[35] while (federal and Länder) government project funding did not increase in the 1990s. As noted, private contract funding also became more important to the FHG in recent years. Comparing relative roles of these funding sources for the FHG since 1984 reveals that *basic* funding fell more or less steadily till 1992 – when *government project* funding began its precipitous decline – and then returned to a relatively high level of approximately 40%. In the same period the share of *contract* funding increased from (approximately) 25% to 32%.

The Large Technological Institutes and the Helmholtz Centres

In addition to TNO there are five Large Technological Institutes (LTIs) in the Netherlands: Delft Hydraulics (WL); Delft Geotechnics (GD); the Maritime Research Institute Netherlands (MARIN); the National Aerospace Laboratory (NLR); and the Netherlands Energy Research Foundation (ECN). Each had a specific composition and evolution of funding during 1984 – 1997.

Only those institutes able to attract new funds experienced increased funding (especially ECN and NLR). The other institutes remained at approximately the same level of funding or saw their funds actually decrease. It appears that only ECN was predominantly dependent on *institutional* financing in 1984; the others already had diversified funding. But in all cases the composition of funds in 1984 and 1997 are significantly different. For ECN *program funding* and *private contracts* became more important, while EU funding slightly increased. The National Aerospace Laboratory (NLR) increased its foreign contract funding relative to contracts from The Netherlands. The relative positions of public and private contracts in the funding of Delft Geotechnics (GD) and Delft Hydraulics (WL) were reversed in this period, with foreign private firms showing particularly strong growth. Finally, MARIN received more funding from Dutch private firms but less from foreign private firms, while public financing remained at approximately the same level (although the relative positions of institutional and program funding reversed). The large and increasing dependency of the LTIs on contract financing is especially striking compared to their German counterparts. For example, institutional funding of NLR is only 27.3% while the German national aerospace research institute DLR received 60.1% of its funding from institutional sources (other German Helmholtz Centres have even higher percentages of institutional funding – but are not as comparable to Dutch LTI's).

Table 5: Financing of Dutch and German large technological institutes

	Institutional		*Total project-based*		*Public project-based*		*Other*	
	M PPP$	*%*	*M PPP$*	*%*	*M PPP$*	*%*	*M PPP$*	*%*
TNO[1]	54.1	14.20%	230.7	60.60%	51.7	13.60%	95.6	25.10%
LTIs[1]	40.2	19.87%	138.0	68.13%	24.7	12.21%	24.3	12.00%
Fraunhofer[2]	213.9	31.6%	297.0	43.9%	116.4	17.2%	48.8	7.2%
Helmholtz[3]	1516.6	76.85%	456.8	23.15%	N/A	N/A	N/A	N/A

[1] Source: NI. Ministerie van Onderwijs. Cultuur & Wetenschappen. 1997 figures - "Other" category includes Goal-oriented.
[2] Source: 1997 Fraunhofer Institutes Annual Report – "Public project-based" category is Federal + Länder contract research.
[3] Source: 1998 Helmholtz Centres Annual Report – "Total project-based" category is "contract-based."

[35] While the FHG receives little institutional financing relative to its new German competitors, it nonetheless receives considerably more than TNO.

3.3.2. Competitive allocation of Institutional funding by the Danish Research Foundation

The Danish National Research Foundation was established in 1991 along the lines of the German Max Planck Gesellschaft. The idea was to create centres of national excellence embodying close links between basic research and Higher Education. It was established as a separate (from the Research Councils) organisation under the Ministry of Research & Information Technology in part because the required funding level far exceeds typical Research Council budgets (currently 2.5% of total public research support). The money is usually competitively allocated as 3-5 year block grants, paid in annual increments on the basis of performance against agreed targets and maintenance of professional standards, with peer review required for extension beyond the initial period. Grants are typically used to create centres within existing institutions. In sharp contrast to most other competitively allocated non-basic ('second-tier') financing, Foundation Centres are not classified by scientific field. Attaining international standards of excellence is viewed as more important than consistency with existing structures. It should be noted that 10 of the 23 Centres established as of 1998 involve co-operation with private companies via exchange of personnel, production of results of commercial importance and/or joint patenting activities.

3.3.3. Competition in Deutsche Forschungsgemeinschaft funding

This section describes changing competitive mechanisms in the funding provided by the Deutsche Forschungsgemeinschaft (DFG). This organisation, which receives institutional funding from both Federal and Länder levels of government, is made up of Universities, Research Institutes and Academies, and thus combines the roles of intermediary and research performer. The scientific members decide on project funding, principally in universities. It disbursed approximately 776 M DM in 1996 to individual projects and a further 900 M DM to joint research projects. Its structure and procedures are particularly interesting from the standpoint of competition and control.

Individual grant proposals are initiated by academics, and selected on the basis of review and competition. Some reviewers are appointed, but many are elected. Project review and selection are separate activities. This independence has recently come under threat; increasing workloads make reviewers reluctant to serve, while at the same time growing excess demand for funds means that criteria beyond scientific merit play a part in funding decisions. In response to falling approval rates, the DFG has developed *adaptive* mechanisms such as large-scale project comparisons. The burden of this longer procedure has been partially offset by introduction of longer-term (3-year) grants in order to reduce the overall volume of applications. Projects themselves are unrestricted: the researcher is free to choose the theme, the staff and even the institution where the work will be performed, and the proposal process is relatively free of deadlines and formal calls. By contrast, priority programmes in specific areas make use of a mix of invited calls for proposal and targeted open competitions (*Leitprojekte*). Funding for research units, clinical research and centres of excellence provides support for a limited period. These funds are allocated competitively; indeed, they compete with individual grant applications. On average, they provide support equivalent to 3-10 individual grants spread over a 6-year period. Collaborative research centres are funded for longer periods (12-14 years) and are intended to realise economies of scale and scope, particularly for junior research personnel. They are 75% funded by the federal government, via their home universities.

Most infrastructure development funds are project-based. Recipients are selected via review and/or competition (though rarely head-to-head). For large-scale equipment - whose purchase is increasingly necessitated by the limits in the University Construction Law - the DFG often requires joint use by several research groups. The only long-term institutional funding the DFG provides goes to central research facilities that provide joint (e.g. data) services to research, though they may be directly linked to individual researchers' needs independently of DFG funding. Recently, this concept of infrastructure as a shared resource has been extended to competitions between regions for large-scale, relatively long-term funding for a mix of related initiatives in the areas of biotechnology (the *Bio-Regio* and *Bio-future* programmes) and nanotechnology.

3.3.4. Contracting and competition in UK SET funding

The UK does not have large institutions directly analogous to the TNO/Fraunhofer Institutes or Large Science/Helmholtz Centres. However, in recent years data have been collected on government

Science, Engineering and Technology (SET) expenditures[36] let by contract and/or subject to competition. They show an increase in contracting in general (except in the Higher Education budget) and competitive contracting in particular (except for Military research). Other changes in organisation and the allocation of non-project funds have enhanced the role of competitive mechanisms.

Higher Education performs a steadily increasing fraction (about 56% in 1995) of publicly supported research in the UK. Support comes from Higher Education Budget (institutional and other financing administered by Higher Education Funding Councils - HEFCs) and the Science Budget (primarily contract-based grants administered by 6 Research Councils - RCs)[37], with smaller amounts from direct ministerial and non-government sources.

Research institutes face pressure to obtain longer contracts or institutional funding, provide separately for formation and maintenance of physical and human capital and involve non-government intermediaries or sources of institutional funding. As a recent review[38] of the Science Budget noted,

> "The Research Council Institutes and Centres are important players in basic and strategic research. In order to encourage them to develop enhanced contacts with users, (...) they will each be set targets (...) for the proportion of funds earned from users. The nature of this funding is important. Short term contract funding may help to sustain an Institute in existence but may contribute little to the Council's core mission."

Some of the most profound changes were organisational. For instance, the review determined that the laboratories of one organisation[39] should remain in public ownership but that, *inter alia*, relationships with principal customers and associated funding mechanisms should be managed through a new Council for the Central Laboratories of the Research Councils (CCL). The 1996 separation of the Engineering and Physical Sciences Research Council Laboratories intended to clarify 'customer contract relationships' between CCL and its principal customers (5 of the 6 Research Councils) and provide greater accountability. The Councils use Service Level Agreements to fund work at CCL that explicitly link revenues to CCL's ability to meet client needs efficiently and effectively.

Certain patterns are evident in the two periods (1995/6 and 1996/7) for which complete data are available. Aggregate RC funding remained stable, with about 50% competitive contracts and 45% non-contract funding. HEFC competitive contract funding was high (around 57%) and growing, while institutional funding (at least partially competitive – see page 22) more than doubled from 19.1% to 40.1%. Competitive contracting among other civil departments grew strongly (64.7% annual rate) with reductions in non-contract support and (especially) non-competitive contracting. The pattern was quite different in military (MOD) supported research, with both non-contractual and competitive contracting giving way to non-competitive contracting. These trends are described in Figure 6.

