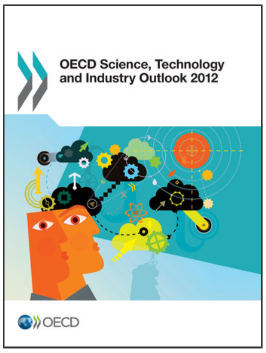

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Methodological Annex to the 2012 OECD STI Outlook Country Profiles

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ANNEX A

Methodological Annex to the 2012 OECD STI Outlook *Country Profiles*

Introduction

Chapter 10 presents, in a series of country profiles, the main features, strengths and weaknesses of national STI systems and major recent changes in national STI policy. This annex describes the conceptual background, sources and methodology used to design these profiles.

For the 2012 edition, the country profiles were expanded to include over 300 key indicators in selected STI areas, a radical expansion of the statistical framework from previous editions (which had some 20 indicators). The policy dimension has been also reinforced through a more systematic and comprehensive use of national science, technology and innovation (STI) policy information.

The new country profiles are at the interface of two main streams of work carried out under the auspices of the Committee for Scientific and Technological Policy (CSTP):

- On the one hand, the policy research conducted by the Working Party on Innovation and Technology Policy (TIP), on the links between innovation and sustainable growth and the evaluation of national STI public support schemes, and the work of the Working Party on Research Institutions and Human Resources (RIHR), on the main institutional, regulatory and management conditions needed to strengthen the knowledge base for innovation and the research capabilities of public research institutions (PRIs). The policy dimension of the country profiles has also benefited from experience gained through the OECD Country Reviews of Innovation Policy and previous OECD work on national innovation systems (NIS). The main and most recent source of country-specific STI policy information is provided by countries' responses to the STI O policy questionnaire 2012 which was circulated to CSTP delegates between January and March 2012. Official documents and external sources, such as the EU Erawatch/TrendChart reports were also used when appropriate.
- On the other hand, the statistical work and empirical research conducted by the Working Party of National Experts on Science and Technology Indicators (NESTI) on the measurement of innovation and the development of internationally comparable S&T indicators for policy analysis. The statistical dimension of the country profiles has also drawn on data collections and empirical work of the Committee on Industry, Innovation

and Entrepreneurship (CIIE) and the Committee for Information, Computer and Communications Policy (ICCP), in their areas of work. Finally, the reviews of STI indicators and STI trends carried out for the *OECD Science, Technology and Industry Scoreboard* are a key reference (OECD, 2009, 2011a).

This methodological annex first introduces the conceptual framework used in this edition to assess national innovation systems (NIS). It then looks at the key indicators chosen to gauge the performance of innovation systems. It reviews the reasons for the choices made, the sources used, some limitations on interpretation of the data and certain technical aspects (calculations, normalisation criteria, etc.).

What should be measured: A conceptual framework

A particular effort has been made to improve evidence on how innovation systems function and perform by mapping and measuring input, output and outcomes (OECD, 2010a).

The following framework provides the standard structure used to describe the NIS and to map the innovation policy mix (OECD, 2010b). It is used throughout the *OECD Science, Technology and Industry Outlook 2012*, in particular to relate the policy profiles (thematic approach) to the country profiles (country approach). It served a role in the re-design of the policy questionnaire used to collect information and official data on major STI policy programmes and on recent changes in national STI policy.

Public intervention may seek to improve: the competences and capacity of STI actors to innovate; STI actors' interactions and capacity to connect to knowledge flows; human resources (HR) for innovation; and STI policy governance.

STI actors' competences and capacity to innovate

Science base

Public-sector research is considerably smaller than business research and development (R&D) in the majority of OECD countries; higher education and government expenditure on R&D account for 30% of total OECD expenditures on R&D (OECD, 2012a). However, PRIs and research universities play an extremely important role in innovation systems by providing new knowledge, especially in areas in which economic benefits are uncertain or less immediate. Public research also meets specific needs of national interest, such as defence, and of the population at large, *e.g.* health care. In addition public research tends to be counter-cyclical and to serve as a buffer by complementing funding gaps arising from declines in private R&D investment during economic downturns. Gross domestic expenditures on R&D (GERD) declined by 1.6% in 2009 in the OECD area, driven by a sharp contraction of business R&D spending (–4.5%), while expenditure by higher education (+4.8%) and government (+3.8%) kept growing (OECD, 2012a). The same occurred in 2002 after the explosion of the IT bubble, although to a lesser extent.

