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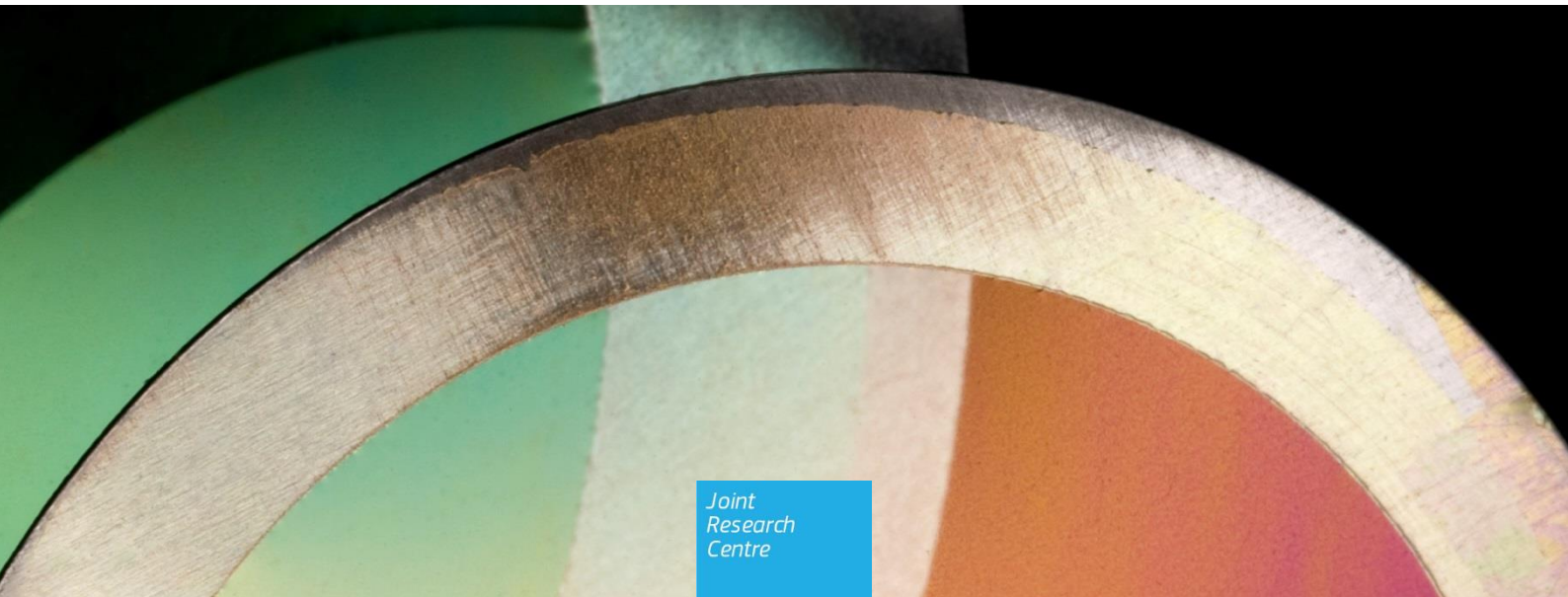
ANALYSIS OF NATIONAL PUBLIC RESEARCH FUNDING (PREF)

Handbook for Data Collection and indicators production

Benedetto Lepori

2017



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Abstract

This document presents the basic definition and methodology for the PREF data collection. It covers basic definitions of funding streams and funding instruments, the thematic classifications, characterization of research funding organizations and umbrella public research organizations. It also provides guidelines concerning the data structure, data collection process, data flagging and collection and management of metadata.

1 Introduction

The study on the Analysis of national public research funding (PREF) aims at collecting information on and providing an analysis of national public research funding, by theme and by allocation mode (project based funding versus institutional funding) including an overview of the evolution and current state of public research funding in European and selected non-European Countries. More specifically, the PREF study aims:

- To collect quantitative data on the evolution of public research funding in the considered counties from the year 2000 to the last available year, including an estimation of the share of public R&D allocated on project basis (respectively through institutional funding). A measure of the level of competitiveness of institutional funding will also be provided.
- To analyse in detail and break down public R&D funding in terms of S&T fields, Key Enabling Technologies, Societal Grand Challenges, beneficiary sector, Type of R&D (basic, applied, experimental development),
- To describe the funding allocation mechanisms, including flows to and from funding agencies and the criteria used for basing funding allocation decisions.
- To develop from these data analytical work addressing specific issues in public research policies, specifically concerning the characteristics of national funding profiles and the analysis of funding devoted to specific research teams.

The goal of this handbook is to devise a conceptual framework and a methodology for the collection, management and analysis of data on public research funding in order to reach the study main goal. This framework will integrate in a single data collection and data management structure all data needed for the study, including both quantitative data and descriptors of organizations and funding mechanisms.

More specifically, this handbook provides the following content:

- Section 2 presents the overall study framework for analysis of public research funding and introduces the basic definitions used throughout the handbook.
- Section 3 introduces the various classification schemes for research funding which will be used in the study.
- Section 4 lists the special codes to be introduced when data are not available, as well as data flags providing information on data problems.
- Section 5 describes the PREF coverage in terms of the type of funding considered, the countries concerned and the time period.
- Section 6 describes the basic structure for data collection, introduces funding streams and instruments and describes the different variables for each level.
- Section 7 defines the managing organizations of public funding and the variables and descriptors to be collected for these organizations.
- Section 8 introduces a number of information to be collected at national level concerning political priorities and topics, which is complementary with the quantitative data on streams and instruments.
- Section 9 presents the indicators on public funding provided by the PREF project and how they are calculated from other data.
- Section 10 presents the data structure, the data collection instruments and the data management procedures.
- Section 11 deals with metadata providing information on data sources and methodological issues, as well as with the data quality process.

2 Conceptual framework and basic definitions

The PREF project deals with a characterization of public funding to research and, particularly, how funding is allocated to performers in terms of the agencies managing it, the allocation mode and the main allocation criteria. The perimeter considered by PREF is therefore largely the same as the one adopted by the Frascati manual for public funding (so-called Government Budget Allocations for R&D; GBARD). Therefore, the quantitative data collection in PREF does not consider public funding devoted to innovation, nor R&D tax incentives. Funding to R&D by the Business enterprise sector is also excluded. A general description of the importance of R&D tax incentives will be included in the qualitative analysis of public research funding.

The PREF study builds on a conceptual framework which has been developed in previous studies of public funding (Lepori, Dinges, Poti, Reale, Slipersaeter, Theves and Van den Besselaar 2007) and which has been described systematically in a recent paper of one consortium member (Lepori 2011).

This framework will be adopted in the tender as the basis of both the quantitative and qualitative data collection. Namely, it allows for a proper understanding of the main analytical units relevant for policy analysis, for a characterization of the available data sources – and the level of the system they refer to – and finally for the design of a set of descriptors in order to characterize national funding policies.

2.1 Overview of the study methodology

The framework is based on four organizational layers and on the distinction between two main allocation modes of public research funding (see **Figure 1**).

a) The four system's layers can be described as follows:

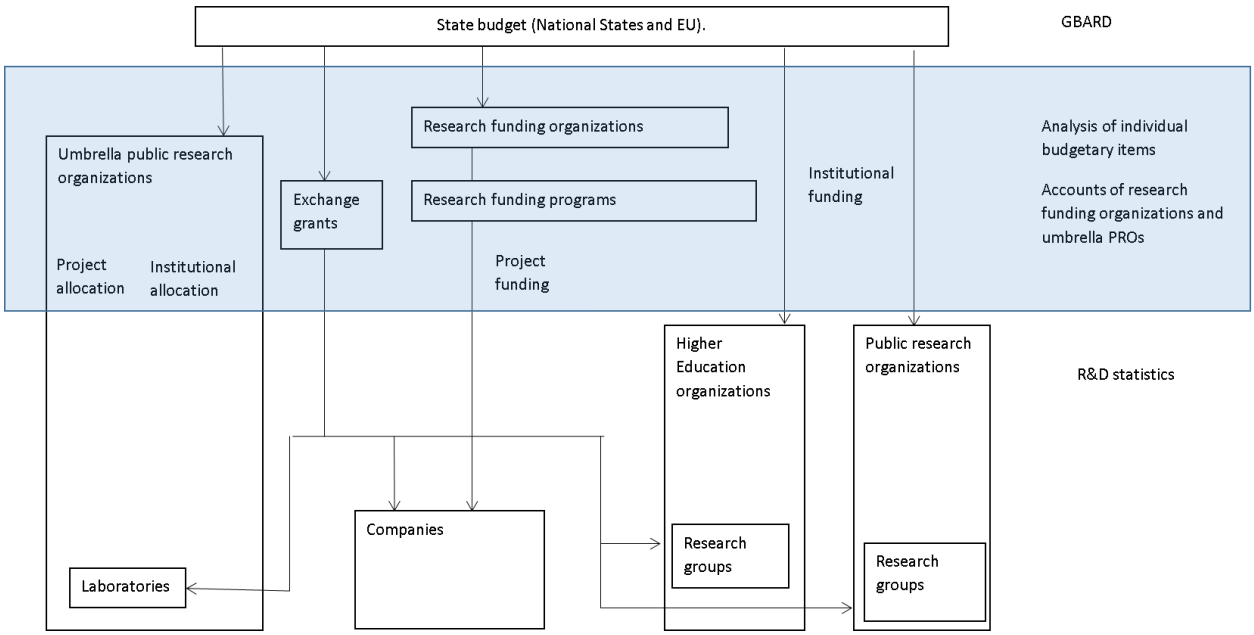
- The first layer is composed by the State (National States, as well as the European Union). At this stage, the overall volume of budgetary appropriations for R&D activities is decided, as well as their division in broad streams – for example distinguishing between institutional funding going directly to Higher Education Institutions and to Public Research Organizations (PROs) from project funding. Information on political priorities is usually included in policy documents, like strategic plans, whereas quantitative data are included in public budgets (and usually exploited for GBARD statistics).
- The second layer is composed by *research funding organizations (RFO)*, a generic name adopted for organizational entities, which are entitled by the State to distribute money to research performers (these are also frequently referred in the literature as *research funding agencies*). Most RFOs distribute project funding, but in some countries, like the UK, also the distribution of institutional funding to higher education institutions is the remit of RFOs. Various broad characterizations of agencies, as well as of their functions, have been developed in the literature (see Braun 1998; see below section 7.1). Most RFOs distribute funding through a number of *funding schemes or programmes.*
- The third layer is composed by large and usually stable *research organizations*, which comprise different research groups and cover different topics. These include, Higher Education Institutions (with both a research and teaching mission), public research organizations (with a research and, in some cases, service mission), as well as non-profit organizations and private companies.
- The fourth layer is composed by different types of research units and groups, which constitute the "production units" of science (Etzkowitz 2003; Joly and Mangematin 1996). They are usually smaller and organizationally not autonomous and, in most cases, are funded through a combination of institutional resources

from their parent organizations and from external third-party funds. This layer is not covered directly by PREF.

While in most cases these layers are organizationally distinct, in a number of countries we find larger *Umbrella Public Research Organizations (UPRO)*, like CNRS in France, CNR in Italy of CSIC in Spain, having the dual function of managing a large part of the national research system and acting at the same time as research funding organization for their laboratories (Thèves, Lepori and Larédo 2007). Given their importance in some national systems and their specific characteristics, these umbrella organizations will be given a specific attention in this study (see below section 7.2).

b) Second, this scheme distinguishes between two main allocation mechanisms for public funding, i.e. institutional funding on the one hand, and project funding on the other hand. While this distinction is well-known in the research studies literature, it has been operationalized in the recent years in a way that it is suitable for quantitative analyses (Lepori, Dinges, Poti, Reale, Slipersaeter, Theves and Van den Besselaar 2007). This approach and the corresponding definitions will be adopted for this study.

Figure 1. General conceptual framework for the analysis of public funding flows for research



Within this structure, the specific focus of PREF will be on characterizing the intermediary layer of the channels and instruments through which public funds are transferred to performers, in terms of the type of organizations managing them, the distinction between institutional and project funding, the specific research topic of each instrument. The specific data collection within PREF will deal with these aspects of public research funding, as well as with the characterization of institutional funding in terms of allocation mode and level of competition,

Moreover, PREF will integrate data collected in official statistics concerning public allocations for research (so-called Government Budget Allocations for Research and Development; GBARD; see section 6.2) and data concerning R&D expenditures at the performers level (see section 6.6), as a reference for the upstream and downstream part of the public funding allocation process.

2.2 Basic definitions

Following general definitions are adopted throughout this handbook. Most of them are based on the Frascati Manual 2015 (FM 2015)

Government public allocations for R&D (GBARD) are the specific funding lines inside the public budgets (national or regional), which are intended to be spent for research purposes. Importantly, GBARD also includes funding transferred to international agencies and research organizations (FM2015).

Gross domestic expenditures on R&D (GERD) are the total intra-mural R&D expenditures performed by organizations located in the country considered, either funded through national sources or from abroad (FM2015).

Project funding. Project funding is defined as money attributed to a group or an individual to perform a research activity limited in scope, budget and time. It can be identified and distinguished from institutional funding based on three main characteristics: a) funds are attributed directly to research groups and not to a whole organization b) they are limited in the scope of the research supported and its duration and c) they are attributed by a research funding organization outside the performing organization to which the beneficiary belongs. *National project funding* is defined as national public appropriations allocated through project funding (Lepori, van den Besselaar, Dinges, et al 2007).

Institutional funding is funding attributed to research organizations (PROs, HEIs) for their running activities and, usually, for an unlimited period of time (the yearly amount might vary). Institutional funding is usually not earmarked to specific activities and to organizational subunits, but the internal allocation is left to the performing organization. A typical example of institutional funding is block transfer to Higher Education Institutions, which in most European countries comprises the largest part of their budget and is allocated in the form of lump sum (Lepori, Benninghoff, Jongbloed, Salerno and Slipersaeter 2007). These allocations may also be performance based. PREF will also aim at the characterizing institutional funds in terms of their performance and output orientation.

The breakdown between institutional and project funding has been introduced in 2012 in the EUROSTAT statistical regulation as a new optional breakdown (Doc.EUROSTAT/G6/STI/2012/4), which adopted the same definition elaborated in Lepori et al., 2007). It is now included in the 2015 edition of the Frascati manual.

R&D exchange funds are funding flows from one statistical unit to another statistical unit in return for the performance of R&D and the delivery of relevant R&D outcomes. The unit funding the work incurs a delivery risk associated with the uncertainty of the project. Examples of exchange funds activities include R&D purchases (sales from the perspective of the performer), R&D outsourcing and contributions in the context of collaborative R&D agreements. The procurement of R&D is one of the most common forms of provisions of R&D exchange funds. It includes funds paid to research services firms or other units performing R&D under contract. Following the Frascati manual, they are considered part of project funding, but labelled as a specific subcategory (FM2015).

R&D transfer funds are funding flows from one statistical unit to another statistical unit to perform R&D that does not require any good or service in return. The unit that provides transfer funds for R&D may impose some conditions on the performer, such as periodic reporting, compliance with the activity or project description as agreed in the terms of the agreement, or even public dissemination of research outcomes. Examples of transfer funds include grants, debt forgiveness, philanthropy, crowdfunding (unless this entails discounted prices for a new product), personal transfers such as gifts and General University Funds (GUF). To be included as R&D transfer funds, the funds should be intended by the originating source to be used for R&D. Normally, the R&D performer will retain most rights to the outcomes of R&D, which explains the transfer nature of this R&D funding transaction (FM2015).

Research funding organizations (RFO) are organizational entities which distribute public funding for research on behalf of the State. The definition adopted is extensive concerning the legal status and the position in respect of the State, covering both independent agencies at arm's length from the public administration, like research

councils (van der Meulen 2003, Slipersaeter, Lepori and Dinges 2007), and ministries and offices within the public administration which perform this role ('quasi-agencies'; Sanz Menéndez and Cruz-Castro 2003). Most research funding organizations distribute project funding, but in some countries, RFOs (like higher education councils) are also charged of distributing institutional funding. In a few cases, both functions are present, like in the case of research councils managing national facilities.

Higher Education Institutions (HEI) are organizations whose main mission is to offer education at the tertiary level (ISCED levels 5 to 8), as well as to preform R&D. HEIs are generally funded through a core State attribution (generally joint the education and research).

Public Research Organizations (PRO) are public-sector organizations, which perform R&D activities as one of their core mission (possibly alongside other functions, like services).

Following recent OECD work (OECD Actor Brief of Public Research Organizations, www.oecd.org/dataoecd/52/62/48136051.pdf*)*, PROs can be broadly characterized in four types. First, traditional mission-oriented centres (MOCs) are owned and sometimes run by government departments or ministries at the national and sub-national levels; their role is to undertake research in specific topics or sectors in order to provide knowledge and technological capabilities to support policy-making. Second, public research centres and councils (PRCs) perform (and in some cases fund) basic and applied research in several fields; these overarching institutions tend to be of considerable size in several countries representing a significant share of the national R&D capabilities (the largest one being included in the UPRO list). Third, Research Technology Organisations (RTOs), also known as industrial research institutes, are mainly dedicated to the development and transfer of science and technology to the private sector and society; although some of them are owned by government, in general, the administrative links of RTOs with governments tend to be looser than the rest. RTOs are often in the semi-public sphere and in the non-profit sector or even in the business enterprise sector (NACE 72) according to the Frascati manual. Finally, a fourth group of publicly supported research institutes of diverse size, labelled as Independent Research Institutes (IRIs) perform both basic and applied research focused on "issues" or "problems" rather than just fields. In many cases IRIs may be termed as "semi-public" as they are founded under different legal forms and work at the boundaries between public and private, but develop their activities with substantial public support and/or participation of public representatives in their governance.