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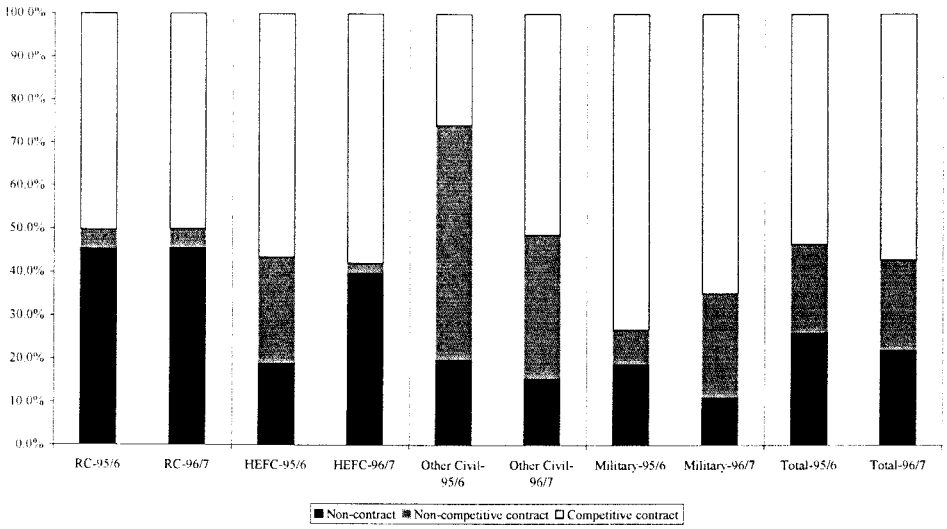
[36] These data include UK contributions to the EU R&D budget (6% of the total) and NHS R&D expenditures. 95.5% of 1996-97 civil SET expenditure was classified as R&D, 3.3% as technology transfer and 1.1% as taught courses and other minor SET activity. No breakdown of R&D *per se* showing contracting was available.

37 The RCs also support a network of Institutes and Centres.

38 The Director General of Research Councils' Review of the Science Budget Portfolio, OST, 1995.

39 The Daresbury and Rutherford Appleton laboratory complex.



Source: based on data in SET Reports 1997, 1998, UK Office of Science and Technology.

Figure 6: Composition of UK SET support

Table 6 shows patterns varying widely across departments and research councils. Particularly notable are variations among RCs and the sharp increase in competitive NHS contracts. The first two columns show the proportions of total contract financing that was subject to competition in the two years for which data are available, while the second two show the proportion of Science, Education and Technology (slightly broader than R&D) support that was allocated by means of contracts[40]. The final column shows the proportion of total SET provided by the individual agencies. These data illustrate the transformation of modalities by intermediaries: both the Research Councils and the Higher Education Funding Council receive institutional funding, and channel a high proportion through competitive contracts.

Table 6: Contracting and competition in UK government SET support

	Competitive contracts / Total contracts		*Contracts / Total*		*Average %*
Source\period	*1995/6*	*1996/7*	*1995/6*	*1996/7*	*of SET*
Biotechnology and Biological Sciences RC	100.0%	100.0%	51.7%	49.6%	3.7%
Economic and Social RC	51.9%	52.1%	95.4%	93.7%	1.3%
Medical RC	98.3%	98.8%	51.5%	51.7%	5.7%
Natural Environment RC	100.0%	100.0%	39.8%	43.8%	3.3%
Engineering and Physical Sciences RC	99.8%	99.8%	73.0%	72.4%	7.7%
Particle Physics and Astronomy RC	65.8%	65.7%	34.2%	32.1%	4.3%
1. Total Science Budget	92.2%	92.3%	54.4%	54.2%	26.5%
2. Higher Education Budget (incl. HEFCs)	69.9%	96.6%	80.8%	59.9%	2.0%
3. Other Departments Total Civil SET	4.0%	3.0%	58.8%	60.1%	0.3%
Civil Departments SET (2+3)	**34.9%**	**62.6%**	**80.0%**	**82.6%**	**29.9%**
Total Civil SET (1+2+3)	**56.3%**	**73.7%**	**68.0%**	**69.1%**	**56.4%**
4. Ministry of Defence	90.4%	73.2%	80.9%	88.6%	43.6%
Total SET (1+2+3+4)	**72.5%**	**73.4%**	**73.6%**	**77.7%**	**100.0%**

Source: based on data in 1997, 1998 SET Reports, UK Office of Science and Technology.

Competition outside contracting

Competitiveness as defined in the SET data refers strictly to contract research. Recent years have seen competition in research equipment funding and the use of competitive Research Assessments to allocate University institutional research funds.

[40] There is some variation among agencies, since some use less-formal "understandings" to fund projects without formal contracts, especially within the frame of an existing institutional arrangement.

1996 saw the first of five annual joint RC/HEFC equipment funding initiatives combining RC/HEFC finance with matching funds from industry, charities, other departments etc. These are co-ordinated competitions for equipment costing up to, or more than £250,000. More significantly, the 1998 Comprehensive Spending Review introduced 3-year funding commitments distinguishing capital and recurrent expenditure. A Joint Infrastructure Fund[41] of £300 million each from the government and the Wellcome Trust was created to alleviate infrastructure deficiencies[42]. Funds will be allocated by peer review of competing bids for scientific excellence and strategic priorities.

The Research Assessment Exercise (RAE) 'ranks' University departments in terms of the quality of past research. This is used to allocate the institutional component of HEFC University research funding, covering permanent academic staff salaries and research facilities. In 1996, these grants comprised 37% of Universities' civil research income, with 24% from Research Councils, about 4.3% each from Government Departments and Universities' own funds, and 6% from the domestic private sector.

The Research Assessment Exercise was introduced in 1986 and has been repeated in 1989, 1992 and 1996. Its purpose is to measure the quality of research and to use the resulting rankings to allocate the institutional component of HEFC research fund allocation, covering permanent academic staff salaries and research facilities. The method used has varied over the years and has grown to be a major exercise. It uses panels of experts in to evaluate each subject area in each HEI. Thus in 1996, 2,896 submissions for assessment were received from 192 HEIs across the UK, listing a total of 55,893 individual active researchers working in 69 areas. In 1996, grants allocated via the RAE comprised 37% of Universities' civil research income, with 24% from Research Councils, about 4.3% each from Government Departments and Universities' own funds, and 6% from the domestic private sector. Research quality was rated as follows:

1 National excellence in none, or virtually none, of the sub-areas of activity.

2 National excellence in up to half the sub-areas of activity.

3b National excellence in the majority of the sub-areas of activity.

3a National excellence in a substantial majority of the sub-areas of activity, or to international level in some and to national level in others together comprising a majority.

4 National excellence in virtually all sub-areas of activity, possibly showing some evidence of international excellence, or to international level in some and at least national level in a majority.

5 International excellence in some sub-areas of activity and to attainable levels of national excellence in virtually all others.

5* International excellence in a majority of sub-areas of activity and attainable levels of national excellence in all others.

The HEFCs use these rankings to allocate funding. Since the first RAE, the proportion of HEFC funds allocated on the basis of the quality rating has risen from 40% in 1986 to nearly 97% for 1997/98. The policy of selectivity has thus steadily intensified - currently no department rated below 3 receives any funds (with some regional exceptions). HEFC funds are thus concentrated on top performers in the RAE, although some flexibility and restructuring funds remain in other programmes.

While this is neither a 'winner-takes-all' competition nor a competition based on prospective research, it has nonetheless profoundly affected the location and, possibly, orientation of research in the largest component of the Science Base.

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[41] 'Allocation of the Science Budget 1999-00 to 2001-02,' HMSO 1998.
[42] Identified in the "Dearing Report;" Report of the National Committee of Inquiry into HE July 1997.

4. PATTERNS AND TRENDS IN RESEARCH FUNDING

4.1. OVERVIEW

According to the OECD[43], overall R&D funding has continued to increase, but at a decreasing rate, while R&D intensity (GERD as a proportion of GDP) has been falling. Figure 7 shows the most recent OECD data for the EU and its members. These trends can be seen as indicators of success, failure or evolution of public research support. The graph showing nominal GERD has been split as a result of the large differences in total GERD.

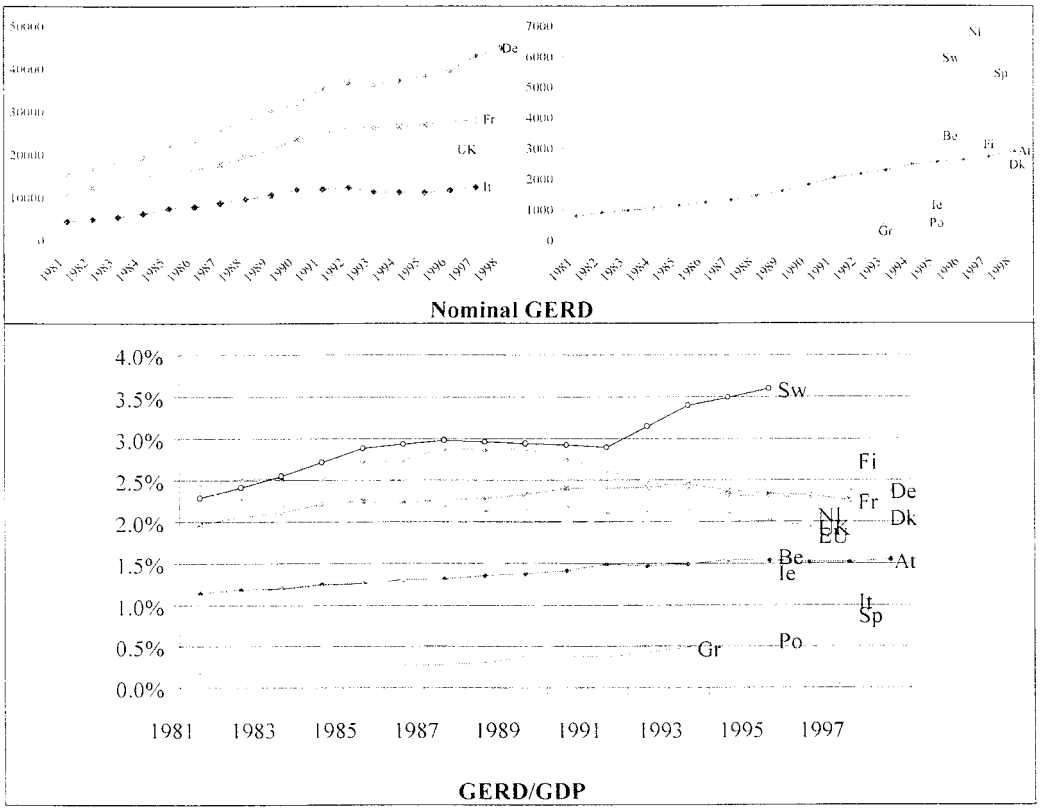


Figure 7: GERD and research intensity

The combination of increasing gross amounts and falling intensity could indicate increasing R&D efficiency - reduced duplication through globalisation of research and sharing of results. This is consistent with recent studies[44] showing that businesses are more likely to invest in new technology through purchases of embodied R&D than to sponsor new R&D; such investments have far higher rates of return. The same data could be seen as evidence of greater R&D effectiveness (at least for GDP growth); they are consistent with an economic cycle in which GDP grows faster (falls slower) than GERD due to better project selection and/or more intensive follow-up into profitable implementation.

Alternatively, the data could indicate shorter planning horizons, crowding-out and a shift from basic to more applied research. Support for basic research magnifies the payoff to other projects but encourages *free riding*, perhaps reducing the scale and/or scope of overall effort. By contrast, 'near-market' research tends to involve *duplication*. Funders find it hard to free ride and may oversupply support for strategic innovations. Historical studies of specific industries confirm that the most

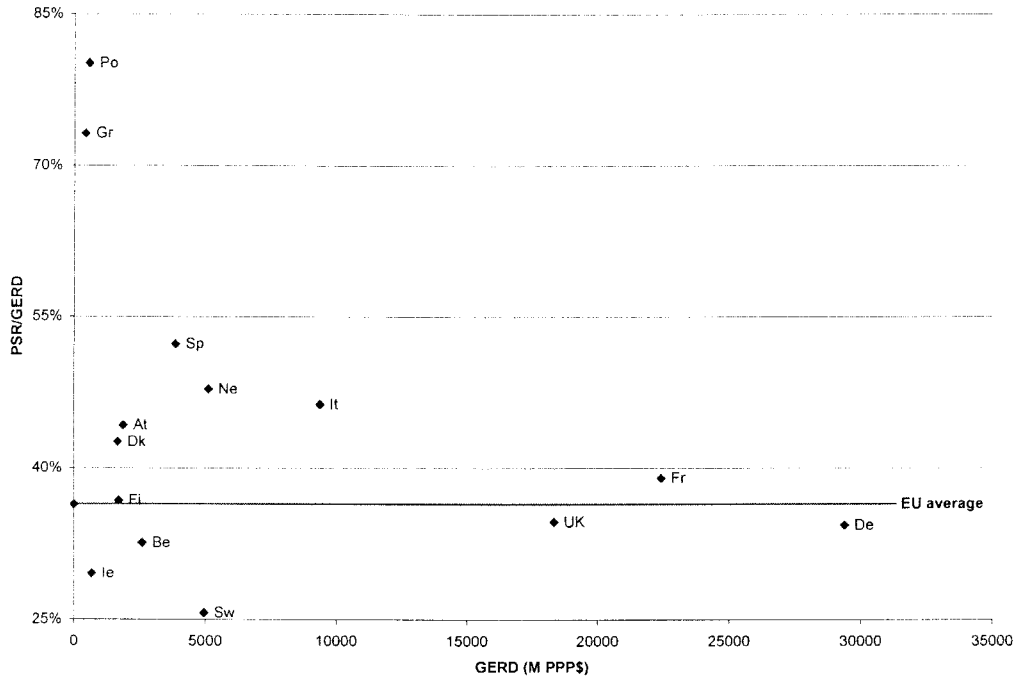
[43] López-Bassols, V. "How R&D is Changing," OECD Observer, No. 213, Aug/Sept. 1998, pp. 16-19.
[44] Cf. "Technology and Industrial Performance," OECD 1997.

successful publicly supported research programmes use a mix of funding and control mechanisms and associated managerial styles.

The data used in this study allow us to compare public and private modalities, but not to evaluate the R&D system as an engine of economic, scientific or social growth. The following subsections discuss the shifting balance among funders and providers to clarify the underlying patterns.

4.2. GENERAL

A first perspective on the patterns of public R&D funding can be obtained by plotting publicly supported GERD against total GERD. In principle, such a diagram might show a relation between funding sources and efficiency. Countries with high levels of GERD might be making conscious efforts to build public infrastructure. Countries that combine low proportions of publicly supported research (PSR) with high levels of GERD would have substantial private-sector research paid for out of private funds, while those with high proportions of PSR and low levels of GERD might suffer from 'crowding-out' of private by public support. The following figure shows PSR as a proportion of GERD against GERD[45]



Source: OECD, EAS (MSTI Database), November 1998.

Figure 8: Publicly supported research intensity v. GERD

In a striking testimony to the role of market forces, we see that 'big spenders' have substantial private R&D sectors. France, Germany and the UK are quite similar (except in GDP) and distinct from the other countries. The range of public v. private R&D is much higher for the countries with smaller total expenditures. There seems to be a rough inverse correlation between the degree of public support and the absolute or relative size of GERD. The countries can be grouped as follows[46]:

Table 7: Grouping of countries by research support

	PSR/GERD	*GERD*	*GERD/GDP*
1. De, Fr, UK	L	H	M

[45] This reflects the latest data that were available: 1993 for Austria and Greece and 1995 for other countries.
[46] Non-EU countries like Norway and Iceland have much higher (> 68%) levels of PSR/GERD and relatively low levels of GERD.

2. Gr. Po	VH	L	L
3. It. Sp	M	M	L
4. Dk. Fi	L/M	L	M
5. Be. Ie	L	L	M
6. At. Nl	M	L	M
7. Sw	L	L	H

Time trends of PSR/GERD show a modest shift from public to private R&D in most countries. The rankings are relatively stable, suggesting that the publicly supported proportion of research may be driven more by institutional factors, rigidities and conscious policy than by external and macroeconomic changes.

Figure 9 and Figure 10 show the relative magnitudes of flows from funders to performers in the first and last years for which complete data were available[47]. The diagrams are drawn using the interactive database prepared as part of the project and available on request. Flows are to scale, with the exception of private-to-private flows, which are represented by a dotted line.

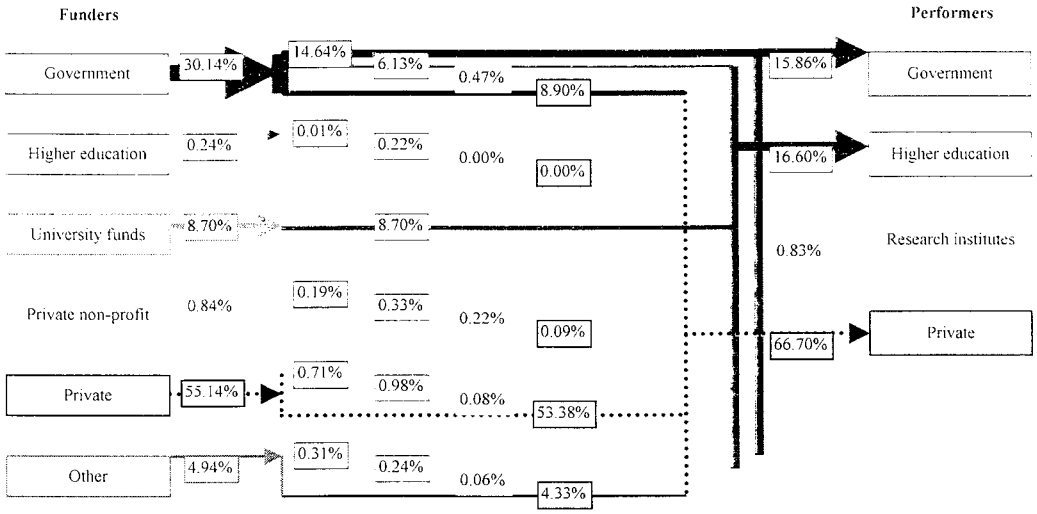


Figure 9: Flow of funding, EU, 1989

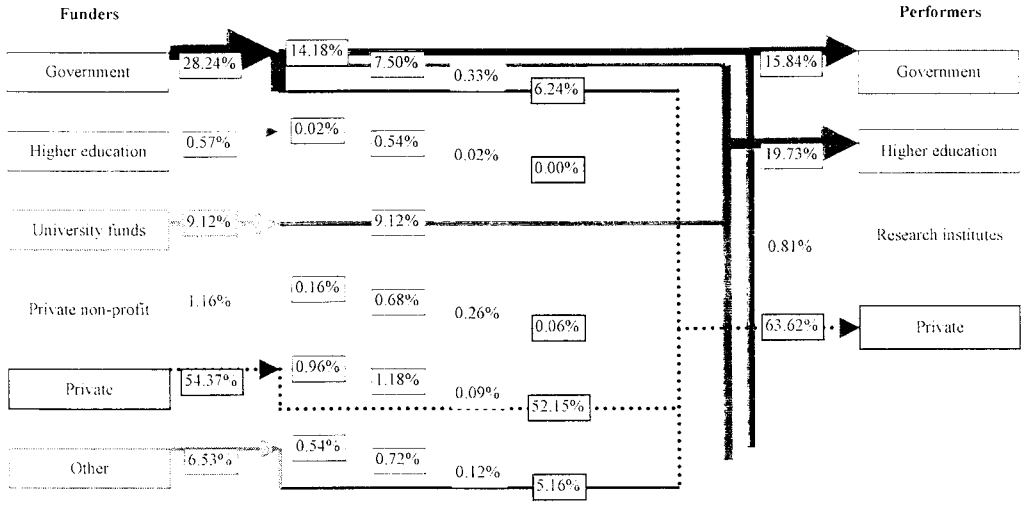


Figure 10: Flow of funding, EU, 1995

[47] These data show flows as a % of GERD aggregated using 1990 PPP$ deflators. Due to data incompatibilities, Figure 9 omits Portugal, and Figure 10 omits Austria and Greece. See Table A1 for details.