Umbrella Public Research Organizations (UPRO) are national-level organizations with the mission of organizing research activities in a specific domain. Unlike normal PROs, they mostly host research laboratories distributed over the whole national territory and they are delegated by the State to manage a specific field of national research policy. Umbrella PROs in many cases have a dual function, i.e. to directly manage laboratories and scientist's careers on the one hand, to provide competitive projects funds on the other hand.

2.3 Funding streams and funding instruments

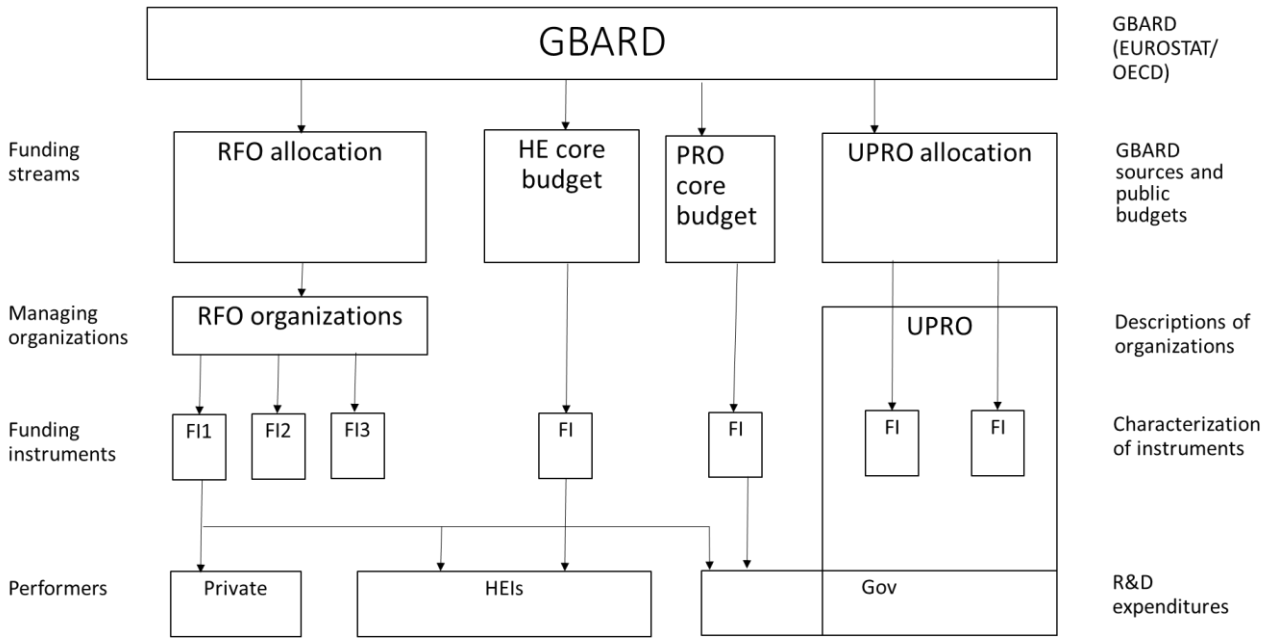
Given its focus on the analysis of public funding to R&D, PREF methodological approach will be based on decomposing the total Government Allocation for R&D (GBARD; FM2015) in distinct streams and funding instruments, which allow for a more fine-grained analysis:

- The level of major *funding streams* which can be identified within the GBARD, like the core allocation to higher education institutions, allocation for funding agencies, to large PROs. PREF will provide for a basic characterization of funding streams particularly whether allocation is institutional or project. Funding streams are relevant in order to analyse the composition of public funding (see section 6.3).

— A more fine-grained level of characterization of *funding instruments*, which are then connected with performing sectors. Funding instruments allow a more in-depth characterization of public funding in terms of the allocation criteria adopted, the type of transfer and the specific topic funded (see section 6.4).

Funding streams and funding instruments are linked to research funding organizations who manage them, hence making the bridge between funding streams and their respective managing organizations (see further chapter 7 of this handbook).

Figure 2. Overview of the study methodology



3 Classifications

PREF will make use of a number of different classification of research activities developed by the OECD, respectively by the European Commission. These classifications have different origins, but also refer to different parts of the research funding systems; their application to PREF differs accordingly. Most statistical classifications are currently included in the Frascati manual (FM2015).

This section provides general information on the classifications and the full list of codes. Their specific use in the PREF data is explained more in-depth in section 6 below.

3.1 Statistical classifications

These classifications are defined in the Frascati manual and routinely used for R&D statistics. This implies that, on the one hand, standard definitions and list of codes exists, and, on the other hand, data are routinely collected using these classifications by NSAs.

Consequently, these classifications will be adopted by PREF.

3.1.1 Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets (NABS)

The EUROSTAT standard code list: Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets (NABS 2007) is a classification included in the Frascati manual as well to classify public research funding according to its specific policy intentions. Given its characteristics, it can be applied most directly to Government Budget Allocations for R&D, as well as to funding instruments and streams.

PREF employs the NABS 2007 classification. If data are still available using the older NABS 1992 classification, they should be converted as of the EUROSTAT correspondence table. Besides renumbering chapters, the only major difference is that NABS 1992 chapter 9 on Social structures and relationships has been divided in three distinct chapters, i.e. chapter 9 Education (former subchapter 9.1), chapter 10 Culture recreation religion and mass media (former subchapter 9.2) and chapter 11 Political and social systems, structures and processes (former subchapter 9.3).

Table 1. NABS 2007 codes and description of content

Code	Name	Description
NABS01	**Exploration and exploitation of the Earth**	This chapter includes research and experimental development (R&D) related to: — The exploration of the earth's crust and mantle, seas, oceans and atmosphere, and their exploitation; — Climatic and meteorological research, polar exploration (under various headings, as appropriate) and hydrology. This chapter also includes R&D related to Mineral, oil and natural gas prospecting; Exploration and exploitation of the sea-bed; Earth's crust and mantle excluding sea-bed; Hydrology; Sea and oceans; atmosphere. This chapter does not include R&D related to: Pollution (included in Chapter 2); Soil improvement (included in Chapter 4); Land-use and fishing (included in Chapter 8).
NABS02	**Environment**	This chapter includes R&D related to: — The control of pollution, aimed at the identification and analysis of the sources of pollution and their causes, and all pollutants, including their dispersal

		in the environment and the effects on man, species (fauna, flora, microorganisms) and biosphere; — Development of monitoring facilities for the measurement of all kinds of pollution; — The elimination and prevention of all forms of pollution in all types of environment. This chapter also includes R&D related to: Protection of atmosphere and climate; Protection of ambient air; Solid waste; Protection of ambient water; Protection of soil and groundwater; Noise and vibration; Protection of species and habitats; Protection against natural hazards; Radioactive pollution.
NABS03	**Exploration and exploitation of space**	This chapter includes all R&D related to civil space. This chapter also includes R&D related to: — Scientific exploration of space; — Applied research programmes; — Launch systems; — Space Laboratories and space travel. This chapter does not include corresponding R&D in the defense field (included in Chapter 14). It should be noticed that civil space R&D is not, in general, concerned with particular objectives, it frequently has a specific goal, such as the increase of general knowledge (e.g. astronomy), or relates to particular applications (e.g. telecommunications satellites).
NABS04	**Transport, telecommunication and other infrastructures**	This chapter includes R&D related to: — Infrastructure and land development, including the construction of buildings; — The general planning of land-use; — Protection against harmful effects in town and country planning. This chapter also includes R&D related to: Transport systems; Telecommunication systems; General planning of Land-use; Construction and planning of building; Civil engineering; Water supply. This chapter does not include R&D related to other types of pollution than harmful effects in town (included in Chapter 2).
NABS05	**Energy**	This chapter includes R&D related to: — The production, storage, transportation, distribution and rational use of all forms of energy; — Processes designed to increase the efficiency of energy production and distribution; — The study of energy conservation. This chapter also includes R&D related to: Energy efficiency; CO2 capture and storage; Renewable energy sources; Nuclear fission and fusion; Hydrogen and fuel cells; Other power and storage technologies. This chapter does not include R&D related to: Prospecting (included in Chapter 1); Vehicle and engine propulsion (included in Chapter 6).
NABS06	**Industrial production and technology**	This chapter includes R&D related to: — The improvement of industrial production and technology; — Industrial products and their manufacturing

		processes. This chapter also includes R&D related to: Increasing economic efficiency and competitiveness; All manufactures as defined in the NACE Rev. 2 (codes 10 to 33); Recycling waste (metal and non-metal). This chapter does not include R&D related to industrial products and their manufacturing processes where they form an integral part of other objectives (e.g. defense, space, energy, agriculture).
NABS07	**Health**	This chapter includes R&D related to protecting, promoting and restoring human health – broadly interpreted to include health aspects of nutrition and food hygiene. It ranges from preventative medicine, including all aspects of medical and surgical treatment, both for individuals and groups, and the provision of hospital and home care, to social medicine and pediatric and geriatric research. This chapter also includes R&D related to: Prevention, surveillance and control of communicable and non-communicable diseases; Monitoring the health situation; Health promotion; Occupational health; Public health legislation and regulations; Public health management; Specific public health services; Personal health care for vulnerable and high risk populations.
NABS08	**Agriculture**	This chapter includes R&D related to: — The promotion of agriculture, forestry, fisheries and foodstuff production; — Chemical fertilizers, biocides, biological pest control and the mechanization of agriculture; — The impact of agricultural forestry activities on the environment; — The field of developing food productivity and technology. This chapter also includes R&D related to: Agriculture, forestry, and fishery; Animal and dairy science; Veterinary science and other agricultural sciences. This chapter does not include R&D related to: The reduction of pollution (included in Chapter 2); The development of rural areas, the construction and planning of buildings, the improvement of rural rest and recreation amenities and agricultural water supply (included in Chapter 4); Energy measures (included in Chapter 5); The food industry (included in Chapter 6).
NABS09	**Education**	This chapter includes R&D related to: — Education general including training, pedagogy, didactics; — Education, special (to gifted persons, those with learning disabilities). This chapter also includes R&D related to: Pre- and primary school; Secondary school; Post-secondary non-tertiary education; Tertiary education; Subsidiary services to education.
NABS10	**Culture, recreation, religion and mass media**	This chapter includes R&D related to: — The social phenomena of cultural activities, religion and leisure activities so as to define their impact on life in society; — Racial and cultural integration and on socio-cultural

		changes in these areas. The concept of "culture" covers the sociology of science, religion, art, sport and leisure and also comprises inter alia R&D on the media, the mastery of language and social integration, libraries, archives and external cultural policy. This chapter also includes R&D related to: Recreational and sporting services; Cultural services; Broadcasting and publishing services; Religious and other community services;
NABS11	**Political and social systems, structures and processes**	This chapter includes R&D related to: — The political structure of society, — Public administration issues and economic policy; — Regional studies and multi-level governance; — Social change, social processes and social conflicts; — The development of social security and social assistance systems; — The social aspects of the organization of work. This chapter also includes R&D related to: Gender-related social studies including discrimination and familiar problems; The development of methods of combating poverty at local, national and international level; The protection of specific population categories on the social level (immigrants, delinquents, "drop outs" etc.), on the sociological level, i.e. with regard to their way of life (young people, adults, retired people, the handicapped etc.) and on the economic level (consumers, farmers, fishermen, miners, the unemployed etc.); Methods of providing social assistance when sudden changes (natural, technological or social) occur in society. This chapter does not include R&D related to Industrial health, the health control of communities from the organizational and socio-medical point of view, pollution at the place of work, prevention of industrial accidents and the medical aspects of the causes of industrial accidents (included in Chapter 07).
NABS12	**General advancement of knowledge: R&D financed from General University Funds (GUF)**	*12.1 R&D related to Natural Sciences - financed from GUF* This heading covers: R&D financed from GUF on mathematics, computer and information sciences, physical sciences, chemical sciences, earth and related environmental sciences, biological sciences (medical included in 12.3, and veterinary included in 12.4), other natural sciences. *12.2 R&D related to Engineering Sciences - financed from GUF* This heading covers: R&D financed from GUF on civil engineering, electrical engineering, electronic engineering, information engineering, mechanical engineering, chemical engineering, materials engineering, medical engineering, environmental engineering, environmental biotechnology, industrial biotechnology, nano-technology, other engineering and technologies. *12.3 R&D related to Medical Sciences - financed from GUF* This heading covers: R&D financed from GUF on basic medicine, clinical medicine, health sciences, medical biotechnology, other medical sciences.

		12.4 R&D related to Agricultural Sciences - financed from GUF This heading covers: R&D financed from GUF on agriculture, forestry, and fishery, animal and dairy science, veterinary science, agricultural biotechnology, other agricultural sciences. *12.5 R&D related to Social Sciences - financed from GUF* This heading covers: R&D financed from GUF on psychology, economics and business, educational sciences, sociology, law, political science, social and economic geography, media and communications, other social sciences. *12.6 R&D related to Humanities - financed from GUF* This heading covers: R&D financed from GUF on history and archaeology, languages and literature, philosophy, ethics and religion, art (arts, history of arts, performing arts, music), other humanities.
NABS13	**General advancement of knowledge: R&D financed from other sources than GUF**	*13.1 R&D related to Natural Sciences - financed from other sources than GUF* This heading covers: R&D financed from other sources than GUF on mathematics, computer and information sciences, physical sciences, chemical sciences, earth and related environmental sciences, biological sciences (medical included in 13.3, and veterinary included in 13.4), other natural sciences. *13.2 R&D related to Engineering Sciences - financed from other sources than GUF* This heading covers: R&D financed from other sources than GUF on civil engineering, electrical engineering, electronic engineering, information engineering, mechanical engineering, chemical engineering, materials engineering, medical engineering, environmental engineering, environmental biotechnology, industrial biotechnology, nano-technology, other engineering and technologies. *13.3 R&D related to Medical Sciences - financed from other sources than GUF* This heading covers: R&D financed from other sources than GUF on basic medicine, clinical medicine, health sciences, medical biotechnology, other medical sciences. *13.4 R&D related to Agricultural Sciences - financed from other sources than GUF* This heading covers: R&D financed from other sources than GUF on agriculture, forestry, and fishery, animal and dairy science, veterinary science, agricultural biotechnology, other agricultural sciences. *13.5 R&D related to Social Sciences - financed from other sources than GUF* This heading covers: R&D financed from other sources than GUF on psychology, economics and business, educational sciences, sociology, law, political science, social and economic geography, media and communications, other social sciences. *13.6 R&D related to Humanities - financed from other sources than GUF*

		This heading covers: R&D financed from other sources than GUF on history and archaeology, languages and literature, philosophy, ethics and religion, art (arts, history of arts, performing arts, music), other humanities.
NABS14	**Defense**	This chapter includes R&D related to: — Military purposes, — Basic, nuclear and space R&D financed by Ministries of Defense. This chapter does not include for example R&D financed by Ministries of Defense in the fields of meteorology, telecommunications and health, should be classified in the relevant chapters.

Source: EUROSTAT.

3.1.2 Fields of R&D

The Fields of R&D (FORD) classification is a functional classification of the scientific and technological domain where R&D is executed and, therefore, refers directly to the performers' level (FM 2015). The Frascati manual recommends this classification to be used for the government, PNP and higher education sectors and, where possible, also for the business enterprise sector, as well as for staff data in all sectors. In practice, availability of data is highly dependent of countries, since not all countries collect data on FORD for the business enterprise sector, while a number of countries only collect data for the 1-digit main field classification and not for the 2-digit level.

The level of disaggregation of R&D expenditures data by FORD will strongly influence the usability of this classification for other levels of analysis in the PREF study. **Table 2** presents the FORD classification, version 2015, which will be adopted in PREF.

Table 2. Fields of R&D Classification (version 2015)

Code	Name	Description
FORD1	1. NATURAL SCIENCES	1.1 Mathematics 1.2 Computer and information sciences 1.3 Physical sciences 1.4 Chemical sciences 1.5 Earth and related Environmental sciences 1.6 Biological sciences 1.7 Other natural sciences
FORD2	2. ENGINEERING AND TECHNOLOGY	2.1. Civil engineering 2.2 Electrical engineering, Electronic engineering, Information engineering 2.3 Mechanical engineering 2.4 Chemical engineering 2.5 Materials engineering 2.6 Medical engineering 2.7 Environmental engineering 2.8 Environmental biotechnology 2.9 Industrial biotechnology 2.10 Nano-technology

		2.11 Other engineering and technologies
FORD3	3. MEDICAL AND HEALTH SCIENCES	3.1. Basic medicine 3.2. Clinical medicine 3.3. Health sciences 3.4 Medical biotechnology 3.5 Other medical sciences
FORD4	4. AGRICULTURAL AND VETERINARY SCIENCES	4.1. Agriculture, forestry, fisheries 4.2 Animal and diary sciences 4.3. Veterinary science 4.4 Agricultural biotechnology 4.5 Other agricultural sciences
FORD5	5. SOCIAL SCIENCES	5.1. Psychology and cognitive sciences 5.2. Economics and Business 5.3. Education 5.4 Sociology 5.5 Law 5.6 Political science 5.7 Social and economic geography 5.8 Media and communications 5.9 Other social sciences
FORD6	6. ARTS AND HUMANITIES	6.1. History and archaeology 6.2 Languages, literature and communication 6.3 Philosophy, ethics and religion 6.4 Arts (arts, history of arts, performing arts, music) 6.5 Other humanities
FORD7	7. INTER- OR MULTI-DISCIPLINARY	

Source: FM 2015.