4.3. FUNDING OF RESEARCH PERFORMERS

The data show shrinking public support for government, higher education and private research performers. They also show that in most countries public research funding rose, but its relative importance decreased. The following tables support these observations. Table 8 shows the proportion of support to various performing sectors derived from public sources, Table 9 shows changes in public or non-private support by country for support to publicly supported research establishments and Table 10 shows changes in total funding by public and non-private sources.

Table 8: Proportion of R&D funding derived from public sources
(1995 data, 1989-1995 annualised growth rate in parentheses except as noted)

Country	*Government*	*Higher education*	*Research Institutes*	*Private*
At[1]	95.2 (-0.9)	97.2 (0)	33.0 (-19.1)	9.8 (14.9)
Be	92.5 (-0.6)	79.7 (-0.7)	8.6 (-15.3)	4.4 (-11.1)
De	93.1 (-0.5)	90.9 (-0.4)	(note 4)	9.0 (-3.4)
Dk	82.3 (-0.7)	89.5 (-0.3)	11.9 (13.9)	5.4 (-12.0)
Fi	84.1 (-0.4)	90.1 (-0.3)	28.4 (-3.2)	5.6 (10.3)
Fr	90.2 (-0.6)	94.6 (0)	44.7 (4.0)	12.7 (-6.7)
Gr[2]	67.1 (-6.6)	65.1 (-6.1)	26.9 (0)	4.6 (-14.3)
Ie	78.0 (-1.0)	66.5 (-0.8)	0.0 (-100)	4.5 (-6.6)
It	95.9 (-0.2)	92.0 (-0.8)	N/A	14.3 (-2.2)
Nl	74.0 (-1.2)	86.0 (-1.8)	76.6 (1.9)	6.6 (-7.7)
Po[3]	90.9 (-1.0)	90.5 (-1.2)	52.1 (31.4)	5.2 (-4.7)
Sp	87.3 (-1.5)	84.1 (-1.1)	16.2 (10.2)	9.2 (-4.1)
Sw	100 (1.3)	86.7 (-0.1)	100 (12.2)	9.5 (-4.7)
UK	84.5 (-0.1)	71.9 (-1.7)	44.8 (-8.4)	12.0 (-5.8)
EU	89.6 (-0.5)	87.0 (-0.7)	42.4 (-4.8)	9.8 (-5.0)

Source: OECD 1. 1993 data, 1989-1993 growth 2. 1994 data, 1989-1994 growth 3. 1995 data, 1990-1994 growth
4. Consistent data cannot be obtained due to reclassification/migration.

Support for government research performers is normally derived from public sources. Exceptions include Greece (due to weak government support and the way EU funds are accounted for), Ireland and the Netherlands (where private funding for government research performers is strong and growing). The proportion of public support used to fund higher education research is high and stable in Austria and France, but shrinking elsewhere. Non-public sources are particularly important in Greece, Ireland (due to 'privatisation' of research centres on University campuses) and the UK (due to vigorous government efforts to shift R&D funding to the private sector).

Table 9: Changes in non-private support for publicly supported research institutions[48]

Source[1]:	*G + HE*		*G + HE + UF*		*G + HE + PNP*		*G + HE + PNP + UF*	
Country	*Δ M PPP$*	*Δ %*	*Δ M PPP$*	*Δ %*	*Δ M PPP$*	*Δ %*	*Δ M PPP$*	*Δ %*
At	69	1.5%	182	-0.1%	70	1.5%	183	-0.1%
Be	72	7.1%	-20	-4.5%	79	8.0%	-13	-3.6%
De	1178	-0.2%	1772	-1.9%	1159	-0.6%	1753	-2.3%
Dk	72	-1.9%	140	-2.3%	86	-1.4%	153	-1.8%
Fi	52	-1.8%	86	-1.6%	47	-2.8%	82	-2.5%
Fr	-31	-4.0%	256	-1.7%	-12	-3.8%	275	-1.5%
Gr	-7	-12.1%	-15	-20.3%	-7	-12.1%	-15	-20.3%
Ie	31	-6.7%	58	-5.1%	33	-6.1%	60	-4.5%
It	-72	-3.0%	-72	-3.0%	-72	-3.0%	-72	-3.0%
Nl	66	-7.9%	416	-6.2%	128	-6.3%	478	-4.6%
Po	98	-14.8%	98	-14.8%	114	-11.7%	114	-11.7%
Sp	343	-3.6%	456	-7.5%	348	-3.5%	461	-7.3%
Sw	-49	-1.0%	-62	0.9%	-29	0.6%	-43	2.5%
UK	172	-2.5%	172	-4.5%	330	-0.7%	330	-2.7%
EU	**1551**	**-2.0%**	**2299**	**-2.5%**	**1679**	**-1.9%**	**2426**	**-2.4%**

Source: OECD 1998. Based on changes between first and last years of available data – see page 37.
1. G = government ministries; HE = Higher Education funds; PNP = private non-profit; and UF = University funds

[48] Government and University laboratories and some PNP research institutes – see Table 3.

These data show clear and interesting patterns[49]. In most countries public funding increased in absolute terms but fell as a proportion of total funding. The opposite pattern is seen in Sweden, where funding (including UF and/or PNP) fell while increasing in relative importance. Non-private support for *all* performers follows the very different pattern shown on the right in Table 10.

Table 10: Changes in non-private research support

Pattern	*Magnitude*	*Proportion*	*To PSRIs*	*To all performers*
1	Up	Up	None	At, De, Nl[2], Po, Sp
2	Up	Down	At[1], De, Dk, Fi, Fr[1], Ie, Nl, Po, Sp, UK, EU	Dk, Fi, Ie, EU[1]
3	Down	Up	Sw[2]	It
4	Down	Down	Be[1], Gr, It	Be[3], Fr, Gr, Sw, UK

1. If UF included 2. If UF or PNP included 3. Unless just PNP included

4.4. SOURCES OF RESEARCH SUPPORT

Aggregate government support has been fluctuating without a clear trend, whilst most other sources show modest growth. Levels and growth rates for publicly supported research institutions are shown in Table 11. Figure 11 and Figure 12 give a graphical view.

Table 11: Proportion of R&D spending flowing to publicly supported research institutions
(1995 data, 1989-1995 annualised growth rate in parentheses except as noted)

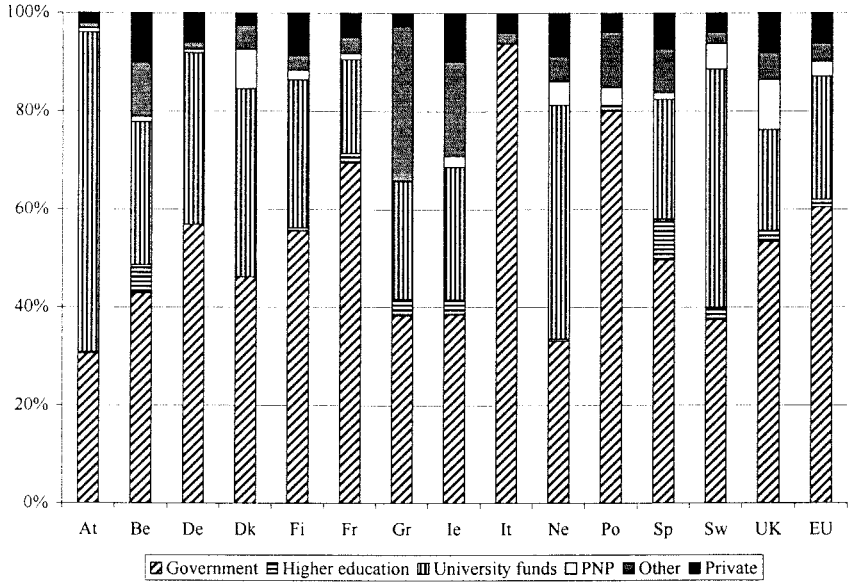
Country	*Government*	*Higher education*	*PNP*	*Private*	*Other (foreign)*
At[1]	71.2 (-2.5)	100 (0)	98.5 (0.1)	1.9 (5.6)	17.0 (33.7)
Be	82.6 (3.3)	100 (0)	55.9 (0)	5.1 (-0.1)	51.6 (-7.5)
De	76.8 (2.4)	N/A	66.7 (1.3)	3.4 (9.7)	27.5 (20.8)
Dk	86.4 (1.9)	N/A	81.9 (1.6)	2.3 (1.6)	21.0 (-13.3)
Fi	85.3 (-1.2)	100 (0)	96.4 (-0.2)	5.3 (1.8)	24.8 (-12.4)
Fr	77.8 (1.3)	99.5 (0.7)	97.2 (0.3)	4.0 (-0.2)	15.7 (6.8)
Gr[2]	95.8 (0)	100 (0)	100 (0)	9.9 (-7.5)	75.8 (2.3)
Ie	78.0 (-1.0)	100 (0)	69.0 (-5.0)	4.3 (-6.7)	69.4 (-0.2)
It	85.0 (0.9)	N/A	N/A	4.1 (11.3)	23.6 (19.9)
Nl	82.3 (2.0)	100 (2.7)	96.8 (2.3)	9.2 (8.2)	26.0 (1.6)
Po[3]	98.4 (0.2)	100 (0.6)	98.4 (0)	16.1 (2.4)	75.9 (0)
Sp	85.6 (1.0)	100 (0)	97.2 (6.1)	8.6 (7.7)	60.2 (21.6)
Sw	57.7 (-1.3)	100 (0)	100 (0)	1.5 (-16.7)	17.4 (-2.8)
UK	70.2 (2.8)	100 (0)	100 (0)	5.8 (2.4)	13.3 (7.0)
EU	77.9 (1.7)	99.9 (0.2)	94.5 (1.0)	4.1 (4.2)	21.0 (9.4)

Source: OECD 1. 1993 data, 1989-1993 growth 2. 1994 data, 1989-1994 growth 3. 1995 data, 1990-1994 growth

The proportion of government R&D funding going to PSRIs ranges from 57.7% (Sweden) to 98.4% (Portugal). These countries are well out in the tails of the distribution and heading further apart, indicating the existence of a wide variety of approaches. Support from Higher Education and PNP funds is almost exclusively destined for PSRIs. Exceptions include Belgium and Germany (due to the existence of 'private foundations' that fund private-sector research) and Ireland (due in part to privatisation of research institutes). Private support for PSRIs is typically below 10%, with the exception of Portugal[50]. In some countries (e.g. Austria, Germany, Italy, the Netherlands and Spain), private support for PSRIs is growing substantially, while in others (esp. Greece, Ireland and Sweden) it is shrinking rapidly. It should be recalled that these figures combine changes in private spending on privately performed R&D with changes in private spending on publicly performed R&D. Thus the decline in Ireland's figure probably represents the privatisation of good R&D performers while the increase in Portugal should be seen in light of an overall downward trend in private sector R&D expenditure. The 'Other' category chiefly is comprised of foreign sources. Countries below the EU average (e.g. Austria, France, Sweden and the UK) tend to have substantial inward private investment and/or strong domestic industries involved in multinational collaboration, providing substantial flows of private R&D support. Countries above the average (esp. Greece, Ireland, Portugal and Spain) are often recipients of public R&D support from EU and other supranational sources.

[49] With relatively few exceptions, the direction of change is insensitive to the definition of public support used.
[50] The high value for Portugal partially reflects low historical levels of Portuguese industrial investment in R&D, so there is only a small private R&D sector. Recent cuts in private R&D spending have, therefore, differentially fallen on the infant private research sectors.

There are striking variations in the sources of support for publicly supported research institutions. Figure 11 shows sources of support for PSR in 1995 (). Non-government, non-profit (university funds and private non-profit) financing makes up more than half of total support for PSRIs in (descending order) Austria, Sweden and the Netherlands. By contrast, such sources fund small or vanishing amounts of PSR in Portugal and Italy. Private money is also an important (> 8%) source of support and direction for PSR in several countries: Belgium, Ireland[51], the Netherlands, Finland, and the United Kingdom. Conversely, the dependence of PSRIs on government support is greatest in Italy, Portugal and France (all of which comfortably exceed the EU average of 62%).



Note: 1993 data used for At, Gr. 1995 for all other countries. Includes PNP.

Figure 11: Funding sources for publicly supported R&D institutions

Figure 12 shows changes in *relative*[52] PSR support between the first and last periods of available[53] data. It illustrates variation among countries and rebalancing of PSRI support among public sources. All but Belgium and Austria shift away from government funding; only Finland[54] shifts away from higher education funding. Almost equal numbers shift towards or away from University funds. These changes affect research direction and spill over benefits to the economy and knowledge infrastructure, particularly in countries where private enterprise provided some support for PSRIs.

[51] This reflects the low level of total support and the generosity of foreign firms rather than the high levels of support from domestic enterprise.
[52] Hence the changes sum to 0 in each case.
[53] See details on page 37.
[54] and Iceland among the EFTA countries.

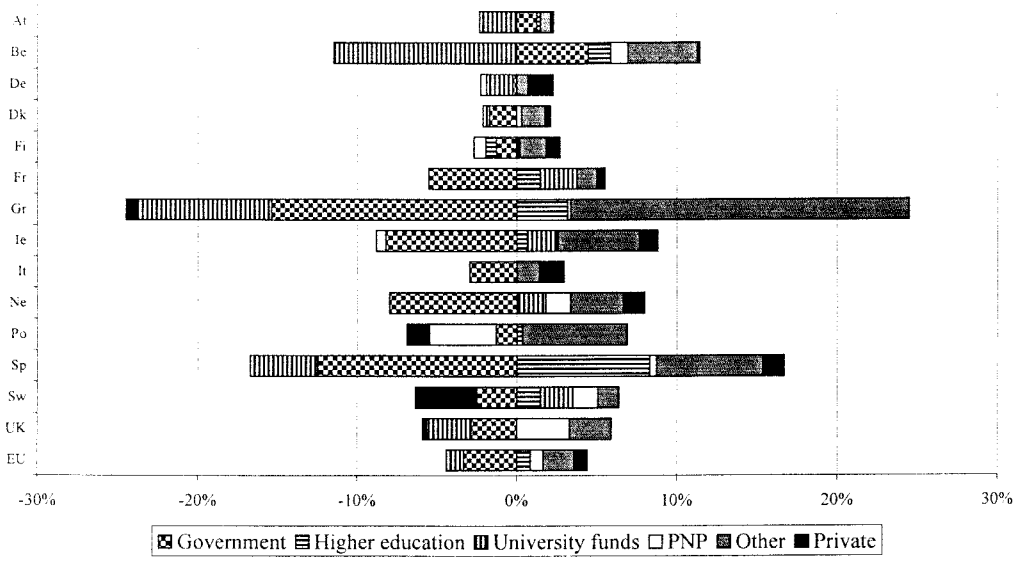


Figure 12: Changes in relative contributions to funding for publicly supported R&D institutions

5. REMARKS AND CONCLUSIONS

5.1. RECENT CHANGES

The recent past has seen large changes in public R&D support.

Global economic factors have prompted shifts from direct to indirect support and waning of defence R&D. The goals of R&D policy have also shifted. It has been suggested[55] that Europe is shifting from technology-led R&D policies based on competitiveness to integrated systems oriented to social needs and joint production of knowledge, goods, services and public welfare. Other recent major changes include: globalisation of markets and research activity; changes in the international legal and financial environments; co-operation and/or consolidation of research institutes; emergence of new countries competing in 'high-tech' areas; increasing R&D costs; increasing unemployment; and the increasingly multi- or international character of firms.

These phenomena have implications for R&D policy. Past governments have used a mix of R&D, education, competition, tax and other policies to strengthen the social benefits of innovation. Steps to protect intellectual property rights were taken to balance the interests and incentives of creators against 'spill over' benefits of wide use of emerging information. European states differ strongly in the mechanisms and philosophy underlying this balance[56]. Erosion of these protections is creating demands for additional public financing (as returns to private investors become less certain) and an increased likelihood that the fruits of such support will not accrue to the funding nation.

Additionality is an interesting aspect of this development. There is always a tendency to use external R&D support to ease the burdens on existing funders[57]. The extent to which this frustrates efforts to increase overall R&D funding or improve its efficiency seems to reflect a 'developmental threshold' in the sector or nation involved. In some countries private enterprise expenditure on extramural R&D is chronically low and public support clearly crowds out private support on a one-for-one or greater basis. This withering of domestic enterprise support for (publicly supported) R&D is often accompanied by internationalisation - global firms[58] and supranational funding sources such as the EU are often more willing to support public institutions. 'Incentive' funding schemes where grants pay a limited share of (proposed) costs are used to limit the extent of adverse crowding-out, but the incentives they provide are still imperfect and are regarded as distorting investment and staffing as well as research orientation. In some cases, the availability of outside funds has even been cited as a contributor to the erosion of government R&D policy capability and vision[55].

5.2. CONCLUDING COMMENTS

This section collects some of the main findings and trends under four headings: changing roles of participants in the R&D system; changing funding patterns among participants; the balance between institutional and project-based funding; and the use of competitive allocation mechanisms. Causal chains link these phenomena (e.g. changing roles may either cause or induce changes in funding). In particular, the latter two categories substantially overlap as a result of the increasing use of competition for fund allocation combined with a trend in some countries and sectors towards institutional or block grant funding to provide stability, increase continuity and enhance researcher input into research agendas.

5.2.1. Changing Roles

The participants in the R&D system have been roughly divided among funders, intermediaries and performers. In general, there is evidence of 'migration' of participants both horizontally (from

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[55] European Commission DG XII 1997, ch. 6.

[56] They differ in ways correlated with the above classification of national innovation systems. In particular, "market" systems tend to protect the *economic* rights of *owners* or *exploiters* of intellectual property, whilst "European integration" systems stress the *moral* rights of the *creators* of such property.

[57] Some such reallocation is consistent with domestic efficiency and may even be collectively desirable. Overall, one might expect that increasing levels of aggregation (e.g. EU as opposed to national) would result in increased emphasis on the "public good" benefits of R&D and on the procedural fairness of funding allocation.