3.1.3 Statistical classification of economic activities (NACE)

NACE is a classification of economic activities by sectors of activity which is widely used in different types of economic statistics within the European Union. It is derived from the United Nations' International Standard Industrial Classification of all Economic Activities (ISIC); NACE uses the same 1-st level items as ISIC, but is more detailed. The classification is hierarchical with four levels, i.e. sections, divisions, groups and classes. The current version of NACE is version 2.0.

In R&D statistics, NACE are used in order to classify R&D performed in the business enterprise sector. Table 3 presents the classification adopted in R&D statistics (EU regulation No 995/2012), which is at different levels of disaggregation depending on the sector. Depending on data availability, PREF might have recourse to more aggregate classification.

Table 3. NACE classification as adopted in R&D statistics (Version 2.0)

Code	**Name**
01-03	AGRICULTURE FORESTRY AND FISHING
05-09	MINING AND QUARRYING
10-33	MANUFACTURING
10-12	Manufacture of food products; beverages and tobacco products
10, 11	Manufacture of food products and beverages
12	Manufacture of tobacco products
13-15	Manufacture of textiles, wearing apparel, leather and related products
13	Manufacture of textiles
14	Manufacture of wearing apparel
15	Manufacture of leather and related products
16-18	Manufacture of wood, paper, printing and reproduction
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
18.2	Reproduction of recorded media
19	Manufacture of coke and refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22	Manufacture of rubber and plastic products
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals
24.1-24.3, 24.51, 24.52	Manufacture of basic iron and steel; casting of iron and steel.
24.4, 24.53, 24.54	Manufacture of basic precious and other non-ferrous metals; casting of non-ferrous metals.
25-30	Manufacture of fabricated metal products, computer, electronic and optical products, electrical equipment, machinery, motor vehicles and other transport equipment
25	Manufacture of fabricated metal products, except machinery and equipment
25.4	Manufacture of weapons and ammunition
26	Manufacture of computer, electronic and optical products
26.1	Manufacture of electronic components and boards
26.2	Manufacture of computers and peripheral equipment
26.3	Manufacture of communication equipment
26.4	Manufacture of consumer electronics
26.5	Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks
26.6	Manufacture of irradiation, electromedical and electrotherapeutic equipment

26.7	Manufacture of optical instruments and photographic equipment
26.8	Manufacture of magnetic and optical media
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment n.e.c.
29	Manufacture of motor vehicles, trailers and semi-trailers
30	Manufacture of other transport equipment
30.1	Building of ships and boats
30.2	Manufacture of railway locomotives and rolling stock
30.3	Manufacture of air and spacecraft and related machinery
30.4	Manufacture of military fighting vehicles
30.9	Manufacture of transport equipment n.e.c.
31	Manufacture of furniture
32	Other manufacturing
32.5	Manufacture of medical and dental instruments and supplies
33	Repair and installation of machinery and equipment
35-39	ELECTRICITY, GAS, STEAM, AIR CONDITIONING AND WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES
35, 36	Electricity, gas, steam and air conditioning supply; water collection, treatment and supply
37-39	Sewerage, waste management, remediation activities
41-43	CONSTRUCTION
45-82	SERVICES OF THE BUSINESS ECONOMY
45-47	Wholesale and retail trade; repair of motor vehicles and motorcycles
46.5	Wholesale of information and communication equipment
49-53	Transportation and storage
49	Land transport and transport via pipelines
50	Water transport
51	Air transport
52	Warehousing and support activities for transportation
53	Postal and courier activities
55, 56	Accommodation and food service activities
58-63	Information and communication
58-60	Publishing, motion picture, video and television programme production, sound recording, programming and broadcasting activities
58	Publishing activities
58.1	Publishing of books, periodicals and other publishing activities
58.2	Software publishing
59, 60	Motion picture, video, television programme production; programming and broadcasting activities
59	Motion picture, video and television programme production, sound recording and music publishing activities

60	Programming and broadcasting activities
61	Telecommunications
62	Computer programming, consultancy and related activities
63	Information service activities
63.1	Data processing, hosting and related activities; web portals
63.9	Other information service activities
64-66	Financial and insurance activities
68	Real estate activities
69-82	Professional, scientific, technical, administrative and support service activities
69-75	Professional, scientific and technical activities
72	Scientific research and development
77-82	Administrative and support service activities
77	Rental and leasing activities
78	Employment activities
79	Travel agency, tour operator and other reservation service and related activities
80	Security and investigation activities
81	Services to buildings and landscape activities
82	Office administrative, office support and other business support activities
84, 85	PUBLIC ADMINISTRATION AND DEFENCE; COMPULSORY SOCIAL SECURITY AND EDUCATION
84	Public administration and defence; compulsory social security
85	Education
86-88	HUMAN HEALTH AND SOCIAL WORK ACTIVITIES
86	Human health activities
87, 88	Residential care activities and social work activities without accommodation
90-93	ARTS, ENTERTAINEMENT AND RECREATION
94-99	OTHER SERVICE ACTIVITIES; ACTIVITIES OF HOUSELHOLDS AS EMPLOYERS AND OF EXTRATERRITORIAL ORGANISATIONS AND BODIES
95.1	Repair of computers and communication equipment

Source: EUROSTAT.

3.1.4 Type of R&D

Type of R&D is a classification of R&D activities depending on their orientation towards basic research, applied research and experimental development, which is introduced in the Frascati manual. Since it refers to the characteristics of performed research, it should be applied to R&D execution only and should not be applied to governmental appropriations, respectively programmes and projects, for which the NABS classification is more appropriate. Data on Type of R&D are routinely collected in the R&D statistics, where such a breakdown is requested for R&D performed.

Table 4 provides the classification and the corresponding definitions.

Table 4. Type of R&D classification

Code	Type	Description
Type01	Basic research	Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.
Type02	Applied research	Applied research is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective.
Type03	Experimental development	Experimental development is systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes.

Source: Frascati manual.

3.2 Non-statistical classifications

These classifications are more related to specific topics of interest to research policy at the European level. No commonly accepted standards exists for them, as definitions might slightly differ between sources; further, they are not all-encompassing classification, but identify specific research areas; finally, there is no regular data collection which makes use of these classifications.

Despite methodological issues, to provide an analysis of the importance of themes in national research policies, PREF will adopt an approach based on the combination of different items:

- Direct classification of funding instruments in terms of their relevance for SGCs and KETs.
- Cross-classification with other statistical classifications providing similar breakdowns, in particular the NABS and FORD classification at level 2. Details on cross-classifications are provided below.
- Complementary information on policy priorities at national level.

The approach for developing indicators concerning SGCs, KETs and, to a subordinate level, FP7 topics is explained in detail in section 10.1.9 of this handbook.

3.2.1 Key enabling technologies (KETs)

Key enabling technologies (KETs) have been defined by the European Commission as 'knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly skilled employment. They enable process, goods and service innovation throughout the economy and are of systemic relevance. They are multidisciplinary, cutting across many technology areas with a trend towards convergence and integration. KETs can assist technology leaders in other fields to capitalize on their research efforts'.

Based on current research, economic analyses of market trends and their contribution to solving societal challenges, following KETs have been identified. **Table 5** also shows that, among the five KETs, two (Nanotechnology and biotechnology) technologies correspond to one or more FORD fields of S&T and another two (micro and nano-electronics and advanced manufacturing technologies) are related to at least one FORD. When level-2

FORD data are available, expenditures by KET can be computed from this matching, with the exception of photonics which has no direct correspondence in the FORD classification.

Table 5. List of KETs and correspondence with FORD

KETs	FORD correspondence
Nanotechnology	2.10 Nanotechnology
Micro- and nano-electronics including semiconductors	2.2 Electrical engineering, electronic engineering, information engineering
Advanced material	2.5 Materials technology
(industrial) biotechnology*	2.9 Industrial biotechnology
Photonics	No matching possible
Advanced manufacturing technologies	2.3 Mechanical engineering

**KET Biotechnology is defined in two different ways: Only including industrial biotechnology (see http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0341:FIN:EN:PDF) or as a broader biotechnological field of which industrial biotechnology is a subset (see http://ec.europa.eu/research/horizon2020/pdf/proposals/com%282011%29_811_final.pdf). We adopt here the more restrictive definition.*

3.2.2 Societal Grand Challenges (SGCs)

The Societal Grand Challenges (SGCs) are the major challenges to which the European society will be confronted in the next years, as identified in the Europe 2020 strategy. They also represent a major pillar of the Horizon2020 EU Programme, i.e. the successor of FP7. The list of SGCs is provided in **Table 6**. As shown by that table, SGCs have some broad correspondence with the NABS classification, but aim to identify more precisely specific orientations between policy domains, which can be identified only through in-depth analysis of programme content.

Table 6. List of SGCs and matching with NABS

SGCs	Correspondence with NABS
Food security, sustainable agriculture, marine and maritime research, and the bio-economy;	Subset of NABS02 Environment and NABS08 Agriculture.
Secure, clean and efficient energy;	Subset of NABS05 Energy.
Smart, green and integrated transport;	Subset of NABS04 Transport, telecommunication and other infrastructures.
Climate action, resource efficiency and raw materials;	Subset of NABS02 Environment and NABS05 Energy.
Health, demographic change and wellbeing;	Subset of NABS11 Political and social systems, structures and processes and of NABS07 Health.
Secure societies - protecting freedom and security of Europe and its citizens;	Subset of NABS11 Political and social systems, structures and processes.
Europe in a changing world - inclusive, innovative and reflective societies.	Subset of NABS11 Political and social systems, structures and processes.

3.2.3 FP7 thematic priorities

Framework Programme 7 (FP7) thematic priorities is a classification of research topics which broadly corresponds to the main thematic areas of FP7. As such, it can be

employed in a rather straightforward way to European Programmes, but less so to national programmes and, in many cases, will require a very detailed disaggregation.

Table 7 provides the list of FP7 priorities and a matching with NABS and FORD categories. To some extent, this matching table should allow providing approximate figure for most FP7 priority domains, even if considerable differences in the precise delimitation remain possible.

Table 7. FP7 thematic priorities

Code	Name	Correspondence with NABS	Correspondence with FORD
FP7-1	Health	NABS07 Health	
FP7-2a	Food, Agriculture and Fisheries	NABS08 Agriculture	
FP7-2b	Biotechnology		FORD2.8, 2.9 and 3.4
FP7-3	Information and Communication Technologies		FORD1.2 Computer and Information sciences
FP7-4a	Nanosciences and Nanotechnologies		FORD2.10 Nanotechnology
FP7-4b	Materials (excluding nanotechnologies)		FORD2.5 Material engineering
FP7-4c	New Production Technologies	NABS06 Industrial production and technology	
FP7-4d	Construction and Construction Technologies		FORD2.1 Civil engineering
FP7-5	Energy	NABS05 Energy	
FP7-6	Environment (including Climate Change);	NABS02 Environment	
FP7-7a	Aeronautics	No match possible (NABS04 is much larger)	
FP7-7b	Automobiles		
FP7-7c	Other Transport Technologies		
FP7-8a	Socio-Economic Sciences		FORD5 Social sciences
FP7-8b	Humanities;		FORD6 Humanities
FP7-9	Space	NABS03 Exploration and exploitation of the space	
FP7-10	Security		

3.3 Sector classification

For the analysis of performers and R&D execution, PREF will adopt the sector classification provided by the Frascati manual and the related implementation of it in national R&D statistics.

It is important to acknowledge that the use of the Frascati manual classification differs somewhat by country and this might lead to some inconsistencies in the data. For example, some PROs are included in the higher education sector when they are

controlled by universities or their supervising body, whereas an organization like CNRS is included in the higher education sector. The same happens for public research organizations which, depending on their characteristics, might be included in the government sector or in the business enterprise sector.

To map these differences, PREF will specifically request information about the national definition of sectors.

Table 8. Sector classification

Code	Name	Description
FMS1	Business enterprise sector	— All resident corporations, including not only legally incorporated enterprises, regardless of the residence of their shareholders. This group includes all other types of quasi-corporations, i.e. units capable of generating a profit or other financial gain for their owners, recognized by law as separate legal entities from their owners, and set up for purposes of engaging in market production at prices that are economically significant. — The unincorporated branches of non-resident enterprises deemed to be resident because they are engaged in production on the economic territory on a long-term basis; — All resident NPIs that are market producers of goods or services or serve business.
FMS2	Government sector	— All units of central (federal), regional (state) or local (municipal) government, including social security funds, except those units that provide higher education services or fit the description of higher education institutions provided in the previous subsection; — All non-market NPIs that are controlled by government units, which are not part of the Higher education sector.
FMS3	Higher education sector	— All universities, colleges of technology and other institutions providing formal tertiary education programmes, whatever their source of finance or legal status, and all research institutes, centres, experimental stations and clinics that have their R&D activities under the direct control of, or administered by, tertiary education institutions, with the restrictions that these research institutes, centres, experimental stations and clinics do not sell their output at an economically significant price and are not controlled by an institution classified to the Business enterprise sector.
FMS4	Private non-profit sector	— All non-profit institutions serving households (NPISH), as defined in the SNA 2008, except those classified as part of the Higher education sector. — For completeness of presentation, households and private individuals engaged or not engaged in market activities
FMS5	Rest of the world	— All institutions and individuals located outside the political borders of a country, except vehicles, ships, aircraft and space satellites operated by domestic entities and testing grounds acquired by such entities. — All international organizations (except business enterprises), including facilities and operations within the country's borders.

Source: Frascati manual, 2002 edition.

4 Special codes and flags

Most PREF data will be in the form of numerical variables, ordinal variables or texts. Two types of special codes are foreseen:

- Special codes when the value of a variable is not available for any reason.
- Flags to identify specific problems with the data.

For both, PREF largely follows EUROSTAT conventions.

4.1 Special codes

As a general rule, no blank cells are allowed in the PREF database, except for the "remarks" fields. The value "0" should be used only when this is the actual value of the variable.

For all other cases, the following special codes apply, following the standard notation from EUROSTAT:

- Code "z" refers to the fact that the variable is not applicable to the unit of observation.
- Code "m" refers to the fact that the data in question is missing.
- Code "x" should be applied when a specific breakdown is not available, but the data are included in the total (for numerical variables only).
- Code "xc" should be used when the value is included in another subcategory (for numerical variables only).
- Code "xr" should be used for data which are included in other rows, which can occur when a programme is part of another programme (for numerical variables only).

Since for public funding data many breakdowns might be only partial and include missing values, a total category is provided for all numerical variables.

Remark: when a breakdown is not available, all corresponding fields should be left blank (and not coded as "0") and flagged with "x", *including the unclassified category*. It should be avoided to introduce the whole amount under unclassified.

4.2 Data flags

In order to document special cases and data quality problems, PREF provides a set of data flags which correspond to those used in EUROSTAT R&D statistics.

As a general rule, when a flag is introduced, an explanatory note should be added in the corresponding remarks field in the data table. More detailed explanations of the flags are included in the metadata sheets.

The following table presents the list of flags.

Table 9. List of flags

Code	Description	Definition
b	break in time series	When changes in definitions or data collection procedures imply that the data are not comparable across years.
d	definition differs	Differences in definitions adopted for data collection imply that the value of the marked cells significantly differs from those complying with the PREF methodology.
i	see metadata	There are specific conditions which imply that the value of a cell should be interpreted in a different way

		or not directly compared with others.
ic	Inconsistent	Both when sum of break down differs from total or if another semantic rule is violated concerning the dependency between two variables.
rd	Rounded	When data have been rounded by the data provided and thus are included in this format in the database.
c	Confidential	When data are available, but restricted to public access.
e	Estimated	Estimate by the project team or by national expert. Details on how the estimate has been made should be added in the remarks section.
u	Low reliability	When, for any reasons, data are deemed to be unreliable (a specific explanation should be added).
p	Provisional	Data have been entered in the database, but it is expected will be revised for some reasons (details to be added in the remarks section).
r	Revised	Data have been revised at later stage and modified in the dataset. A description of the revision should be included in the remarks.
n	Not significant	When the value of numerical variable is below the lowest unit of measurement.

Source: EUROSTAT.

5 Perimeter and coverage

5.1 Scope of public funding

Given its focus on the public funding of R&D, PREF follows closely the definition from the Frascati Manual of *Government Budget Allocation for R&D* as all the budgetary items in the public budgets which involve support to R&D (FM 2015, chapter 12). Following the FM, government includes central or federal government and regional government when its contribution is significant (particularly in federal countries). In practice, support from regional government is included in PREF when this is significant at national level, in most cases as institutional funding to the higher education sector.

Therefore, in general terms, the perimeter of PREF data collection is the same as GBARD defined in the Frascati manual, and the total amount of PREF funding streams should be the same (see section 6.2).

According to the FM, the *central government* consists of the institutional unit or units making up the central government plus those non-market non-profit institutions (NPIs) that are controlled by central government. The departments may be responsible for considerable amounts of R&D expenditure (intra or extra-muros) within the framework of the government's overall budget, but often they are not separate institutional units capable of owning assets, incurring liabilities, engaging in transactions, etc., independently of central government as a whole.

On the contrary, funding from public agencies with separate legal identity and substantial autonomy, which have discretion over the volume and the composition of their expenditures, like public utilities and public foundations, are not included in GBARD.

The *state government* subsector consists of state governments that are separate institutional units plus those non-market NPIs that are controlled by state governments. This subsector exercises some of the functions of government at a level below that of central government. Such "states" may be described by different terms in different countries, i.e. "regions" or "provinces". State government funding of R&D should be included in GBARD when its contribution is significant.

Finally, R&D funds raised within *local government* should be in principle excluded on the ground of expected limited significance and data collection burden.