[58] Often attracted by government policies directly aimed at innovation rather than inward investment.

public to private, esp. at the performer level) and vertically (with the emergence of some hybrid funder-intermediary or intermediary-performer institutions or the specialisation of some hybrids to a single layer).

Funding organisations are evolving in terms of the instruments used to provide support, the co-ordinating institutions and allocation of responsibilities among them (esp. for Ministries with specific social missions beyond the advance of knowledge) and the nature of their engagement with intermediaries and performers. These trends are not uniform; in many cases 'frame budgeting' (for spending ministries), and 'institutional support' (for intermediaries and performers) that give considerable latitude are being replaced with 'line-item' or contractual approaches intended to increase oversight and accountability. On the other hand, some countries are moving their non-institutional funding towards block grants in order to increase sustainability and continuity.

Intermediaries are important players in many countries, but their roles are shifting. In particular, the widely copied Research Council system is changing in response to budget pressures and public demands for greater focus and accountability. These modifications increase the importance of competitive mechanisms and economic and social selection criteria in combination with scientific and human resource considerations. Other forms of intermediary facilitate co-operation among different types of R&D entities, particularly as a means of increasing connections between publicly supported research and the industrial base without jeopardising their separate 'cultures.'

At the performer level, many publicly supported research establishments are being privatised in some way. In addition, organisational and funding initiatives are increasingly used to strengthen links among different types of performers. Finally, recent reductions in government RTD spending have increased the relative importance of Universities as performers of publicly supported research and development. This has occurred in part because the University component of Government expenditure (and in particular the relatively institutional GUF funds) is difficult to reduce for political reasons.

5.2.2. Funding

Overall, gross expenditures on R&D continue to increase, but at a decreasing rate; they also make up a (recently) falling proportion of GDP. This may be due to increased R&D efficiency or a by-product of R&D targeting changes from publicly funded fundamental research towards private, near-market research. Nominal Government expenditure on R&D has stagnated, and forms a diminishing proportion of gross expenditure. This reflects increasing pressure on government R&D budgets and pressure on performers to find other sources of support.

5.2.3. Institutional and Project Funding

The distinction between institutional and project-based funding has become blurred by classification difficulties and recent changes: increases in contract length and size give some project-oriented support an institutional character; while competitive allocation of infrastructure funding increasingly links funding to specific (past and future) projects. Choices as to research direction, priorities and conduct are increasingly left to research performers. Budget data suggest[59] that choices about research orientation are increasingly left to performers: at the aggregate (EU) level general university funds and non-oriented funding are on the increase, while oriented research is falling. The pattern is largely continued in individual countries, with some significant variations due to e.g. realignment between public and private parties. Despite this apparent increase in the latitude allowed research performers, funders are demanding greater accountability[60], in response to budget pressures and implementation of strategic R&D policy. This control does not necessarily involve research topic selection or the use of contract as opposed to institutional funds as represented in the overall data.

In many countries, a falling ratio of institutional to project funding has prompted concern over the adequacy of research infrastructure and the co-operation, renewal and basic research orientation of the publicly supported R&D sector. In response, initiatives have been developed to supply additional

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[59] This pattern may overstate the transfer of control, as GUF (typically) includes a fixed proportion allocated to teaching, so much of the increase may be attributable to rising student numbers. In addition, institutional funding is increasingly allocated via "hybrid" mechanisms involving greater funder control (cf discussion in Sec. 2.3.).

[60] cf Geuna (1999), Massy (1996) and discussion at Sec. 3.2.

infrastructure and large-scale, long-term support, often on a regional basis[61], and to lengthen the term of contract support to increase long-term spill over benefits and reduce administrative burdens and costs. In specific areas, the trends are in the opposite direction; for example, with increasing external funding and privatisation of defence research establishments, institutional funding is giving way to contracts, often on a sole-source (non-competitive) basis.

5.2.4. Competition

Competitive allocation of funds, whether as a conscious policy choice by funders or a by-product of realignments in the performing sector, seems to be on the increase. By and large, competition is used primarily to allocate scarce resources, secondarily for candidate selection, and rarely as a means of providing incentives. We encountered various competitive processes ranging from simple quality screens to intensive head-to-head ranking of proposals using pre-set criteria. Some ostensibly non-competitive allocation procedures were in fact competitive over a broad range of activities and a long sweep of time e.g. benchmarking and research assessment 'league tables' used to allocate institutional research funds. Finally, expected and actual competition among research performers took different forms. Some proposal funding competitions were strongly oriented to scientific merit or social benefit, while others were more sensitive to nationality, seniority, disciplinary balance or cost and economic considerations. The nature of competition affects the balance between the effects listed above and influences 'unintended consequences.'

We observed interesting variations and trends in three aspects of competitive funding: the motive for introducing competition; the competitive mechanisms; and the *effects*, including unintended consequences:

M*otivations* for using competitive mechanisms include: resource rationing; candidate selection; performance incentives; value for money; separation of performers and funders; and risk transfer.

C*ompetitive mechanisms* cover a wide range. They include: classic screening of individual project proposals based on peer review; selection of tenders based on criteria that include, but are not limited to scientific merit; reallocation of institutional funding for Higher Education based on assessments of past performance; head-to-head competitions for research equipment/infrastructure funding on an institutional or regional basis; and extended mechanisms in which a subset of bidders are provided limited support in order to support development of ideas, preliminary work and proposals.

E*ffects* vary with mechanism and context. Overall, efforts to link research priorities and funding modalities to wealth creation, competitiveness and related economic goals have certainly increased in both selectivity and competitiveness. In addition, there is some evidence that the research strategies of major intermediaries and performers have changed to reflect the new environment. This is particularly striking in the case of Germany, where the Government's changed priorities (beginning in 1996) envisage a future where all publicly supported research institutions will compete against each other for a fairly large proportion of their funding[62]. Preliminary research has traced the use of competitive mechanisms in higher education to a variety of effects that include: i) concentration of research resources and agendas; ii) increased attention to intellectual property rights; iii) closer co-operation between public and private entities; iv) increased research labour mobility; v) higher proportions of contract researchers among University personnel; vi) spill over effects on teaching and knowledge diffusion, etc. One particular consequence of increasing contract RTD is pressure on the infrastructure provided by institutional and equipment funds; as the proportion of contracts rises, so too do the claims on these public good resources. The effect would be there even if the contracts represented additional money - downward pressures on public institutional funding exacerbate it.

Economists are accustomed to thinking of modal choice (along the control/competition dimensions) as a mechanism to accomplish the rationing, selection, incentive, separation and risk transfer functions, etc. In many countries, however, modalities are historical artefacts (especially the breakdown between institutional and project funding) or are due to other factors. Even recent changes may have more of 'modal shift' than 'modal choice' about them. Thus it may be difficult to assess them

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[61] Examples include the German 'Bio-Regio' and nanotechnology initiatives and the Danish 'Centres without walls' programmes in e.g. biotechnology, materials technology and engineering research.

[62] Contract and other (non-institutional) funding is often referred to as the "third way" or *Drittmittel*.

as 'best practices' outside their specific historical, economic and organisational/institutional contexts. They may be slow to change or perverse in the ways they change.

In terms of prevalence, countries for which detailed data were available showed a growth in the use of competition that was almost independent of changes in the balance between institutional and project funding. This varies by institution and scientific field. While the bulk of funding takes place along the diagonal of the 'funding modalities' diagram (Figure 2), there are significant 'off-diagonal' elements. First, are competitive institutional flows[63],. Second, there remain substantial non-competitive project-specific flows in both *projects* (esp. in countries without a good mechanism for competition and review) and *tenders* (where a Ministry simply asks another or a research establishment to do a specific task). In addition to the intended benefits of competition, competitive block grant funding may trigger profound institutional changes[64]. By the same token, what may appear to be an inefficient or discriminatory lack of competition in project- or tender-based funding may in fact promote long-term co-operation between funders and performers, or long-term competition across a range of projects or *within* a given research endeavour[65]. The central point is that competition *for* a project is not necessarily superior to competition *within* a research programme or *co-operation* in solving fundamental problems.

Even the nature of competitive selection processes is changing under resource pressures. For example, the Deutsche Forschungsgemeinschaft has recently modified its procedures to insulate scientific merit assessment from 'budget' pressure. It uses a process that changes the selection and funding modality in response to market conditions. The underlying idea is to prevent higher competition from conflating different dimensions (scientific merit, budget pressures, economic payback, etc.).

Finally, it is worth recording that competition is not limited to performers. Competition between funding sources is sharp in some areas (e.g. the enterprise sector) and increasing in others, particularly those identified as being of strategic advantage. Competition among national systems resembles an arms race in some ways - it can greatly accelerate the pace of scientific progress, but perhaps at the expense of social benefits and the culture of free exchange in the research community. Competition between national and supra-national sources raises well-known dangers of capitulation (crowding-out). On the other hand, immiserising competition can develop where the evolution of common standards is a public good and an individual bad. Where funding modalities allow client control, competition among clients can help to reconcile social, scientific and business interests. The existence of diverse interests would seem a natural reason for co-operation, but the possibility exists that co-operative funding might mask competition for influence over research agendas. A more balanced (if implicit) co-operation may emerge when funders attempt to out-do each other in presenting attractive and generous forms of support.

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[63] E.g. the Research Assessment Exercise used to allocate UK Higher Education Funding Council University block grants, or the regional infrastructure projects referred to in note 61.

[64] E.g. personnel instability, increasing relative numbers of contract staff on university payrolls, department closure and an increasing between the 'haves' and 'have-nots' of the higher education research community.

[65] There are US examples of this in non-competitive selection of multiple candidates to perform research as a preliminary to competitive award of a production contract.

APPENDIX: NUMERICAL DATA

This appendix contains information about the data used in the text. They are available as an Excel application on request.

A.1 DETAILED DEFINITIONS OF FUNDING CATEGORIES

This section provides more precise definitions of the various funding flows referred to in the report. For the most part, these are based on the Frascati Manual (cf. esp. OECD 1994), and are to be understood as referring to funds directed towards the Frascati concept of Research and Development.

Gross domestic expenditure on R&D (GERD) is total intramural expenditure on R&D performed on the national territory during a given period. It includes R&D performed within a country and funded from abroad but excludes payments made abroad for R&D. GERD is constructed by adding together the intramural expenditures of the government, Higher Education, private and private non-profit sectors described below.

Government funds: funding, except budget allocations specifically earmarked for performers in the University sector, by all departments, offices and other bodies which furnish but normally do not sell to the community those common services, other than higher education, which cannot otherwise be conveniently and economically provided and administer the state and the economic and social policy of the community (Public enterprises are included in the business enterprise sector).

Higher Education funds: funds provided by all universities, colleges of technology, and other institutes of post-secondary education, whatever their source of finance or legal status. It also includes all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education establishments. These are funds generated within the Higher Education sector, and include income from endowments and other non-research income flows. (See Discussion of public general university funds below)

University funds (GUF): government budget allocations specifically earmarked for performers in the Higher Education sector described above. (See Discussion of public general university funds below)

Private funds: funding by all firms, organisations and institutions whose primary activity is the market production of goods or services (other than higher education) for sale to the general public at an economically significant price.

Private non-profit funds: funding by non-market, private non-profit institutions serving households (i.e. the general public), such as professional or learned societies, charities, relief or aid agencies, trades unions, consumers' associations, etc., plus any funds contributed directly to R&D by households. In principle, this excludes funding by organisations: mainly rendering services to enterprises; that primarily serve government; entirely or mainly financed and controlled by government; or offering higher education services or controlled by institutes of higher education.

Public general university funds: University R&D activities are usually financed by three types of funds: a) R&D contracts and earmarked grants from government and other outside sources; b) income from endowments, shareholdings, and property, plus receipts from the sale of non-R&D services such as fees from individual students, subscriptions to journals, and sales of serum or agricultural produce; and c) general grants from the Ministry of Education or corresponding provincial or local authorities in support of overall research/teaching activities. According to OECD[66], "This case gives rise to a conflict between the principle of tracing the original source and that of using the performer's report and also to some disagreement about how the criterion concerning the intentions of the funder should be applied. In the first approach one argues that, as government is the original source and has intended at least part of the funds concerned to be devoted to R&D, the R&D content of these public general university funds should be credited to government as a source of funds. Using the second approach, one argues that it is within universities that the decisions are taken to commit money to R&D out of a pool which contains both "own funds" as narrowly defined in (b) and public general university funds; therefore, the sums concerned should be credited to higher education as a source of funds. While no recommendation can be made for national practice, government-financed GUF should be credited to the public sector as a source of funds for the purposes of international comparisons. For clarity, publicly financed GERD is divided into two sub-categories: direct government funds and GUF. ... Real or imputed social security and pensions provisions ... should

[66] OECD 1994, pars. 381 and 382.

be credited to GUF as a source of funds; monies from the higher education "block grant" should be classified as GUF, and other monies generated by the sector should be considered as "own funds"; adjustments related to "other current costs" to account for real or imputed payments of rents, etc., should be debited to direct government funds."

Government budget appropriations for R&D (GBAORD): this measure is based on government budgets through identification of budget items involving R&D and estimating their R&D content. These data cover government-financed R&D in the government, business enterprise, private non-profit and Higher Education sectors (including GUF). It includes direct support and some categories of indirect support (e.g. loans that may be forgiven), and comprises both current and capital expenditure. GBAORD flows are also oriented to specific objectives – measured as far as possible by the primary purpose behind the research rather than the content of the supported activities or ancillary purposes. Broadly, these are aggregated into economic, health & environment and space. The OECD warns against overt international comparisons in part due to imperfect fit of actual purposes and the 11 categories suggested in the manual. These categories are:

1. Development of agriculture, forestry and fishing
2. Promotion of industrial development
3. Production and rational use of energy
4. Development of the infrastructure
   4.1 Transport and telecommunications
   4.2 Urban and rural planning
5. Monitoring and protection of the environment
   5.1 Prevention of pollution
   5.2 Identification and treatment of pollution
6. Health (excluding pollution)
7. Social development and services
8. Exploration and exploitation of the Earth and the atmosphere
9. General advancement of knowledge
   9.1 Advancement of research
   9.2 GUF
10. Civil space
11. Defence.

A.2 DATA AVAILABILITY

The following tables refer to the common data set. Additional data in individual country reports were difficult to place on a common footing due to definitional differences and other factors.

Table A1: Data availability

Country	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
Gross Budget Appropriations on Research and Development (GBAORD)																		
Austria	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Belgium			X	X	X	X	X	X	X		X		X	X	X			
Denmark	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Finland	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
France	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Germany	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Greece	X					X		X	X		X		X					
Ireland	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Italy	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Netherlands	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Portugal		X		X		X		X		X		X			X			
Spain	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Sweden	X		X		X		X		X		X		X		X			
United Kingdom	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X		
European Union	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Gross Expenditures on Research and Development (GERD)																		
Austria									X				X					
Belgium									X		X		X	X	X			
Denmark									X	X	X	X	X		X			
Finland									X		X		X		X			
France									X	X	X	X	X	X	X			
Germany									X	X	X	X	X	X	X	X		
Greece									X		X		X					
Ireland									X	X	X	X	X	X	X			
Italy									X	X	X	X	X	X	X	X		
Netherlands									X	X	X	X	X	X	X			
Portugal										X		X			X			
Spain									X	X	X	X	X	X	X			
Sweden									X		X		X		X			
United Kingdom									X	X	X	X	X	X	X			

A.3 To-from matrices

The following tables describe aggregate funding flows by funding and performing sector in numerical (M PPP$, deflated to 1990) and percentage (% GERD) terms. In interpreting these data it is important to take account of the missing elements in the data set. These data are based on all EU countries in the sample. Percentages were computed from aggregate numerical data - equivalent to a GERD-weighted average.

Table A2: To-from R&D funding flows in 1990 M PPP$, European Union

Year	From	Government	Higher education	Private	Research Institutes	Grand Total
1989	Government	14815	6198	9001	479	30492
	Higher education	10	226	3	4	242
	Other	310	242	4385	61	4998
	PNP	195	337	93	221	846
	Private	717	987	54011	80	55795
	University funds	0	8808	0	0	8808
	1989 Total	16047	16796	67492	845	101181
1990	Government	14581	6016	8932	490	30020
	Higher education	11	186	2	4	202
	Other	333	225	4828	50	5436
	PNP	196	327	95	257	875
	Private	706	859	49255	89	50909
	University funds	0	7745	0	0	7745
	1990 Total	15827	15359	63111	889	95186
1991	Government	15585	6562	8658	439	31244
	Higher education	14	264	3	4	286
	Other	389	339	4930	63	5720
	PNP	209	422	102	247	981
	Private	835	1103	54184	75	56198
	University funds	0	9777	0	0	9777
	1991 Total	17033	18468	67876	828	104205
1992	Government	14447	6216	7119	358	28140
	Higher education	10	217	3	18	249
	Other	393	426	4629	81	5530
	PNP	192	398	95	329	1013
	Private	920	973	49835	81	51810
	University funds	0	8922	0	0	8922
	1992 Total	15963	17152	61682	867	95663
1993	Government	15241	7039	7173	369	29822
	Higher education	13	288	2	23	326
	Other	492	580	4812	107	5991
	PNP	155	530	102	322	1109
	Private	898	1205	55051	87	57241
	University funds	0	10824	0	0	10824
	1993 Total	16798	20467	67140	907	105312
1994	Government	13987	7057	5994	174	27212
	Higher education	13	295	3	28	339
	Other	499	645	4898	95	6137
	PNP	145	576	60	322	1103
	Private	872	1088	49256	71	51287
	University funds	0	8668	0	0	8668
	1994 Total	15517	18330	60209	690	94746
1995	Government	14850	7852	6536	343	29581
	Higher education	16	564	1	17	598
	Other	563	752	5405	126	6845
	PNP	169	711	68	270	1218
	Private	1001	1232	54634	94	56960
	University funds	0	9555	0	0	9555
	1995 Total	16599	20666	66643	850	104758