There is a number of potential differences between GBARD data, as published by OECD/EUROSTAT, and PREF data on public funding; these include:

- The inclusion of funding streams which are not currently covered by GBARD in all countries, particularly transfer funds (see section 6.3).
- A different treatment of international funding flows (see section 6.5).
- Different ways of accounting public funding between GBARD (based frequently on budgets) and the analysis of streams and instruments (which might be based on actual transfers).
- Only direct R&D funding is considered in the PREF project. Tax incentives and other forms of indirect incentives are excluded from the data collection. However the balance between direct and Indirect R&D support will be included at the outset and as a starting point for the further analyses of direct funding, which is the main issue in this project.

5.2 Country coverage and currency

PREF covers 40 countries as given in **Table 10**.

For China, Japan, the US, Israel, FYROM, Montenegro, Serbia and Turkey data collection will be limited to total public appropriations and to a basic breakdown by funding streams which allows computing the share of institutional and project funding. No detailed information on funding instruments and managing agencies is foreseen.

All monetary values will be provided in the national currency for the reference year *expressed in thousands monetary units and rounded to the unit.* The PREF database will include conversion rates from national currency to euros at the official exchange rate and in Purchasing Power Parities. For purposes of time series analysis, it will also include a table of GDP deflators by country on the baseline year 2000.

Table 10. List of countries covered in PREF (ISO-3166)

ISO country code	Country	Currency	ISO currency code
AT	Austria	Euro	EUR
BE	Belgium	Euro	EUR
BG	Bulgaria	lev (pl. leva)	BGN
CH	Switzerland	Swiss Franc	CHF
CN	China (Peoples Republic)*	Chinese Yuan	CNY
CY	Cyprus	Euro	EUR / CYP before 2008
CZ	Czech Republic	Czech koruna (pl. koruny)	CZK
DE	Germany	Euro	EUR
DK	Denmark	Danish krone (pl. kroner)	DKK
EE	Estonia	Euro (1)	EUR / EEK before 2011
ES	Spain	Euro	EUR
FI	Finland	Euro	EUR
FR	France	Euro	EUR
EL	Greece	Euro	EUR / GRD before 2001
HR	Croatia	kuna (inv.)	HRK
HU	Hungary	forint (inv.)	HUF
IE	Ireland	Euro	EUR
IL	Israel*	Israeli Shekel	ILS
IS	Iceland	króna (pl. krónur)	ISK
IT	Italy	Euro	EUR
JP	Japan*	Japanese Yen	JPY
LI	Liechtenstein	Swiss franc	CHF
LT	Lithuania	litas (pl. litai)	LTL
LU	Luxembourg	Euro	EUR
LV	Latvia	lats (pl. lati)	LVL
ME	Montenegro*	Euro	EUR
MK	Former Republic of Macedonia*	denar (pl. denars)	MKD
MT	Malta	Euro	EUR / MTL before 2008
NL	Netherlands	Euro	EUR
NO	Norway	Norwegian Krone	NOK
PL	Poland	zloty (pl. zlotys)	PLN
PT	Portugal	Euro	EUR

RO	Romania	Romanian leu (pl. lei)	RON
RS	Serbia*	Serbian dinar	RSD
SE	Sweden	Swedish krona (pl. kronor)	SEK
SI	Slovenia	Euro	EUR / SIT before 2007
SK	Slovakia	Euro	EUR / SKK before 2009
TR	Turkey*	Turkish lira (inv.)	TRY
UK	United Kingdom	pound sterling (pl. pounds)	GBP
US	United States of America	US dollar	USD

5.3 Time coverage

PREF provides for two types of data collection with different time frames:

— First, *descriptors and characterization of funding streams, instruments and managing organizations*. The reference date for this information is 31.12.2014. This implies that the lists of funding streams and instruments, as well as of managing agencies, is established for that year. Major structural changes will be tracked specifically in the descriptors, for example through dates of establishment of new programmes or organizations.

  When a funding stream, instrument or organization is included in the data collection because of its relevance even if it ceased to exist before 2014, descriptors should be provided for the last applicable year.

  When a funding stream or instrument underwent a substantial change in its function and criteria for allocation of funds during the period 2000-2012, the stream or instrument should be split between the two periods.

  Example: when the allocation criteria for higher education funding moved from historical to formula-based on 2005, two distinct instruments should be included for the period 2000-2005 and 2006-2014 providing a separate set of descriptors.

  This should be applied to major changes, not to minor restructuring like changes in the panel composition.

— Second, *financial data on funding amounts*. This information is collected for individual years in the period 2000-last available year (calendar year: 01.01-31.12 of each year).

6 Structure and analysis of funding flows

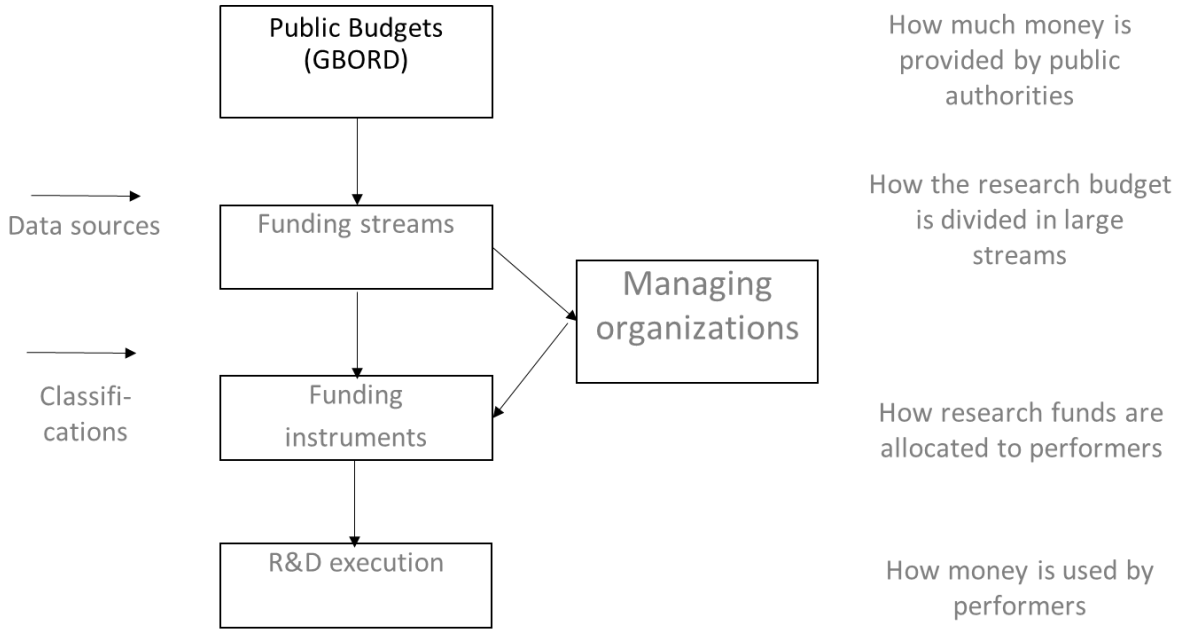
The methodological approach of PREF is based on the notion of decomposing public research funding, as they can be identified in the public budgets, in distinct streams and funding instruments, which allow for a more fine-grained analysis.

Therefore, the basic reference perimeter is constituted by the GBARD; data on national GBARD (including their breakdown by NABS), derived from EUROSTAT and OECD databases are included in PREF as a reference. National public funding will be decomposed at two levels:

- The level of major funding streams which can be identified within the GBARD, like the core allocation to higher education institutions, allocation for funding agencies, to large PROs. PREF will also provide for a basic characterization of funding streams (see below).
- A more fine-grained level of characterization of funding instruments, specifically within project funding, which are then connected with performing sectors.

Funding streams and funding instruments are linked to research funding organizations who manage them, hence making the bridge between funding streams and their respective managing organizations (see further chapter 7 of this handbook).

Figure 3. Basic data structure



PREF will specifically collect data on three components: funding streams (see 6.3), funding instruments (see 6.4) and managing organizations (see 7). It will also integrate official data on GBARD (see 6.2) and R&D expenditures (see 6.6) from international statistics as a reference on total public appropriations and expenditures at the performer's level respectively.

6.1.1 Reconciliation between different levels

It is important to recognize that delimitation of research funding at each level follows slightly different criteria. Specifically, GBARD is based on policy intention, as described for example in State decisions, while R&D expenditures are based on the effective activities done by performers. This leads to differences between aggregates which are

well-known in official statistics. The same is expected to happen at the level of funding stream and funding instruments.

PREF will not do any attempt to reconcile the total volume of funding/expenditures across level and we expect that totals might be slightly different by level. However, following totals will be computed for each year:

1. Total GBARD as in the R&D statistics.
2. Total funding volume of the streams included in the data collection (with funding source in the concerned country).
3. Total funding volume of the instruments included in the data collection.
4. Total R&D expenditures funded by the government sector.

It is generally expected that 1 and 2 totals are very similar; differences might come from the inclusion of exchange grants, which are currently not always covered by GBARD.

Total at the instruments level should be near to total GBARD less the funding streams transferring funds to RFOs and performers abroad. This total should be quite similar to total R&D funded by the government. Some difference might arise by the fact that funding instrument might also include some PNP or Business Enterprise funding (for example ROFs receiving, additional to public funding, some resources from charities).

6.2 Government Budget Allocations for R&D (GBARD)

Government Budget Allocations for R&D (GBARD) is a measure of the public investment in the R&D based on the analysis of the public budget, which foresees individuating those specific budgetary lines intended for R&D purposes, like transfers to RFOs or research organizations. Therefore, GBARD refers to *policy intentions* to devote public funding to research.

The GBARD methodology is defined in detail in chapter 12 of the Frascati manual and data are provided on a yearly basis by national statistical authorities and published by EUROSTAT and OECD.

The PREF database will integrate GBARD statistical figures as a reference for the perimeter of public funding in the considered countries; GBARD data also provide a breakdown by policy domain using NABS. For those countries which delivered it to EUROSTAT, the breakdown between project and institutional funding will also be included and compared with the data provided by PREF based on a detailed analysis of funding streams (see below 6.3.1).

6.2.1 Variables of GBARD

Country. The country to which the GBARD value refers.

Year. The calendar year to which the GBARD value refers.

Amount. Total GBARD in the considered country and year, in thousands currency units at current price rounded to the unit.

Currency. The ISO-code of the currency.

Amount institutional funding. The amount of GBARD devoted to institutional funding (when available).

Amount project funding. The amount of GBARD devoted to project funding (when available).

Amount NABS. The amount of GBARD in the considered year devoted to a specific socio-economic objective (one variable for each NABS code).

Flag. Flag for specific data issues (see 4.2).

Remarks. A textual field for explaining flags and other comments.

6.3 Funding streams (FS)

Funding streams (FS) are aggregate streams of public money transferred to RFOs or research organizations.

Examples of funding streams are the following:

- Transfer from the State budget to a research council.
- The overall envelope of general university funds (GUF) to all HEIs in a country.

The definition of FSs is closely related to the structure of public budgets; they provide a first-level aggregated decomposition of GBARD, without details on the exact beneficiary and characteristics of the allocation process. In many cases, FS will correspond to a specific item in the public budget, but in some cases they might provide a more fine-grained disaggregation, respectively an aggregation of different budgetary items.

6.3.1 Categorization and level of disaggregation.

The table below provides a basic categorization of FS, as well as some details on the envisaged level of disaggregation of information.

Rules for disaggregation of streams are as follows:

- Disaggregation is based on budgetary allocation and not on funding instruments, which are dealt separately in PREF.

  As a general rule, there should be only one stream for the whole central government transfer to managing agencies (RFOs or UPROs), while the disaggregation by different instruments (even if related to different budgetary lines) should be done at the instrument level.

- Major streams should be singled out, for example individual transfers to large funding agencies or, at the European level, it is strongly advised to single out transfers to the European Space Agency (ESA) and, for associated states, to European Framework Programmes (EU-FP) given their size. It is also requested to divide funding for higher education between federal and regional government in federal countries.
- A residual category should be added in order to provide reconciliation with the total GBARD as shown in international statistics.
- Category 03 (funding to PROs) and CAT07 (exchange funds) should be in principle aggregated as a single stream for all national government. Exceptions might be made for ministries which make a substantial part of public funding. For these streams, the managing RFO will be set to "national government" (respectively "regional government")

  Example: if the science ministry manages a large number of research contract, which make a substantial share of national project funding, a separate stream might be included. In that case, the ministry should be listed as RFOs.

- Regional funding streams should be in principle aggregated, except when one region plays a very special role in R&D funding.

  Example: in countries where higher education is funded by regions, a single stream will cover funding to higher education by all regions together.

  Example: when a single region has a very large R&D funding program, a specific stream should be included.

Table 11. Categorization of funding streams

CODE	Category	Definition	Level of disaggregation	Examples and remarks	Indicative mode of allocation
CAT01	Public project funding	Transfers of public funds to RFOs, which then might be subdivided by different funding instruments (see 6.4) and allocated to performers.	One FS by RFOs as identified in the list of RFOs by country (see chapter 7.1). An additional item is provided in each country to aggregate transfers to agencies not included in RFOs (if applicable).	National budget to the Research Council or to the national innovation agency. Only national-level budget included.	Project
CAT02	Public funding to HEIs	The share of the core governmental allocation to HEIs devoted to R&D.	In federal countries two distinct FSs by government level (central and regional). Distinction by HEI type is also advised in binary systems when possible.	Definition complies with the one of General University Funds in the Frascati manual. This FC is usually estimated as a share of the core governmental allocation to HEIs for all their activities (see FM, section ***).	Institutional
CAT03	Public funding to the PRO sector	Total core funding allocation to the PRO sector	A single stream for all PROs (excluding UPROs). Exception: when a single ministry allocates a very large amount of public funding to PROs.		Institutional
CAT04	Public funding to international performers	Amount transferred to international performers like CERN.	A single stream	Corresponds to the same category in the EUROSTAT data collection on transnational research.	Institutional
CAT05	Public funding to international funding agencies	Amount transferred to international funding agencies like ESA.	ESA as a separate stream. A separate stream for contribution to EU-FP for associated countries.	Corresponds to the same category in the EUROSTAT data collection on transnational research.	Project
CAT06	Public funding to UPROs	Transfers of public funds to UPROs.	One FS by UPRO as identified in the list of UPROs by country (see	Public allocation to organizations like CNRS or CNR.	Institutional

			chapter 7.1).		
CAT07	Exchange funds	Total exchange funds	A single stream. Exception: when a single ministry allocates a very large amount of public funding to PROs.	Following FM2015 definition.	Project
CAT08	Intra-mural R&D of the government	Total intramural R&D expenditures of the government	A single stream Exception: when a single ministry allocates a very large amount of public funding to PROs.	This stream includes funding to intra-mural R&D expenditures of the government sector, for example internal to ministries and other parts of the public administration.	Institutional

6.3.2 Variables of funding streams

PREF will include a number of variables to characterize the funding stream as follows.

- *Funding stream ID*. A unique identifier of the funding stream with the following format: FS-countrycode-XXXX (for example FSCH0001).
- *Name of funding stream* in English. For example "Funding to the national research council". The name should be informative of the main characteristics of the stream.
- *Start year*. Start year of the stream. There might be cases where this information is not available with precision, especially for the older stream and instruments. In that case, following conventions apply:
  - Date 1900 for streams which started during the XX century, but before the Second World War.
  - Date 1800 for streams which started before 1900.

  Remarks should be added in any case.
- *End year*. End year of the stream when it ended within the reference period 2000-2014, not applicable otherwise.
- *Category* as in **Table 11**. When a stream is too composite to identify a main category, the code "not applicable" should be used. When the stream is composite, but a prevalent category can be identified, the corresponding category should be used, but a remark be added,
- *Source country of funds.* The country which provides the funds for that stream. The code EU is allowed only for streams where funds come from the EU budget (like EU Framework Programmes), but it is not allowed in national data collection.
- *Source level of funds*. This variable distinguishes between international sources of funds (allowed only for EU funds), central government and regional government funds (particularly in federal country).
- *The managing organization* (see section 7), which receives the funding provided by that stream.

  Following rules apply for managing organizations:

  - For streams providing resources to RFOs and UPROs, the managing organization is the one which receives the funding and distributes it to performers. Particularly, funding to international agencies (CAT05) have the

corresponding international agency as a managing organization, not the national organizations transferring the fund abroad.

- For streams providing resources to performers (for example universities, CAT02 and PROs CAT03), the managing organization is the entity distributing the funding to performers (for example a research or higher education ministry).

6.3.3 Funding stream amount

For each funding stream, the funding amount is recorded for each individual year in the period 2000-2012. As a preference, the amount should correspond to the effective expenditures recorded in the State accounts. As foreseen in the Frascati Manual, other ways of accounting, for example the engagement in the State budget, might be used. In this case, a specific remark should be added.

The amount should be recorded during the whole period of existence of the stream, even if for some years data are missing. However, when no data for all streams in a country are available in a given year, the corresponding lines will not be included in the database.

The corresponding table includes the following variables.

Reference year. The calendar year to which the amount refers.

Amount. Total amount in thousands. currency units at current prices (rounded to the unit).

Currency. The ISO country code of the currency used for the amount.

Amount project. The amount attributed as project funding for each year.

Amount institutional. The amount attributed as institutional funding for each year.

For most streams, it is expected that all funding is attributed either as project or as institutional funding, as in **Table 11**, but some streams might be mixed in this respect (for example public allocation to an UPRO, which is then distributed partly as institutional partly as project to individual units or allocation to an RFO which distributes project overheads to universities).

In that case, the breakdown between project and institutional should be based on the breakdown by funding instruments (which have to be either project or institutional). Such cases are expected for CAT01 (RFOs) and CAT06 (UPROs), but not for the other streams.

Amount by NABS. The amount attributed for each NABS category (see section 3.1.1). An unclassified category is provided. Total sum of subcategories should add to the total.

When the exact distribution of amounts is not known, an estimate is accepted, but it should be clearly labelled and explained in the remarks.

Accounting methods. A categorical variable which can take following values: *budget* if the amount refers to the (engagement) budget, *expenditure* if the amount refers to the actual expenditures; *other* in other cases, to be explained in the remarks field.

Data source. The source from which the data were retrieved.

The following four variables measure the extent of performance-based allocation for each stream and year; explanations and details on the methodology are provided in chapter 8 of this handbook.

Competitive bid. This variable is computed from the corresponding instrument-level information and is 1 when the allocation procedure is "competitive bid" and 0 when it is not (see chapter 8 for methodological details). This variable is set to "not applicable" for purely project funding streams.

Performance allocation, This variable measures the extent of ex-post performance orientation of institutional funding, computed from information at the instrument level

(see chapter 8 for methodological details). It ranges from 0 to 1. This variable is set to "not applicable" for purely project funding streams.

Amount ex-ante. The amount of funding attributed through ex-ante performance evaluation. It is computed as follows:

*Amount ex-ante = (amount project) + (amount institutional) * (competitive bid).*

Amount ex-post. The amount of funding attributed through ex-post performance evaluation. It is s computed as follows:

*Amount ex-post = (amount institutional) * (performance allocation).*

Remark: for countries for which non FI is collected, computation will be based on additional FS variable (see below).

6.3.4 Additional variables

For the countries for which no data on Funding Instruments are collected (i.e. China, Japan, the US, Israel, FYROM, Montenegro, Serbia and Turkey) some additional descriptors are collected at the level of funding streams in order to allow for the distinction between competitive and non-competitive institutional funding.

These variables will allow constructing a characterisation of the instruments in terms of the level of output orientation, respectively of competition for funds, in the analytical part of the PREF project.

Reduced allocation procedure. This categorical variable distinguish between basic types of allocation procedures, distinguishing between:

- *Formula-based allocation*, i.e. the amount of the funding is computed from a formula based on quantitative indicators (code=1).
- *Negotiated allocation*, i.e. the amount of the funding is negotiated directly between the funder and the beneficiary (code=2).
- *Historical basis with some adaptation,* i.e. the amount of the funding is basically determined by the allocation for the past year, but with some adaptation depending on other criteria (code=3).
- *Competitive bid*, i.e. the decision to provide funds and the amount is based on the selection between competitive offers (code=4).

For instruments where different criteria are adopted, the most important one should be chosen, but a remark should be added.

Reduced FS mode = 1 when the allocation mode is formula, 0.5 when the allocation mode is negotiated and 0 when the allocation mode is historical or grant. Intermediate scores are possible.

Reduced FS criteria = 1 when the allocation criteria are based on research performance, like third-party funds, bibliometrics or outcome of peer evaluation, 0 when the criteria are input based or based on educational activities. These criteria are assessed by national experts.

6.4 Funding instruments (FI)

Funding instruments (FI) are specific mechanisms to allocate public research funding to (groups of) performers. The identification of funding instruments is principally based on the following criteria:

- Their visibility as a unique funding instrument for research, like a clearly distinguishable programme managed by a research funding organization.
- The internal consistency in terms of the allocation mechanism and criteria, the allocation mode (project or institutional) and concerning the allocation criteria (for example performance-based).

Funding instruments provide a more disaggregated view of public funding than funding streams; as a general rule, for each funding stream there has to be at least one associated funding instruments, but in many cases there will be more than one. However, since in most countries there is a large number of funding programmes and schemes, decisions on the level of disaggregation will depend also on practical questions, as it will be difficult to manage data collection when the number of funding instruments grows too large.

As a general rule, there must be at least one funding instrument for each funding stream, since funding instruments include additional information on beneficiaries as well as on how funds are allocated. *The exception for national data collection are international funding streams – i.e. funding transferred to international performers or RFOs -, for which the corresponding funding instruments are describe in a separate international data collection (see 6.5).*

In practical terms, the following disaggregation level is advised for the funding streams described in **Table 11**:

- *Research funding organizations*. Distinct funding instruments should be included for the main instruments managed by each RFO, like investigator-driven projects, support to careers, structural programmes, etc. Usually, this will represent the first layer of funding instrument by RFOs
- The base criterion for disaggregation is that an instrument is sufficiently homogeneous in terms of the Type of R&D it is funding (for example basic vs. applied or investigator-driven vs. thematic), respectively the allocation procedure and the criteria adopted. Thematic programmes should be singled out only when they are lasting and of large size, but it is not generally requested to disaggregate programme groups covering different topics within the same funding scheme (as a breakdown by field of amount is required). For RFOs supporting also national facilities and research centres through institutional funding, a specific instrument should be foreseen.

  Specific instruments for public-private cooperation, i.e. instruments which are specifically required to foster this cooperation and require the participation of both a public research organization and of a private company should be singled out irrespectively of their size.

- *Umbrella Public Research Organizations*. At least for each UPRO distinct instruments should distinguish institutional and project funding allocation (when applicable).
- *Institutional funding to HEIs*. In many cases a single instrument can be sufficient. However, when institutional funding is allocated through different mechanisms with clearly different allocation rules, distinct instruments should be included.

  Example: HEI institutional funding is allocated based on past budget (50% of the amount), on the number of students (30% of the amount) and the research performance (20%). In this case, there streams should be included by apportioning the total amount according to the allocation criteria.

  Important remark: in most cases institutional funding to HEIs is attributed both for R&D and education and the R&D content has to be computed ex-post based on survey of the time of staff (so-called General University Funds, GUF). In these cases, the descriptors of the instrument refer to the allocation of the whole amount, whereas data on amounts refer only to the R&D component.

- *Institutional funding to PROs*. PRO funding schemes should be disaggregated in order to build homogeneous instruments in terms of the managing organization (for example PRO institutional funding through a research council) and the allocation criteria (for example performance-based funding).
- *Funding to international performers*. A single instrument will be considered covering all transfers to international performers.

— *Exchange funds*. In most cases a single instrument will be considered, except when a specific thematic area is particularly large and well identified.
— Intra-mural R&D expenditures of the government. No disaggregation foreseen.

6.4.1 General variables of funding instruments

PREF will include a number of variables to characterize the funding instruments as follows:

— *Instrument identifier*. A unique identifier with the format FI-ISO. Country.code – XXXX (for example FICH0001).
— *Instrument name* in English. The name of the instrument in English, as it is officially labelled in the concerned country (for example the programme name).
— *Start year*. Start year of the stream. There might be cases where this information is not available with precision, especially for the older stream and instruments. In that case, following conventions apply:
  - Date 1900 for streams which started during the XX century, but before the Second World War.
  - Date 1800 for streams which started before 1900.

  Remarks should be added in any case.

— *End year*. End year of the instrument when it ended within the reference period 2000-2014, not applicable otherwise.
— *Funding stream*. The funding stream providing the resource for that instrument. Multiple funding streams are possible.
— *The RFO/UPROs managing the instrument* (see section 7). Multiple managing organizations are allowed.
— *The instrument website,* i.e. the website where the instrument is described (for example programme website).

6.4.2 Characteristics of the funding instrument and their allocation methods

These variables aim at providing information on how funding within instruments is allocated to performers dealing with following dimensions: the composition of the decision-making committee, the way the money is attributed, the main allocation criteria, etc.

a) General characterization of the instrument. This block of variables includes a number of general classification of the instrument.

— *Project or institutional.* Whether the instrument can be characterized as project funding or institutional funding (binary variable; 0=institutional; 1=project).

  To distinguish between project and institutional, following criteria should be considered:

  - Whether funding is recurrent or is limited in time.
  - The organizational level to which funding is allocated (the whole organization vs. research units or individuals).
  - Whether funding is more or less a right or it is intended to be selective (with most participating entities being excluded.

  Particularly, instruments which allocate funds at the level of the whole organization should be classified as project only if funding clearly temporary and selective, like in the case of the German excellence initiative.

— *Exchange or transfer.* Whether the instrument provides exchange funds (where a service delivery is required) or is a transfer without compensation (like general funding to universities), following the definition introduced in the 2015 edition of the Frascati manual. 1 = exchange, 0 = transfer.

— *Cooperative instrument for academic-private cooperation*. This is a binary variable characterizing whether the instrument is specifically devoted to public-private cooperation. 1 = public/private cooperation. The definition should be handled in a restrictive way to identify these instruments whose main goal is to foster cooperation, which is enforced through specific rules (like having an academic and industrial partner).
— *Type of transfer*. This is distinguished between the four following categories:
  - *Block transfer* for the normal operation of the organization (mostly coinciding with institutional funding).
  - *Project*, i.e. funding for a specific research activity limited in time and scope.
  - *Personal grant*, i.e. funding provided to individuals for their own career and development of human resources.
  - *Network*, i.e. funding for cooperative research between different organizations, usually of larger size than projects.

  Remark: when an instrument is institutional, only block transfer is allowed. When an instrument is project, project, personal grant and network are allowed.

b) Characterization of the procedure and criteria for the allocation of funding. These variables will allow constructing a characterisation of the instruments in terms of the level of output orientation, respectively of competition for funds, in the analytical part of the PREF project.

— *Allocation procedure*. This categorical variable distinguish between basic types of allocation procedures, distinguishing between:
  - *Formula-based allocation*, i.e. the amount of the funding is computed from a formula based on quantitative indicators (code=1).
  - *Negotiated allocation*, i.e. the amount of the funding is negotiated directly between the funder and the beneficiary (code=2).
  - *Historical basis with some adaptation,* i.e. the amount of the funding is basically determined by the allocation for the past year, but with some adaptation depending on other criteria (code=3).
  - *Competitive bid*, i.e. the decision to provide funds and the amount is based on the selection between competitive offers (code=4).

  Remark: for project instruments, only competitive bid and negotiated allocation are allowed, for institutional instruments only formula-based, negotiated and historical.

  The category mixed should be use when and only when the instrument is so heterogeneous in terms of the allocation procedure that no dominant procedure can be identified.

— *Composition of the decision-making body*. This variable characterises the members of the decision-making body in terms of the following alternatives:
  - Academic, i.e. composed mostly by university professors and/or other public-sector researchers (code=1).
  - Experts, i.e. composed mostly by experts from policy, society and economy (code=2).
  - Policy and administration, where the decision is taken by public administrators and/or at the political level (code=3).
  - Mixed (code=4). This code should be used only when the committee cannot be characterized clea
  - No committee, in case decision is based on some automatism (for example formula) and the managing organization only has an executive function (code=5).

Details on the composition should be provided in a specific field.

— *Success rate*. When allocation procedure is bid, the average success rate of applications in the year 2014. When all organizations eligible receive funding (for

example in the case of institutional funding), this variable should be set to "a" (not applicable).

— *Main allocation criteria*. The importance of each criterion is evaluated with a scale from 1 to 5 (5 = very important; 4 = important; 3 = moderately important; 2 = of little importance; 1 = unimportant). Following criteria are assessed:
  - Input (for example number of students or personnel's costs).
  - Output (publications, degrees, third-party funds).
  - Academic quality
  - Topicality to instruments subject
  - Potential for economic innovation and public/private cooperation.

  Remark: input and output are not applicable for project funding instruments.

c) *Thematic information.* The aim of these variables is to provide information on the existence of specific research themes and on the span of topics covered. The level of disaggregation will depend on the characteristics of the instruments.

— *Thematic/generic instrument*. This classification distinguishes between four groups of funding-instruments:
  - Instruments devoted to the general advancement of knowledge. These broadly correspond to the instruments for the General advancement of knowledge (NABS13), without an explicit topic in the NABS classification.
  - General University Funds (GUF; NABS12). This is the R&D component of institutional funds attributed to higher education institutions (FM2015). In most cases, these funds are attributed together with funds for educational activities and the research component has to be determined ex-post.
  - Policy-oriented instruments Specific topics might vary within the same instrument. A precise identification of NABS domains is not requested, since at this level of disaggregation it is expected that most instrument would cover multiple domains. These broadly correspond to the NABS domains NABS1-5. NABS 7-11 and NABS14.
  - Instruments oriented towards economic innovation and the creation of market value. These broadly corresponds to NABS06 category (industrial production).

  The category mixed should be used only when the instrument is so heterogeneous that a dominant orientation cannot be found. Importantly, this classification essentially refers to the policy intention, not to the actual type of research funding.

— *Societal Grand Challenges (SGCs) relevance*. This variable identifies the level of relevance of societal grand challenges for the instrument considered. The following scale is adopted:

  2 = central, the instrument is purposefully designed around (some) SGCs. This is signaled usually by the fact that SGCs (or a national similar concept) are explicitly mentioned in the instrument's mission and goals and that most programs' research topics refer to them.

  1=relevant, the instrument definition and mission might cover also (some) SGCs, but it is usually broader. For example, a program on technology might refer to the need of promoting efficient energy technology as one of its priority subdomains, but together with other technological domains.

  0 = not relevant, implying that SGCs are not part of the instrument's definition (while some research linked with SGCs might be nevertheless funded). For example, a research council might also support within its investigator driven instrument some SGCs-relevant research, but this is not explicitly part of the program goal and selection criteria.

  The category "not applicable" should be used only when the instrument is too composite to set a score. For example, generally university funds (with no string attached) will be in most cases classified as "not relevant".

A precise identification of SGCs concerned is not requested, since at this level of disaggregation it is expected that most instrument would cover multiple domains and SGCs.

— *Key Enabling Technologies (KETs)* relevance. This variable identifies the level of relevance of key enabling technologies for the instrument considered. The following scale is adopted:

  2 = central, the instrument is purposefully designed around (some) KETs. This is signaled usually by the fact that KETs (or a national similar concept) are explicitly mentioned in the instrument's mission and goals and that most programs' research topics refer to them.

  1=relevant, the instrument definition and mission might cover also (some) KETs, but it is usually broader. For example, a program on technology might refer to the need of promoting efficient energy technology as one of its priority subdomains, but together with other technological domains.

  0 = not relevant, implying that KETs are not part of the instrument's definition (while some research linked with KETs might be nevertheless funded). For example, a research council might also support within its investigator driven instrument some KETs-relevant research, but this is not explicitly part of the program goal and selection criteria.

  The category "not applicable" should be used only when the instrument is too composite to set a score. For example, generally university funds (with no string attached) will be in most cases classified as "not relevant".

  A precise identification of KETs concerned is not requested, since at this level of disaggregation it is expected that most instrument would cover multiple domains and KETs.

d) Information on beneficiaries

— Level of openness. Whether the instrument foresees the funding of research performed by organizations not located in the country. Categories: 2 = yes, in general, 1 = with limitations, 0 = no. Complementary funding for travel is not considered.
— Eligible sectors. The Frascati manual sectors which are in principle eligible to receive funding from the instrument. The considered Frascati manual sectors are Higher Education, Government and Business Enterprise (one dummy variable by each sector). The variable should be set to 1 when a substantial portion of the sector is eligible to participate. When required, details should be added in the remarks.
— Whether the instrument can provide funding also to for-profit performing organizations (independently from the legal status). This is a dummy variable (1=yes, 0=no).

e) *Short description*. A short textual description of the funding instrument, its main goals and design (5 lines maximum).

This description should explicitly cover relevant changes in the instruments characteristics during the period 2000-2014 in respect to the descriptors provided for the year 2014.

6.4.3 Funding instrument amount

For each funding instrument, the funding amount is recorded for each individual year in the period 2000-2012. As a preference, the amount should correspond to the effective transfer to performers, as for example recorded in accounts of RFOs. Funding decisions are however acceptable when other data are not available. A specific variable for accounting method is introduced.

The amount should be recorded during the whole period of existence of the instrument, even if for some years data are missing. However, when no data for all streams in a country are available in a given year, the corresponding lines will not be included in the database.

The corresponding table includes the following variables.

Reference year to which the amount refers.

Beneficiary country. The country where beneficiaries receiving the amount are located. In case of international instruments awarding funds to multiple countries (EU-FPs), separate rows should be introduced for each country (see below section 6.5). For national instruments, a single country should be introduced.

Total amount awarded in thousands currency units (rounded to the unit). *For institutional funding to HEIs, this amount refers only to the GUF component.*

Currency. The currency used for the amount in that year.

The amount of the funding instrument transferred to performers by Frascati sector (Government, higher education, private non profit, business enterprise; abroad; see 3.3):

- Amount for the higher education sector.
- Amount for the government sector.
- Amount for private non-profit.
- *Amount for the public sector,* defined as the sum of higher education, government and private non profit. This variable is relevant when a more fine-grained breakdown is not available.
- Amount for the business enterprise sector.
- Amount for abroad.

Amount by field of R&D (FORD). The amount devoted to each Field of R&D at the first digit level (**Table 2**). In most cases, it is expected that this information is published by the funding agencies themselves based on project contents or beneficiaries, particularly for science-oriented instruments.

It is generally expected that this breakdown can be reconstructed from agencies' classification of projects for project funding instruments. This breakdown might be more problematic for institutional funding; therefore, the collected data will be integrated with R&D statistics data in order to provide indicators of the breakdown of project and institutional funding by FORD.

Accounting method. A categorical variable which can take following values: *decision* if the amount refers to the funding decision, transfer if the amount refers to the actual transfer to the performing organizations; *other* in other cases, to be explained in the remarks field.

Data source. The source from which the data were retrieved.