Table A3: To-from R&D funding flows as % GERD, European Union

Year	From	Government	Higher education	Private	Research Institutes	Total
1989	Government	14.64%	6.13%	8.90%	0.47%	30.14%
	Higher education	0.01%	0.22%	0.00%	0.00%	0.24%
	Other	0.31%	0.24%	4.33%	0.06%	4.94%
	PNP	0.19%	0.33%	0.09%	0.22%	0.84%
	Private	0.71%	0.98%	53.38%	0.08%	55.14%
	University funds		8.70%			8.70%
	1989 Total	15.86%	16.60%	66.70%	0.83%	100%%
1990	Government	15.32%	6.32%	9.38%	0.51%	31.54%
	Higher education	0.01%	0.20%	0.00%	0.00%	0.21%
	Other	0.35%	0.24%	5.07%	0.05%	5.71%
	PNP	0.21%	0.34%	0.10%	0.27%	0.92%
	Private	0.74%	0.90%	51.75%	0.09%	53.48%
	University funds		8.14%			8.14%
	1990 Total	16.63%	16.14%	66.30%	0.93%	100%
1991	Government	14.96%	6.30%	8.31%	0.42%	29.98%
	Higher education	0.01%	0.25%	0.00%	0.00%	0.27%
	Other	0.37%	0.32%	4.73%	0.06%	5.49%
	PNP	0.20%	0.41%	0.10%	0.24%	0.94%
	Private	0.80%	1.06%	52.00%	0.07%	53.93%
	University funds		9.38%			9.38%
	1991 Total	16.35%	17.72%	65.14%	0.79%	100%
1992	Government	15.10%	6.50%	7.44%	0.37%	29.42%
	Higher education	0.01%	0.23%	0.00%	0.02%	0.26%
	Other	0.41%	0.45%	4.84%	0.08%	5.78%
	PNP	0.20%	0.42%	0.10%	0.34%	1.06%
	Private	0.96%	1.02%	52.09%	0.08%	54.16%
	University funds		9.33%			9.33%
	1992 Total	16.69%	17.93%	64.48%	0.91%	100%
1993	Government	14.47%	6.68%	6.81%	0.35%	28.32%
	Higher education	0.01%	0.27%	0.00%	0.02%	0.31%
	Other	0.47%	0.55%	4.57%	0.10%	5.69%
	PNP	0.15%	0.50%	0.10%	0.31%	1.05%
	Private	0.85%	1.14%	52.27%	0.08%	54.35%
	University funds		10.28%			10.28%
	1993 Total	15.95%	19.43%	63.75%	0.86%	100%
1994	Government	14.76%	7.45%	6.33%	0.18%	28.72%
	Higher education	0.01%	0.31%	0.00%	0.03%	0.36%
	Other	0.53%	0.68%	5.17%	0.10%	6.48%
	PNP	0.15%	0.61%	0.06%	0.34%	1.16%
	Private	0.92%	1.15%	51.99%	0.07%	54.13%
	University funds		9.15%			9.15%
	1994 Total	16.38%	19.35%	63.55%	0.73%	100%
1995	Government	14.18%	7.50%	6.24%	0.33%	28.24%
	Higher education	0.02%	0.54%	0.00%	0.02%	0.57%
	Other	0.54%	0.72%	5.16%	0.12%	6.53%
	PNP	0.16%	0.68%	0.06%	0.26%	1.16%
	Private	0.96%	1.18%	52.15%	0.09%	54.37%
	University funds		9.12%			9.12%
	1995 Total	15.84%	19.73%	63.62%	0.81%	100%

A.4 THE LOGICAL FRAMEWORK METHODOLOGY

The logical framework methodology is a means of classifying steps in a project in terms that shed light on the way these steps contribute to overall project, programme and sectoral benefits. It is a generalisation of methods common in programme evaluation.

The logical framework can be related to a sequence of events, with associated performance criteria, concrete indicators, information-gathering techniques and assumptions or risk factors. For a generic project, these steps are indicated in Figure A1. The lightly shaded boxes and the associated criteria by the double-bordered boxes underneath the flow chart indicate the main elements of the logical framework methodology.

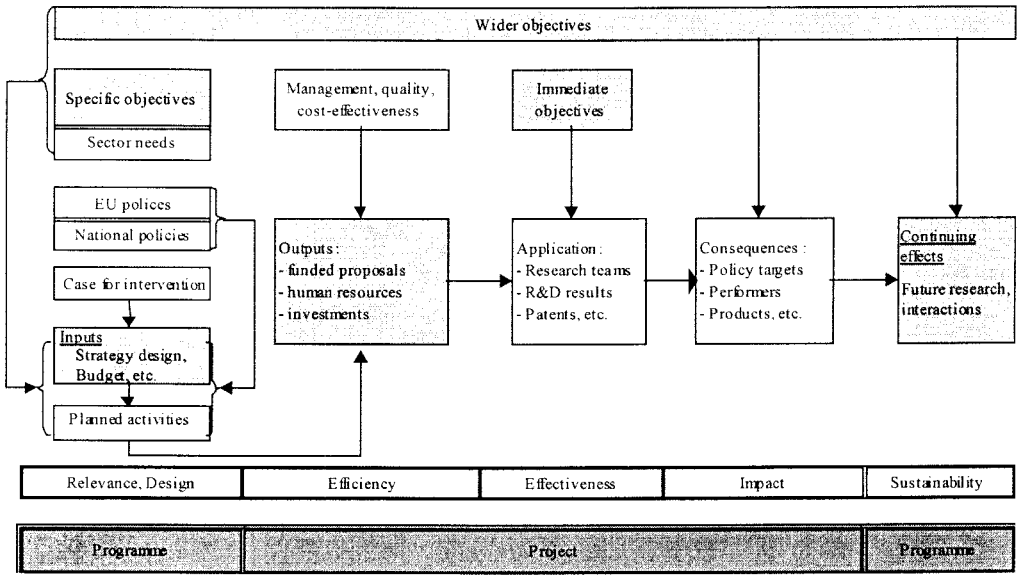

Figure A1: Elements of the logical framework methodology

For convenience and clarity, these elements are usually simplified into a matrix, as follows:

Table A4: Logical framework matrix

Step	Focus	Criterion	Indicators	Risk factors	Level
1	*Project choice, design*	Relevance			Programme
2	*Inputs → Outputs (Activities)*	Efficiency			Project
3	*→ Immediate objectives*	Effectiveness			Project
4	*→ Wider objectives*	Impact			Project
5	*→ Continuing effects*	Sustainability			Project, Programme

To organise the evaluation of specific programmes and projects, such a matrix is filled in by first specifying the important elements of project choice and design, the mandated activities, immediate and wider objectives and anticipated long-term effects. For each criterion, appropriate and measurable indicators are supplied together with the methods used to gather information for each indicator. Collecting the known risk factors and other aspects of context that could influence the project's performance according to each criterion completes the framework. Unmentioned in the matrix, but implicit in the underlying methodology, are the scoring methods used to collect, scale and summarise

the indicator results. It should be stressed that the first and last rows of the matrix refer to events beyond specific projects.

With specific reference to R&D initiatives, the first step in applying the methodology involves placing R&D support in the context of the national system of innovation and analysis of programme documentation to determine the planned activities, and the immediate and wider objectives. In addition, planned departures from standard accounting and contracting practices should be included. The second step entails collection and analysis of information on the inputs (in this case programme inputs such as funding received by the spending institution, programme manpower, advisory committee and strategic plan development etc.) and proximate outputs (primarily spending flows in most cases, by modality and targeting). The output measures may also include services and facilities provided 'in-kind' such as co-ordination activities and access to publicly controlled infrastructure. The overall assessment looks at the efficiency of the process, so it is appropriate to develop measures of average and marginal cost – e.g. funding received divided by total programme cost. Such measures can be compared across programmes, modalities and sectors to 'benchmark' efficiency. The risk factors include the availability of: suitable research manpower; complementary external funding; appropriate intermediary and performing institutions; sufficient research infrastructure (for project-based support); and support for applications and allocation. The criteria for measuring progress towards immediate objectives depend on the precise objectives, but may include measures of research performed and other progress indicators such as: success in obtaining additional funding, existence of co-operative initiatives involving Government, Higher Education, PNP and/or Private entities; and 'portfolio balance' measures applied across the programme, funding institution or public funding sector. To the extent that funding is contract-mediated, criteria could use measures of the effectiveness and enforceability of contract terms, and IPR activities such as patenting or licensing. Here the evaluation looks at effectiveness, so that summary measures are related back to the underlying short-run objectives in terms of the amount and type of support provided. Risk factors include organisational aspects of the NSI, the influence of providers of additional funds on research agendas, quality and dissemination, and the extent of duplication, technology transfer, and similar aspects off the connection between the supported sector and others in the economy. The fourth step is concerned with impact, and measures are more global and long-term in scope. Criteria look at such things as the career paths of supported scientists; training and other knowledge transfer activities; funding stability and institutional continuity; and others derived from the programmes long-term goals. The critical observation is that, the further one gets from immediate activities, the harder results are to measure and the more they depend on other initiatives and factors. Apparent success may disguise *substitution* in which public funding was used to provide support that private (for-profit or non-profit) sources might have provided, or even *crowding-out* in which the creation of closed channels of support actually decreases total funding or reduces the societal value of supported research. Alternatively, ostensible failure may contribute in the long run via demonstration effects. This can take the form of 'lessons learnt' for the next generation of support initiatives or inducements for other parties (e.g. private parties) to provide support in order to correct perceived failures of funding level, targeting or quality. Risk factors at this level include political and organisational changes, manpower supply and mobility and changes in social priorities. The final step involves integration of the results of prior evaluations into an assessment of programme sustainability. It should be recognised that some R&D support programmes are intended to provide long-term support, 'protecting' scientists from market forces in order to allow them to concentrate on long-range basic research and/or wide dissemination. Other programmes are intended to provide 'seed money' or 'steering resources' to make marginal changes in direction that will eventually be sustained by other sources. In the latter case, the appropriate definition of sustainability includes renewal of programme resources.

As a final comment, it should be remarked that this methodology requires a fair amount of information that, as this research effort found, is often hard to come by. Such information should be routinely tracked on a continuing basis, either as part of the government's overall auditing function or as a crucial step towards the 'self-evaluating organisation.' Such processes can help an organisation to improve 'from within' and also place it on a better footing to engage constructively with pressures 'from without,' including political pressures and overall economic, environmental, industrial and related policies.

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