Remarks. A field text for more detailed information.

The following two variables measure the extent of performance-based allocation for each instrument and year; explanations and details on the methodology are provided in chapter 8 of this handbook. Scores are set to "not applicable" for instruments classified as project funding.

FI_mode = 1 when the allocation mode is formula, 0.5 when the allocation mode is negotiated and 0 when the allocation mode is historical or grant. Intermediate scores are possible.

FI_criteria = 1 when the allocation criteria are based on research performance, like third-party funds, bibliometrics or outcome of peer evaluation, 0 when the criteria are input based or based on educational activities. These criteria are assessed by national experts

based on the information provided under the allocation criteria. Intermediate scores are possible.

6.5 International funding streams and instruments

PREF includes two types of information on international funding flows:

a) Funding from national budgets to international research funding organizations and international performers. These are covered by specific funding streams (see section 6.3) distinguishing between:

- Contribution to EU-FPs when this is part of the national research budget – i.e. for associated countries. This is distinct in order to allow for cross-country comparisons, since in the case of EU member states this contribution is not part of GBARD.
- Contribution to the European Space Agency.
- Contribution to other international RFOs.
- Contribution to international performers like CERN.

These streams are collected at national level and are uniquely identified by the funding streams categories CAT04 (transfer to international performers) and CAT05 (transfer to international RFOs; see **Table 11**). Importantly, this does not fully correspond to the total national funding transferred abroad, since some national funding streams might include an international component (for example an RFO supporting performers abroad). This emphasizes that funding stream deal with primary recipients of budgetary contributions (for example RFOs) and not with the final destination of funds (which is analysed at the level of funding instruments).

Streams in categories CAT04 and CAT05 have no corresponding instruments at national level, since this money is transferred to RFOs and performers abroad. Streams in CAT05 should have the respective international agencies (for example ESA and the EU) as managing RFOs.

b) Funding from international research agencies to national performers. For these instruments, the same descriptors as for national descriptors are provided. Following instruments are covered:

- EU FP
- EU structural funds
- ESA as the most representative funding of other European funding instruments

The funding amount table for these instruments includes separate rows for each receiving fund with the corresponding amount. This allows computing indicators on incoming funding and its characteristics for each individual country (see section 9).

For each of these instruments the same variables and measures of funding amounts will be provided as for national instruments (see section 6.4 above). Additionally, the following breakdown of funding amounts will be provided.

Amount by NABS. The amount devoted to each NABS category by year.

Breakdowns by FORD and NABS for European funding instruments will be contingent to the availability of detailed statistics by sub-programme, particularly for FPs.

These streams are collected at central level by the PREF team from international data sources and are therefore not included in national data collection.

6.6 R&D expenditures

R&D statistics provide data on research activities at the level of performers, which fall under the definition of research and development provided by the Frascati manual (FM2015). They are routinely measured through surveys of performers, as well as, in the case of higher education institutions, by breaking down the time of academic personnel between research and teaching (OECD 2000),

PREF will include these data since they are relevant for comparing aggregates and for classification purposes, as some of the classifications employed in PREF – FORD, NACE and Type of R&D – are routinely adopted at this level.

More specifically, three types of data will be included (see sections 6.6.1 to 6.6.3 below).

They are stored in three separate table in the PREF database. They pre-filled in the data collection by using international databases (OECD/EUROSTAT).

Chapter 9 of this handbook explains how these data are combined with other information in order to produce synthetic indicators.

6.6.1 GERD by sector

Information on R&D expenditures by sector and source of funds is central in PREF for matching purposes, since R&D breakdowns by classification are not available by source of funds, as this is information is not collected through the R&D questionnaire. However, if it can be assumed that R&D in the government and higher education sector is mostly funded by the government, the corresponding breakdowns could be used for computing classification of government funding.

Therefore, data are provided both on R&D expenditures by sector and on the corresponding amount funded by the government.

This table include following variables.

Country. The country to which the R&D expenditures value refers.

Year. The calendar year to which the R& expenditures value refers.

Sector. The performance sector to which the value refers, following the FM classification.

Amount. Total R&D expenditures for the concerned sector in the considered country and year, in national thousands currency at current price.

Amount funded by the government. Total R&D expenditures for the concerned sector funded by the government in the considered country and year, in national thousands currency at current price.

Currency. The ISO-code of the currency.

Flag. Flag for specific data issues, based on the EUROSTAT categorization (see section 4.2).

Remarks. A textual field for explaining flags and other comments.

Data will be derived from published statistics from OECD/EUROSTAT.

6.6.2 R&D expenditures by sector of performance and by Field of R&D

Information on R&D expenditures by sector and field of R&D is relevant in PREF for matching purposes, as it allows cross-checking information on funding by FORD derived from the classification of funding instruments.

This table include following variables.

Country. The country to which the value refers.

Year. The calendar year to which the value refers.

Sector. The performance sector to which the value refers, following the FM classification.

Amount by FORD. Total R&D expenditures for the concerned sector and by FORD (level-1; one variable by FORD) in the considered country and year, in national currency at current price.

Currency. The ISO-code of the currency.

Flag. Flag for specific data issues, based on the EUROSTAT categorization (see section 4.2).

Remarks. A textual field for explaining flags and other comments.

Data will be derived from published statistics from OECD/EUROSTAT.

6.6.3 R&D expenditures by sector of performance and by Type of R&D

Information on R&D expenditures by sector and Type of R&D is relevant in PREF for matching purposes, as it allows cross-checking information on funding by FORD derived from the classification of funding instruments.

This table include following variables.

Country. The country to which the value refers.

Year. The calendar year to which the value refers.

Sector. The performance sector to which the value refers, following the FM classification.

Amount by Type of R&D. Total R&D expenditures for the concerned sector and by Type of R&D (1 variable by type) in the considered country and year, in national currency at current price.

Currency. The ISO-code of the currency.

Flag. Flag for specific data issues, based on the EUROSTAT categorization (see section 4.2).

Remarks. A textual field for explaining flags and other comments.

Data will be derived from published statistics from OECD/EUROSTAT.

6.6.4 Business R&D funded by the government by economic activity

PREF will include available R&D statistics concerning Business Enterprise R&D Expenditures (BERD) funded by the government sector, as these are used to compute the specific breakdown of public funding to the business enterprise sector by economic activity (see section 3.1.3).

This table includes following variables.

Country. The country to which the BERD funded by the government value refers.

Year. The calendar year to which the BERD funded by the government value refers.

Amount. Total BERD in the considered country and year, in national currency at current price.

BERD funded by government. BERD funded by the government in the considered country and year, in national currency at current price.

Currency. The ISO-code of the currency.

Amount by NACE. The amount of BERD in the considered year devoted to a specific economic sector domain by using the NACE classification (see 3.1.3; one variable for each NACE code).

Flag. Flag for specific data issues, based on the EUROSTAT categorization (see section 4.2).

Remarks. A textual field for explaining flags and other comments.

Data will be derived from published statistics from OECD/EUROSTAT.

7 Managing organizations

PREF will cover two types of organizations having a central function in public research funding: first, Research Funding Organizations, i.e. organizations whose task is to distribute public research funding (*Research Funding Organizations; RFO*) and, second, vertically integrated organizations (*Umbrella Public Research Organizations; UPRO*), vertically integrated organizations which manage and distribute funds to a large number of internal units.

Characterizing these organization is of high importance to understand the dynamics of public funding, as their mission, structure and way of working is likely to deeply influence how funds are attributed. The characterization of managing organizations is therefore largely complementary to the one of funding instruments (to whom they are linked).

For both types of organizations, this section provides a basic definition, criteria for identification and delimitation, as well a list of descriptors and variables to be collected.

For sake of simplicity, we consider RFOs and UPROs as distinct and exclusive types of organizations; RFOs mostly provide funding to external performers, while UPROS mostly to internal research groups. The exceptional presence of internal laboratories (for RFOs) and of funding schemes open to external performers (for UPROs) will be handled through a specific descriptor.

7.1 Research funding organizations

Research Funding Organizations (RFOs) are organizations whose mission includes the distribution of public research funding through regular and structured instruments.

Typical examples of RFOs are national research council distributing funding for academic research and innovation agencies.

The key criterion to identify RFOs is their mission, i.e. the fact that the State formally endorsed them to distribution public research funding; this criterion excludes bodies in the public administration which support occasionally research to respond to their own specific mission (for example for getting support and advice for policies). On the contrary, sector ministries whose mission includes the support of R&D in their specific area (for example energy technology for an energy ministry) should be included. The perimeter for public funding is defined by GBOARD, therefore agencies mostly providing support to innovation or economic activities are excluded.

The legal status and position within the public administration are not determinant criteria. Legally private organizations are included when they distribute public funding and they have an official mission from the State (for example as stipulated in the research act). Also, some RFOs might not have their own legal status, but be part of the public administration; in that case, the units should be identified where the selection and decision are situated, irrespectively of the fact that the final decision is taken at the higher level (for example ministry).

For practical reasons, only RFOs managing substantial portions of the GBARD should be included. A threshold of 5% of total GBARD is suggested, but exceptions might apply depending on the political visibility of the RFO and the duration of the managed programmes. This threshold will be reconsidered after the pilot data collection. Information on RFOs excluded and their implications in terms of coverage of research funding will be provided in the country metadata in order to allow for an assessment of the implications of this threshold on coverage.

Ministries managing a large share of national project funding should be singled out as distinct RFOs receiving a separate stream of funding and managing their own instruments.

Remark1: in order to handle cases where disaggregation in not possible, following generic funding agencies are introduced:

— For each country individually, "National government aggregated". This agency is used when no disaggregation by ministry is possible, for example when only the total amount of governmental contracts is available.
— For all countries, an international funding agency "International agencies aggregated", with code RFOINT999 when all contributions to international agencies are in a single stream.

Remark2. International agencies, like ESA, receive a unique code as RFOINTXXXX for all countries in the data collection.

7.1.1 Variables of research funding organizations

PREF will include for each RFO the following variables.

— *RFO identifier*. A code identifying the RFO in the format of RFO-country ISO code-XXX (for example RFOCH001).
— *Country*. For national and regional agencies only, the country where the RFOs is established.
— *Acronym*. The official acronym of the RFO, if available.
— *Name of the RFO in official language*. The full name in the language of establishment. For international RFOs, the official English name should be used.
— *Name of the RFO in English language*. Full name of the RFO in English, e.g. the one adopted in policy documents or on the RFO website (if available).
— *Authority of establishment.* This variable characterizes the authority establishing the RFO and allows particularly distinguishing between:
  - National RFO established by a single country.
  - International RFOs, established by the European Union or international treaties.
  - Regional RFOs established by a regional authority.

  The authority of establishment does not necessarily correspond to the geographical space where performers can be funded.

— *RFO website.* The official website of the RFO, if available insert the link to the English section. This should be inserted to quickly retrieve additional information for the purposes of analysis.
— *RFO classification*. PREF will adopt the two-level classification of research funding organizations developed within the JOREP project. The classification of funding agencies is two-level, the first one refers to the position with respect to the State, while the second one specifies more precisely the domain of activity.

Table 12. Classification of research funding organizations

Level 1	Description	Level 2	Code
Governmental RFO	RFOs which are functionally part of the public administration, meaning for example division of ministries, ministerial committees, etc. Typical examples at the European level are DG research (managing the European FP), at national level research ministries.	National government (aggregated)	RFO0100
		National research/science ministry.	RFO0101
		National sector ministry (e.g. energy).	RFO0102
		Regional government (non-divided in subcategories).	RFO0103
Independent RFO	RFOs which have functionally a large degree of independence from the	Innovation agency, whose mission and funding are oriented towards innovation and creation of economic	RFO0201

	State in managing their activities and selecting the projects to be funded; in some cases this might be realized by a specific legal status granting autonomy. A key criterion to distinguish the two types of agencies is if the State (e.g. ministry) retains the right to take the final decision on granting money to specific projects.	value, but fund substantial amounts of R&D.	
		Research council, whose funding is mainly oriented towards basic research and having strong connection to the academic community (for example in the composition of decision-making committee).	RFO0202
		Sectoral RFO – related to specific topic (energy, environment, etc.), e.g. sectoral regulatory agencies or sectoral funding agencies.	RF00203
		Higher Education Agency, whose main function is to manage either the whole higher education sector or significant part of it and distributing substantial portions of HE institutional funding.	RFO0207
International RFOs		Intergovernmental RFO created by international treaty (ESA).	RFO0204
		EU-implementation RFO based on EU law (e.g. the organization managing AAL).	RFO0205
		International non-governmental association (European Science Foundation).	RFO0206
		Aggregated international agency	RFO0210
International RFOs	Organizations whose main mission is to perform R&D activities, even if might host some funding agencies activities.	Public research organizations (PRO) assuming also a function in funding.	RFO0301
Performers	Organizations whose main mission is to perform R&D activities, even if might host some funding agencies activities.	Public research organizations (PRO) assuming also a function in funding.	RFO0301
		Private research organizations.	RFO0302

— *Mission*. This is a set of scales from 1 to 5 measuring the importance of different goals in the RFO mission. Each goal is evaluated with a scale from 1 to 5 (5 = very important; 4 = important; 3 = moderately important; 2 = of little importance; 1 = unimportant). Following goals are assessed:

- Scientific excellence.
- Promotion of research careers.
- Support to research addressing policy-relevant problems.
- Economic innovation.
- Management of Research Infrastructures.
- Institutional funding to higher education institutions and public-sector research.
- Support to international research cooperation.

In case of bodies with other functions (for example policy functions of ministries), these descriptors refer solely to the RFO specific activities.

— *RFO description*. A short description of the RFOs, its main functions (maximum 10 lines).
— *RFO position in respect to the State*. A short description of the RFO legal basis and position in respect to the State (dependency relationships, level of autonomy, etc.).
— *RFO main organizational bodies and their composition*. A short description of the main bodies and organisational structure of the RFO, including information on the composition of committees (academic, policy, innovation, civil servants).
— *Foundation year*. The year in which the RFO can be traced back originally (for example when it was originally created).
— *Current status year*. The year when the RFO got the current status, functions, name.
— *RFO history*. A short description of main changes over time in the RFO mission, functions and structure (maximum 10 lines).
— *Performer role*. This variable informs whether the RFO has also a performer role directly managing research laboratories and research facilities. A binary variable is provided (yes/no), plus a remark section for details.

7.2 Umbrella public research organizations

Umbrella Public Research Organizations (UPRO) are special types of public research organizations, which are characterized as follows:

— The presence of a mission that explicitly recognize to the organization the task to distribute funding and to perform research. Beside the mission, UPROs can be also entitled by the State or by the local government to act as research funding organization for pursuing specific research purposes or for managing specific funding instruments. Funding to performers outside the UPRO perimeter is however not required.
— A large size, with research units –that can be labeled laboratories, institutes, units, centres, sections, etc., geographically distributed in the national territory.
— These organization should manage a substantial share of national-level research effort in a specific domain (or for a specific type of research).
— An organizational integration aimed at: i) coordinating the research units' activities, ii) managing the researchers' career, iii) providing resources, facilities and identity to the research units.

Remark: the definition of UPRO is purposefully restricted to large national research organizations, which account for a sizeable share of the national public R&D expenditures. It not sufficient that a research organization is located in different sites to be considered as a UPRO.

UPROs can be characterized by different levels of organizational integration; in some cases (CNRS in France, CNR in Italy, MPG in Germany) we find strong headquarters with centralized rules and coordination power, steering units that maintain in any case a substantial autonomy as to: a) the research agenda setting, and b) designing strategies for third party funding attraction. In other cases, a light integration of independent research institutes can be envisaged (e.g. Helmholtz Association in Germany). Purely holding structures, with no internal structure, should not be considered as UPROs.

As in the case of RFOs, the legal status and position within the public administration are not determinant criteria. Legally private organizations are included when they distribute public funding and they have an official mission from the state (for example as stipulated in the research act).

7.2.1 Variables of Umbrella Public Funding Organizations

PREF will include for each UPRO the following variables.

— *UPRO identifier*. A code identifying the UPRO in the format of UPRO-country ISO code-XXX (for example UPROCH001).

— *Country*. For national and regional agencies only, the country where the umbrella organization is established.
— *Acronym*. The official acronym of the umbrella organization, if available.
— *Name of the UPRO in official language*. The full name in the language of establishment. For international agencies, the official English name should be used.
— *Name of the UPRO in English language*. Full name of the umbrella organization in English, e.g. the one adopted in policy documents or on the organization website (if available).
— *UPRO website.* The official website of the organization, if available insert the link to the English section. This should be inserted to quickly retrieve additional information for the purposes of analysis.
— *UPRO classification*. PREF will adopt a two-level classification of umbrella public research organizations. The first one refers to the position with respect to the State, while the second one specifies more precisely the domain of activity.

Table 13. Classification of umbrella public funding organizations

Level 1	**Description**	**Level 2**	**Code**
Governmental UPRO	UPROs with functional linkages with the public administration, meaning that they perform the activities under an instrumental relationship with the Government. Typical examples at the European level are the EPIC in France and the Instrumental Research Organizations in Italy.	National research/science ministry.	UPRO0101
		National sector ministry (e.g. energy).	UPRO0102
Independent UPRO	UPROs which have functionally a large degree of independence from the State in designing and managing their activities and selecting the projects to be funded; this is generally realized by a specific legal status granting autonomy. A key criterion to distinguish the two types of UPROs is if the State (e.g. ministry) retains the right to take the final decision on granting money to specific projects.	Innovation UPROs, whose mission and funding are oriented towards innovation and creation of economic value, but fund substantial amounts of R&D (e.g. Fraunhofer in Germany)	UPRO0201
		Generalistic National Research Centres, covering all the research fields, whose funding is mainly oriented towards basic or applied research and having strong connection to the academic community (for example in the composition of decision-making committee or the mixed composition of the labs).	UPRO0202
		Sectoral UPRO – related to specific topic (energy, environment, etc.) or field of science (e.g. Physics, Health, Agriculture, etc.), e.g. INRA in France or INFN in Italy.	UPRO0203

— *Mission*. This is a set of scales from 1 to 5 measuring the importance of different goals in the UPRO mission when it acts as funding body. Each goal is evaluated with a scale from 1 to 5 (5 = very important; 4 = important; 3 = moderately important; 2 = of little importance; 1 = unimportant). Following goals are assessed:

- Scientific excellence.
- Promotion of research careers.
- Support to research addressing policy-relevant problems.
- Economic innovation.
- Management of Research Infrastructures.
- Institutional funding to higher education institutions and public-sector research.
- Support to international research cooperation.

Since UPROs perform other functions (research functions and sometime policy functions of ministries), these descriptors refer solely to the UPRO funding activities.

— *UPRO description*. A short description of the UPROs, its main functions (maximum 10 lines).
— *UPRO position in respect to the State*. A short description of the UPRO legal basis and position in respect to the State (dependency relationships, level of autonomy, etc.).
— *UPRO organizational integration*. Define the level of the UPRO organizational integration as *high* (in case of centralized headquarter which retain important decision making power (e.g on researchers career), *low* (in case of a decentralized organization where there is not an headquarter retaining power), *medium* (where there is some kind of centralization, but the labs might maintain a full autonomy under specific circumstances).
— *UPRO main organizational bodies and their composition*. A short description (max 10 lines) of the main governmental bodies and organisational structure of the UPRO, including information on the composition of committees (academic, policy, innovation, civil servants) and the number of labs.
— *Foundation year*. The year in which the UPRO can be traced back originally (for example when it was originally created).
— *Current status year*. The year when the UPRO got the current status, functions, name.
— *UPRO history*. A short description of main changes over time in the UPRO funding mission, functions and structure (maximum 10 lines).

8 Measuring performance orientation of public funding

The measure of the extent to which allocation of public funding is based on the performance of the receiving organization is particularly important for the evaluation of national research policies; it is generally believed that attributing money based on performance improves the overall output of the national research system, but empirical evidence is very scarce, also because of the lack of reliable data ({{3228 Hicks, Diana 2012; 1373 Nieminen,Mika 2010}}).

PREF provides for a systematic approach to a quantitative measure of performance orientation, which is explained in this chapter. The corresponding variables are integrated in the two tables on funding streams and funding instruments amounts.

8.1 Basic definitions

We define *performance-based allocation* as the extent to which the allocation of public funds is linked to the level of performance of the concerned organization. This indicator is a composite scale based on the characterization of funding instruments and the amount of funding devoted to each stream. PREF distinguishes in this respect between

- *Ex-ante performance allocation*, i.e. the extent to which allocation of funding is based on expectation on future research output. The main case of ex-ante performance allocation is project funding, based on the evaluation of grant proposals, but also some institutional funding might be allocated with the same allocation mode.
- *Ex-post performance allocation* is the extent to which funding is allocated based on the past performance of the organization.

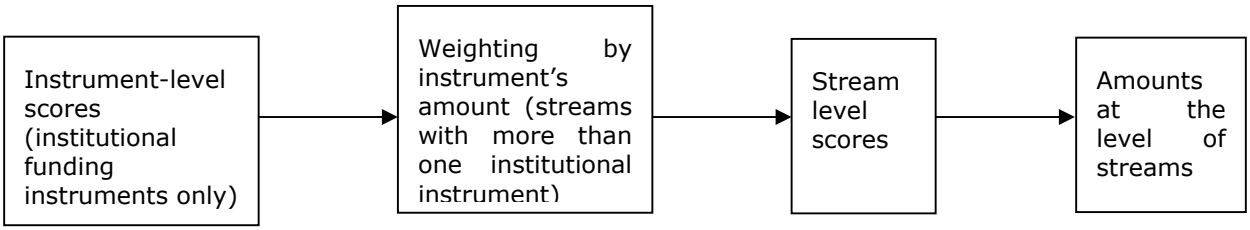
Two variables are provided for each funding stream and year, i.e. the amount allocated through ex-ante, respectively ex-post performance allocation. They can be further aggregated to provide indicators of the overall performance orientation of national systems (see below section 8.3).

8.2 Computation of the scores

The computation of the amount for ex-ante and ex-post performance allocation is based on the funding amounts at the stream level, but on descriptive information at the instrument level. This choice recognizes that the quality and completeness of financial data in the PREF database is much better for streams, but descriptive information is available at the instruments' level.

The procedure to compute the scores is represented in 4.

Figure 4. Procedure for the computation of scores



a) First, the following scores are computed for each instrument and year, *only for instruments classified as institutional funding*. Scores are set to "not applicable" for instruments classified as project funding.

FI_mode = 1 when the allocation mode is formula, 0.5 when the allocation mode is negotiated and 0 when the allocation mode is historical or grant. Intermediate scores are possible.

FI_criteria = 1 when the allocation criteria are based on research performance, like third-party funds, bibliometrics or outcome of peer evaluation, 0 when the criteria are input based or based on educational activities. These criteria are assessed by national experts based on the information provided under the allocation criteria. Intermediate scores are possible.

These two variables are the only ones collected from experts, all other variables are constructed by combining them with information already available in the PREF database.

These rules will serve as a benchmark for expert-based attribution; experts might slightly depart based on their substantive knowledge of the national system (for example, a score slightly above or below 0.5 might be assigned depending on an assessment of the performance orientation of negotiated allocation).

Change over time. In the case allocation mechanism for one instrument change radically, it is suggested to provide two distinct entries for each period, with the corresponding descriptors. More gradual changes (like some increase in the importance of performance indicators in the basket of indicators used to allocate funds to universities) can be recorded by experts by slightly changing the score per year.

b) In the frequent case where there is only one *institutional* funding instrument associated to one stream, indicators at the stream level will be computed directly as follows from these variables.

Competitive bid (FS level) = 1 if at the instrument level allocation mode = competitive bid, 0 otherwise.

Performance allocation (FS level) = FI_mode * FI_criteria.

When more than one institutional instrument is associated to one stream, the corresponding scores will be computed as the average of the instruments' scores *weighted by their respective amount of funding for that year*.

Both variables are set to "not applicable" for purely project funding streams.

Remark: in case a stream has associated project and institutional instruments, only the latter will be considered in the construction of the scores.

International streams do not have corresponding instruments: funding to international research performers (CAT04) are attributed historical allocation, since usually allocation is based on long-term international agreements. Funding to international research agencies (CAT05) are attributed to project funding by default.

c) Finally, the following two monetary amounts are computed for each stream and year:

Amount ex-ante. The amount of funding attributed through ex-ante performance evaluation. It is computed as follows:

*Amount ex-ante = (amount project) + (amount institutional) * (competitive bid).*

Amount ex-post. The amount of funding attributed through ex-post performance evaluation. It is s computed as follows:

*Amount ex-post = (amount institutional) * (performance allocation).*

8.3 Computation of indicators

Based on these scores, indicators for (ex-ante performance) and (ex-post performance) will be computed for each stream and year.

Aggregated indicators will be then computed based on FS amounts for:

- The whole GBARD.
- Domestic funding only (excluding CAT04 and CAT05).

— Specific funding stream categories, particularly institutional funding to higher education (CAT02).

The three following indicators are computed. All of them range from 0 to 1.

Ex-ante performance allocation. The share of funding for the considered perimeter which is allocated through ex-ante performance.

Ex-post performance allocation. The share of funding for the considered perimeter which is allocated through ex-post performance.

Performance allocation = ex-ante performance allocation + ex-post performance allocation.

Table 14. Summary table of the computation of indicators by funding instrument characteristics

**Scores can be slightly adapted by expert knowledge.*

Project/ institutional	**Allocation mode**	**Allocation criteria**	**FI_mode**	**FI_Criteria**	**FS competitive_bid**	**FS performance_allocation**
Project	Indifferent	Indifferent	Not applicable	Not applicable	Not applicable	Not applicable
Institutional	Competitive bid	Indifferent	1	Not applicable	1	Not applicable
Institutional	Historical	Indifferent	0	0	0	0
Institutional	Negotiated	Input or education	0.5*	0*	0	0*
Institutional	Negotiated	Research	0.5*	1*	0	0.5*
Institutional	Formula	Input or education	1*	0*	0	0*
Institutional	Formula	Research	1*	1*	0	1*

9 Country level information

Complementarily from the information in funding instruments and streams, PREF will collect a limited amount of information on national policies and funding priorities. This information will allow completing quantitative data for the development and analysis of country profiles (see section 10.2) and will be combined with other data in order to provide an analysis of the importance of Societal Grand Challenges and Key Enabling Technologies within national policy systems.

This section will be developed and completed in parallel with the definition of contents of country profiles.

9.1 Key Enabling Technologies and Societal Grand Challenges

To provide additional information on KETs and SGCs, following descriptors are collected.

General assessment of the importance of KETs/SGCs in the national policy debate. This an overall short assessment of the importance of SGCs and KETs in the national policy debate.

Importance of individual SGCs/KETs. A more specific assessment in three levels: high = top priority where specific measures (like ad hoc funding programmes) have been recently decided; medium = important and frequently mentioned in national policy documents; Low = not visible or visible only sporadically.

The remarks section allows to provide more information, particularly for highly relevant topics.

Specific funding instruments for that topic. A yes/no variables identifying whether there are specific funding instrument devoted to that topic (yes/no). These instruments might not be included in the national list of funding instruments because of their size. The remarks section allows to provide details on the instruments, as well as on the main regular funding instruments supporting that topic.

10 Indicators

Besides the collection of data and descriptors of national funding systems, a major goal of PREF is to provide a set of indicators which allow characterizing and systematically comparing national systems. These indicators will be mostly computed from the data collected and stored in the PREF database and then stored in a separate table in the database. This section provides details on how indicators should be calculated and on how specific problems can be addressed.

10.1 Quantitative indicators on public funding

The indicators on public research funding which will be produced from the PREF database. All these indicators can be computed directly from the data collected and integrated in the dataset, even if some estimates might be needed when some information is missing.

Indicators will be computed for all countries included in the data collection; for the non-European countries (China, Japan, Israel, US) and the candidate countries (FYORM, Montenegro, Serbia and Turkey) only a limited number of indicators will be provided.

Aggregated figures will be produced for ERA countries (EU28 + EFTA, FYROM, Montenegro, Serbia, Turkey, Israel) and for EU28. Suitable procedures will be devised in order to deal with the possibility of missing values for some countries when constructing group totals.

In principle, all indicators will be produced for individual years in the period 2000-2012 (depending on the availability of data).

The following sections provide detailed indications on how these indicators are computed for PREF and the respective breakdowns.

10.1.1 Total Global Budgetary Allocation for R&D (GBARD)

Definition

Following the FM2015, total GBARD includes all public allocation, from national and regional government, which are intended to be use for R&D activities.

Coverage

All PREF countries.

Calculation

Total GBARD is directly derived from EUROSTAT R&D statistics. Breakdown by KETs and SGCs computed by PREF as in section 10.1.9).

Breakdowns and their calculation

- Socio-economic objective (NABS). This breakdown will be directly derived from EUROSTAT data.
- KETs/SGCs relevance (see section 10.1.9).

10.1.2 R&D expenditures indicators

Definition

Following the FM2015 definitions, the three following indicators are provided:

- Total R&D expenditures in the government sector (GOVERD)
- Total R&D expenditures in the higher education sector (HERD).
- Total Business Enterprise sector R&D expenditures financed by the government (GOV-BERD)

Coverage

All PREF countries.

Calculation

Directly derived from EUROSTAT R&D statistics.

Breakdowns and their calculation

- GOVERD and HERD by field of R&D (FORD). This breakdown will be directly derived from EUROSTAT data.
- GOV-BERD by economic sector (NACE). This breakdown will be directly derived from EUROSTAT data.

10.1.3 Total public appropriations as project funds

Definition

Amount of GBARD allocated as project funds. This amount will also include exchange grants consistently with FM2015 definitions; however, separate subfigures for exchange grants will be provided (see section 10.1.5).

Coverage

All PREF countries. For the non-European countries (China, Japan, Israel, US) and the candidate countries (FYORM, Montenegro, Serbia and Turkey) no breakdowns will be provided.

Calculation

The calculation of total amounts and breakdown will be based on the amount of project funding by funding streams (see section 6.3.3). Conforming to EUROSTAT practices, this amount includes also transfers to international funding agencies, like ESA and contribution to EU-FPs for associated countries.

Complementarily, for the total amount, EUROSTAT data could be used or from the OECD/NESTI pilot on project funding.

Breakdowns

Following breakdowns will be provided:

- Project funding divided by socio-economic objective (NABS). It is computed directly from the breakdown by NABS of each funding stream.
- Project funding divided by KETs/SGCs relevance (see section 10.1.9).
- Project funding divided by field of execution (FORD). It is computed directly from the breakdown of project funding by FORD for each funding instrument, when available (see section 6.4.3).

Breakdown by managing organization: this breakdown will be computed directly using the classification of managing organizations and distinguishing between following categories (see section 7.1):

- Amount managed by UPROs.
- Amount managed by national research ministry (RFO0101).
- Amount managed by other ministries (RFO0102).
- Amount managed by regional government (RFO0103).
- Amount managed by innovation agencies (RFO0201).
- Amount by managed by research councils (RFO0202)
- Amount managed by sector RFOs (RFO0203)
- Amount managed by international agencies (RFO0204-6).
- Amount managed by Higher Education Agencies (RFO0207).

10.1.4 Total public appropriations as institutional funds

Definition

Amount of GBARD allocated as institutional funds.

Calculation

The calculation of total amounts and breakdown will be based on the amount of institutional funding by funding streams (see section 6.3.3). Crosschecking with funding instruments might be needed when a FS includes a share of both institutional and project.

Complementarily, for the total amount, EUROSTAT data could be used or from the OECD/NESTI pilot on project funding.

This amount includes also transfer to international research performers (funding stream category CAT04).

Coverage

All PREF countries. For the non-European countries (China, Japan, Israel, US) and the candidate countries (FYORM, Montenegro, Serbia and Turkey) no breakdowns will be provided.

Breakdowns

Following breakdowns will be provided:

- Institutional funding divided by socio-economic objective (NABS). It is computed directly from the breakdown by NABS of each funding stream.
- Institutional funding divided by KETs/SGCs relevance (see section 10.1.9).
- Breakdown by managing organization: this breakdown will be computed directly using the classification of managing organizations and distinguishing between:
    - Amount managed by UPROs.
    - Amount managed by RFOs, further divided by types of RFO based on the classification provided in section 10.1.3).
- Institutional funding allocated competitively. This amount will be computed by multiplying the amount of institutional funds for each stream by a share of competitive allocation.

  The latter is computed from the funding instruments associated to each stream and providing institutional funding as follows:

    - Group 1. Competitive: when the allocation procedure is "formula" or "competitive bid" (see section 6.3.2).
    - Group 2. Non-competitive: when the allocation procedure is "negotiated" and "historical".

  The share of competition for the corresponding FS is then computed as the sum of amounts for (institutional) funding instruments associated to that stream belonging to group 1 divided by the total amounts for (institutional) funding instruments associated to that stream.

  This share is then multiplied by the amount of institutional funding for the considered stream.

- Institutional funding divided by field of execution (FORD). When data cannot be computed directly from the breakdown of institutional funding by FORD for each funding instrument (see section 6.4.3), the following approximation is suggested, based on R&D statistics.

$$\%\,Institutional\ (FORD = x) = \frac{R\&D\ expenditures\ (FORD = x) - Project\ (FORD = x)}{R\&D\ expenditures\ (FORD = x)}$$

Since the breakdown of R&D expenditures by FORD is usually available only for the public sector (government and higher education), this formula is reliable under the condition that the share of public funding to the private sector is not too high.

10.1.5 Exchange grants

Definition

Total amount of public funding (GBARD) allocated as exchange grants.

Coverage

All PREF countries, excluding the non-European countries (China, Japan, Israel, US) and the candidate countries (FYORM, Montenegro, Serbia and Turkey).

Calculation

Sum of all funding instruments classified as exchange grants.

Remark. When data on exchange grants are not available and therefore no such instruments have been listed, this indicator should be put to "m" not to "0".

Breakdowns

- Exchange grants divided by KETs/SGCs relevance (see section 10.1.9).
- Exchange grants divided by FORD, computed directly from the instrument's breakdown.

10.1.6 Total project funding for national performers

Definition

The total amount of project funding transferred to national performers. This differs from the indicator on total public appropriations as project funds for two main reasons: transfers to international funding agencies are not included and incoming funds from European funding instruments are included.

Coverage

All PREF countries, excluding the non-European countries (China, Japan, Israel, US) and the candidate countries (FYORM, Montenegro, Serbia and Turkey).

Calculation

Calculation of this amount should be in principle based on *instruments* and include the funds transferred to national performers for each instrument (therefore excluding funds transferred abroad). Funding from European sources should be included as well.

When data at the instrument level are not available, it is acceptable to use as a proxy the total amount of the corresponding funding stream, assuming that for national instruments the amount transferred abroad is very small.

Breakdowns

- Project funding to national performers divided by KETs/SGCs relevance (see section 10.1.9).
- Project funding to national performers divided by FORD, computed directly from the instrument's breakdown, when available.

10.1.7 Incoming funding from European sources

Definition

This indicator provides for each country and year the amount incoming funding from European funding instruments as defined in section 6.5.

Coverage

All PREF countries, excluding the non-European countries (China, Japan, Israel, US) and the candidate countries (FYORM, Montenegro, Serbia and Turkey).

Calculation

Amount of funding for European instruments (see 6.5).

Breakdowns

- By instruments, distinguishing between EU-FPs, structural funds and ESA.
- Breakdown of amount b fields of R&D (FORD).
- European funding divided by KETs/SGCs relevance (see section 10.1.9).

10.1.8 Cooperative instruments for academic-private cooperation

Definition

This indicator provides for each country and year the amount devoted for instruments providing research funds to foster public-private cooperation (see section 6.4.2).

Coverage

All PREF countries, excluding the non-European countries (China, Japan, Israel, US) and the candidate countries (FYORM, Montenegro, Serbia and Turkey).

Calculation

Amount of funding instruments labeled as public-private cooperation

Breakdowns

- Breakdown of amount b fields of R&D (FORD).

10.1.9 Societal Grand Challenges (SGCs) and Key Emerging Technologies (KETs)

Computation of breakdowns concerning SGCs and KETs are directly based on descriptors at the level of funding instruments. Each funding instrument is classified for its relevance for SGCs and KETs in three categories: central, relevant, not relevant.

By selective the respective variables for each instrument, it is possible to provide for each country tables which break down the indicator by each category as follows.

Total GBARD. All funding instruments. In order to be consistent with GBARD, amounts will be multiplied by the ratio between total GBARD / total amount instruments.

Appropriations as institutional/project funding. All funding instruments classified as project/institutional. In order to be consistent with GBARD, amounts will be multiplied by the ratio between (total allocation project or institutional)/ (total amount instruments project or institutional).

Exchange grants for R&D. All instruments classified as exchange grants for R&D.

Public-private co-funding. All instruments classified as public-private co-funding.

Incoming funding from the European Union. All instruments classified as incoming funding from the European Union.

Country	Year	Relevance	Total GBARD	Appropriations as institutional funding	Appropriations as project funding	Exchange grants for R&D	Public/private co-funding	Incoming funding from the European Union
DE	2012	SGC Central						
DE	2012	SGC Relevant						
DE	2012	SGC Not relevant						
DE	2012	SGC missing						
DE	2012	SGC not applicable						
DE	2012	KET Central						
DE	2012	KET Relevant						
DE	2012	KET Not relevant						
DE	2012	KET missing						
DE	2012	KET not applicable						
			All funding instruments	Only institutional funding instruments	Only project funding instruments	Only exchange grants	Only Public/private co-funding instruments	Only EU funding instruments

Coverage

All PREF countries, excluding the non-European countries (China, Japan, Israel, US) and the candidate countries (FYORM, Montenegro, Serbia and Turkey).

10.2 Dimensions of the country profiles

The country profiles should allow comparison of public funding between countries. The understanding of the characteristics of national research funding must take into account the relationships between government, funding agencies and research actors, trying to control using empirical data:

- The evolving patterns of the funding modes (institutional and project), taking a comparative perspective with the ERA countries, and non-ERA countries;
- Mapping the public funding objectives of the country in order to understand what they reveal of national policy, with a specific focus on public-private collaboration and human resources;
- The extent to which the funding instruments show complementarities, and how the new ones interact with the existing ones, producing differences on how the countries are likely to use funding instruments emerging at European level;
- The identification of the institutional arrangements existing in the countries (project funding configuration, core funding based systems, vertically integrated systems);
- How far national funding instruments are integrating strategic objectives emerging at European level, e.g. focusing on "cross cutting" Key Enabling Technologies (EC, 2012), and addressing the Societal Grand Challenges as defined by the implementation of Horizon 2020.[1]

Table 155 provides a preliminary list of variables for the country profiles, as well as their sources. It will be progressively extended and updated in the course of the project.

Table 15. Indicators for the country profiles.

Indicators	**Main data source**
List of funding agencies per country	Analysis of national systems by country; available evidence from JOREP ERAWATCH NETWATCH and web sites

[1] http://ec.europa.eu/programmes/horizon2020/en/h2020-sections

Characterization of research funding organizations	ERAWATCH and JOREP; reports of funding agencies, web sites Data collection on RFOs complemented with expert assessment
Characterization of research funding instruments	ERAWATCH and JOREP; reports of funding agencies, web sites Data collection on funding instruments complemented with expert assessment
Funding mechanisms, practices and criteria used in the allocation of project funding	ERAWATCH and JOREP; reports of funding agencies, web sites Data collection on funding instruments complemented with expert assessment
Qualitative analysis of the shares of modes of funding and themes of funding	Data collection of funding instruments, complemented with reports and a review of the relevant literature on changes across time.

11 Database structure and data collection

11.1 Roles in the data collection

Role in data collection will be managed as follows:

- Within the PREF core team, Austrian Institute of Technology (AIT) has set up the template for data collection and data collection guidelines (based on this handbook). AIT also managed the contacts with national experts, received from them the data and integrated the data in the PREF database.
- National experts have been in charge of collecting most descriptive information, mostly from publicly available sources like websites. They also functioned as a contact point for national data providers.
- National statistical authorities are the main provider of statistical data for PREF, particularly for what concerns GBARD and funding streams.
- National RFOs and UPROs are involved in the data collection process as providers of additional information concerning the funding instruments they are managing, particularly when more detailed breakdowns are required.

The list of national experts is provided in section 12.

11.2 Data collection process

Figure 5 presents an overview of the data collection process.

Data are collected from national experts through excel sheets, which include preformatted list of variables and categories and include all classifications, as well as some basic checks for data consistency.

Additionally, the PREF database integrates two data packages provided centrally:

- Data from R&D statistics (see section 6.5).
- Data on international funding instruments (see section 6.6).

Data collection will be organized in three steps:

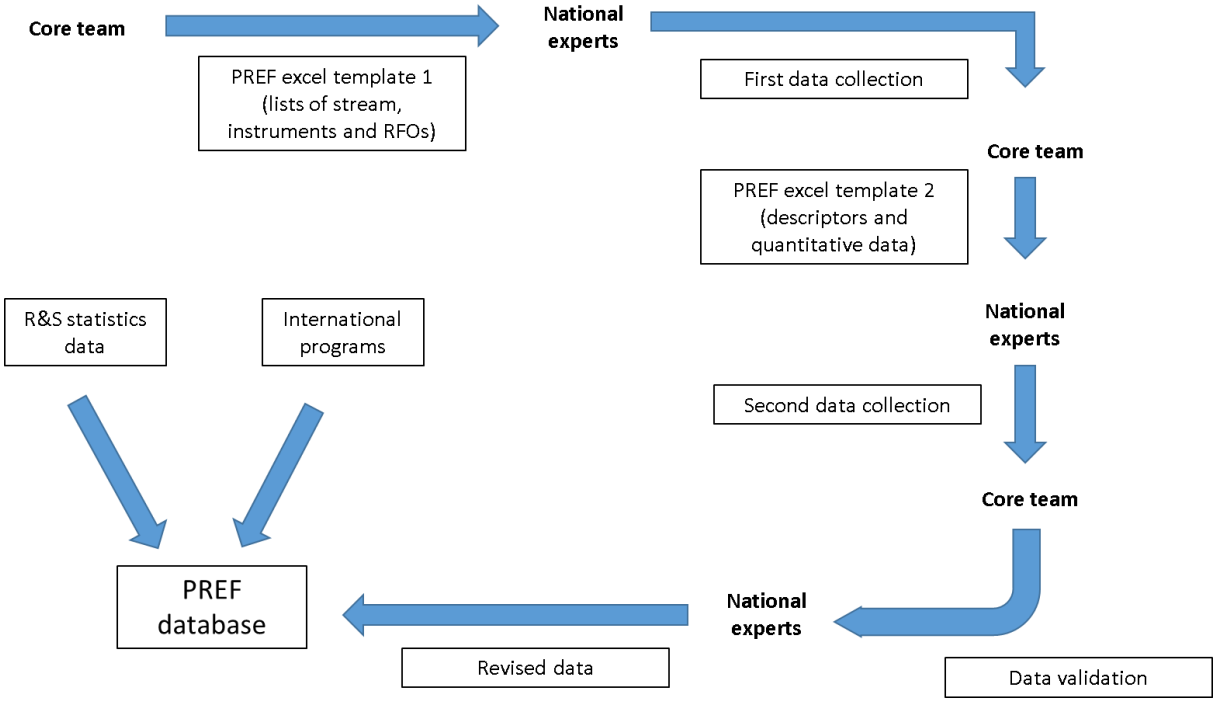
- In step 1 the list of funding streams, funding instruments, RFOs and UPROs for each country has been constructed. This will also allow attributing centrally the respective codes, and to prepare the excel sheet for the main data collection.

- In step 2, all additional data on funding streams, instruments, RFOs and UPROs have been collected, including data on financial amounts.

- In step 3, the provided data have been validated and checked by the PREF core team and any emerging issues have been clarified with national experts.

- In step 4, data have been integrated in the PREF database and subject to quality control. Remaining issues have been clarified at this stage with national experts.

Figure 5. Overview of the data collection process



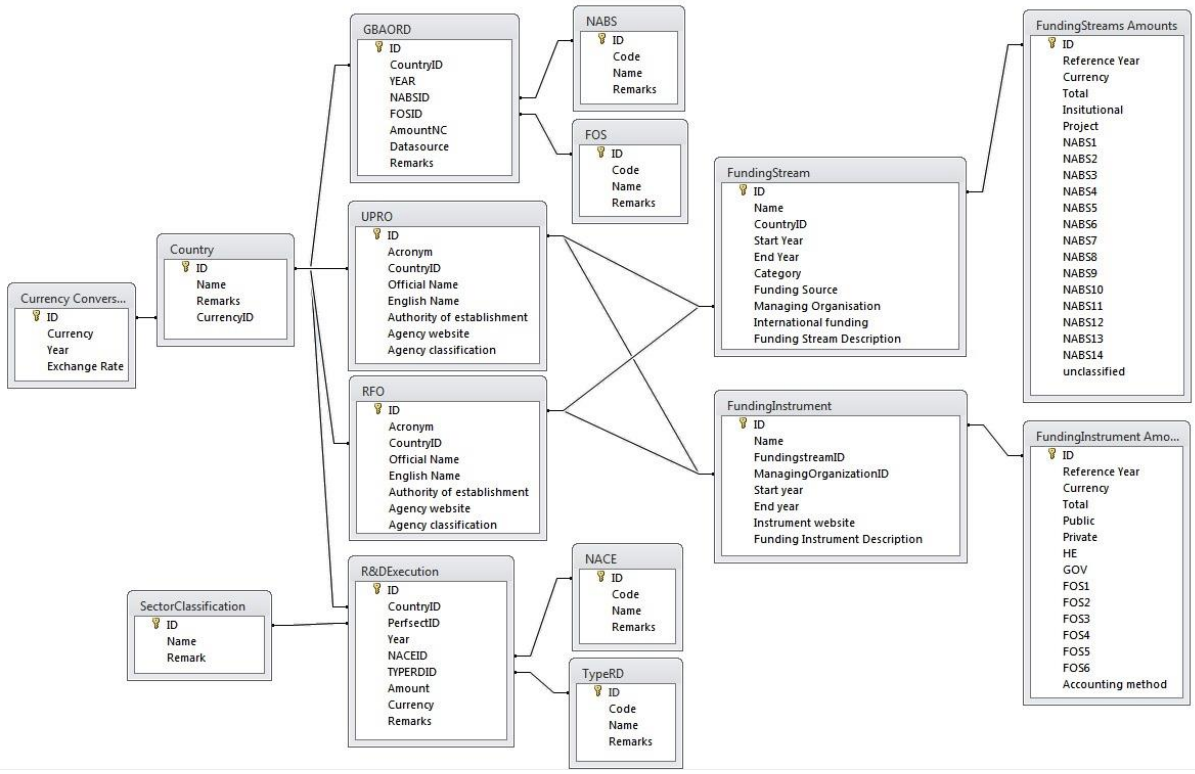
11.3 Data sources

PREF relies on the combination of different data sources, partially from official statistics, partially from public sources and direct requests to RFOs and UPROs.

A systematic list of data sources is provided within the PREF database.

11.4 Database structure

A preliminary structure of the database structure was presented in the Tender specifications and it is now refined as follow:



11.5 Data quality checks

In order to ensure a reasonable quality of the data and to spot any inconsistencies and potential sources of mistakes, a large number of data quality checks have been implemented in the different steps of data handling and data collection.

a) A first step of data check has been introduced already in the data collection templates. These check control for example whether the sum of breakdowns of financial amounts is equal to the total indicates. Other checks include the consistency between streams and instruments.
b) A second step of checks involved a systematic control of internal consistency, for example whether internal streams are assigned to international RFOs as managing organizations, respectively checking for missing categorizations (streams and instruments not assigned to RFOs). Consistency in the assignment of funding streams and instruments was also systematically checked – for example for cases of project funding instruments linked to streams with no project funding amount.
c) A third step included internal differences in amount, particularly between streams and instruments; for example, following rules have been applied:
   - Differences between total instrument and total stream amounts (excluding international streams) up to +/-25% -> if larger specific country solution to be discussed;
   - Differences between single stream amount and corresponding instruments amounts up to +/-10% -> remarks needed
   - Differences between stream level and total GBARD up to +/- 10% -> if larger residual stream (one stream, assigned to CAT01 or sometimes Cat03, RFO and descriptors not applicable; if CAT01 it is assumed as competitive, if CAT03 it is assumed as non-competitive, with the exception secure other evidence is provided).
d) A final step involved consistency checking between PREF data and EUROSTAT statistics, looking to following comparisons:
   — Total gbaord EUROSTAT – total gbaord PREF
   — Breakdown by NABS EUROSTAT/PREF
   — Total funding for all streams / total funding for all instruments.

— Share project funding EUROSTAT / share project funding PREF.

As a general rule, differences exceeding a certain threshold required an explanation; in some cases, NSAs confirmed that PREF data are more precise (particularly for the breakdown between project and institutional), in other case the explanation was in a different perimeter of research funding adopted in PREF. Such cases are duly explained in the national reports.

These checks led to a large number of revisions in the PREF database; cases which could not be resolved, for example because of lacking information, are duly noted in the country reports and whenever presenting the results.

12 Annex. List of national experts and contacts and NSAs

This list will be completed during the data collection process.

Country	National Expert	Organization
Austria	Matthias Weber	AIT
Belgium	Jan va Steen	Rathenau
Bulgaria	Ines Marinkovic	ZSI
Croatia	Ines Marinkovic	ZSI
Cyprus	Matthias Weber	AIT
Czech Republic	Matthias Weber	AIT
Danemark	Espen Solberg	NIFU
Estonia	Espen Solberg	NIFU
Finland	Mats Benner	NIFU
Former Yugoslav Republic of Macedonia	Elke Dall	ZSI
France	Benedetto Lepori	USI
Germany	Matthias Weber	AIT
Greece	Matthias Weber	AIT
Hungary	Mattias Weber	AIT
Iceland	Lisa Scordato	NIFU
Ireland	Federica Rossi	Birkbeck University of London
Italy	Emilia Primeri	IRCRES CNR
Israel	Daphne Getz	SNI-Samuel Neaman Institute
Latvia	Espen Solberg	NIFU
Liechtenstein	Benedetto Lepori	Università della Svizzera italiana
Lithuania	Espen Solberg	NIFU
Luxembourg	Jan van Steen	Rathenau
Malta	Emilia Primeri	IRCRES CNR
Montenegro	Elke Dall	ZSI
Netherlands	Jan van Steen	Rathenau
Norway	Ole Wiig	NIFU
Poland	Matthias Weber	AIT
Portugal	Emilia Primeri	IRCRES CNR
Romania	Matthias Weber	AIT
Serbia	Klaus Schuch	ZSI
Slovakia	Matthias Weber	AIT
Slovenia	Matthias Weber	AIT
Spain	Emanuela Reale	IRCRES CNR
Sweden	Mats Benner	NIFU

Switzerland	Benedetto Lepori	Università della Svizzera italiana
Turkey	Daphne Getz	SNI-Samuel Neaman Institute
United Kingdom	Federica Rossi	Birkbeck University of London
EU	Lisa Scordato	NIFU
China	Espen Solberg	NIFU
Japan	Ole Wiig	NIFU
USA	Espen Solberg	NIFU

List of abbreviations

BE	Business Enterprise sector
BERD	Gross Business Expenditures for R&D
EC	European Commission
ERA	European Research Area
ESA	European Space Agency
ESF	European Science Foundation
EU	European Union
EUFP	European Union Framework Programme
FI	Funding Instrument
FM2015	Frascati manual, 2015 edition
FORD	Field of R&D
FP7	Framework Programme Seven
FS	Funding stream
GBARD	Government Budget Allocations for R&D
GERD	Gross Domestic Expenditures for R&D
GOV	Government sector
GUF	General University Funds
HEI	Higher Education Institution
JOREP	Joint and Open Research Programs project
KETs	Key Enabling Technologies
NABS	Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets by Socio-Economic Objective
NACE	Statistical Classification of Economic Activities in the European Community
NESTI	*OECD* Working Party of National Experts on Science and Technology Indicators
NSA	National Statistical Authorities
OECD	Organisation for Economic Co-Operation and Development
PNP	Private non Profit sector
PREF	Public Research Funding study
PRO	Public Research Organisation
R&D	Research and Development
RFO	Research Funding Organisation
S&T	Science and Technology
SGCs	Societal Grand Challenges
UPRO	Umbrella Public Research Organisation

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