Business R&D and innovation

Firms are major actors in national innovation systems. They turn ideas into economic value, account for the largest share of domestic R&D in many countries and also carry out non-technological innovation.

Public-sector innovation

Increasingly sophisticated public demand and new challenges due to fiscal pressures require innovative public-sector approaches. Public-sector innovation involves significant improvements in public services delivery in terms both of the content of these services and of the instruments used to deliver them. Many OECD countries intend to create services that are more user-focused, better defined and better target user demand. However, there is limited knowledge and awareness of the full range of tools available to policy makers for accelerating innovation in this area.

STI actors' interactions

Science is the basis of most innovation, especially in frontier fields (such as biotechnology). Innovation is increasingly achieved through the convergence of scientific fields and technologies (OECD, 2010c). The rapidly increasing amount of knowledge required for innovation has encouraged STI actors to co-operate and connect to global knowledge flows.

ICT and scientific infrastructure

Empirical studies point to a positive link between increased adoption and use of information and communication technologies (ICTs) and economic performance at the firm and macroeconomic level (OECD, 2012b). Governments see ICTs and the Internet as a major platform for research and innovation.

To conduct scientific research and to attract and retain world-class researchers requires a critical mass of large-scale scientific infrastructures, costly equipment and modern facilities and thus large amounts of public and private investments.

Clusters

Clusters are geographic concentrations of firms, universities, PRIs, and other public and private entities that facilitate collaboration on complementary economic activities. Clusters facilitate knowledge spillovers and a collective pool of knowledge that result in higher productivity, more innovation and more competitive firms. Governments promote clusters through investments in ICT, scientific infrastructure and knowledge, networking activities and training.

Knowledge flows and the commercialisation of public research results

Various mechanisms facilitate knowledge valuation, circulation and commercialisation. Intellectual property rights (IPRs), such as patents or trademarks, facilitate the transfer of knowledge and technologies by ensuring that the knowledge generated will not be misappropriated and that much of the benefits can be internalised. Technology transfer from academia is encouraged to increase the economic impact of investments in public research. The commercialisation of public research results via the cession of intellectual property (IP), the establishment of new ventures (*e.g.* academic spin-offs), contracting to universities and PRIs by industrial actors or the setting up of collaborative R&D projects may also create additional financial resources for universities and PRIs. IPRs are therefore increasingly traded in markets and the number of intermediaries that broker commercialisation activities, notably IP services, has risen. Open science also increases the channels for transferring and diffusing research results (*e.g.* ICT tools and platforms, alternative copyright tools) and open innovation in firms creates a division of labour in the sourcing of ideas and their exploitation.

Globalisation of STI systems

Trade, investment and research systems are increasingly globalised (OECD, 2009). Countries and firms engage in international co-operation in STI with a view to tapping into global pools of knowledge, HR and major research facilities, to sharing costs, to obtaining more rapid results, and to managing the large-scale efforts needed to address challenges of a regional or global nature effectively.

Human resources for innovation

Education

Because it raises attainment levels and the general level of education, can inspire talented young people to enter innovation-related occupations and equip people with the highest skills, formal education remains the main vehicle for improving the supply of the diverse and complex skills required for innovation. In addition to scientific, technological, engineering and mathematics skills innovation requires soft skills (entrepreneurship, creativity, leadership etc.).

Employment and lifelong learning

The supply of the highly skilled can be further enlarged by improving the attractiveness of research and entrepreneurial careers, by facilitating the sectoral and international mobility that eases the cross-fertilisation of ideas and learning, or by facilitating the transition from higher education and training to employment and *vice versa*. The acceleration of technological change has made lifelong learning a key means of preserving and upgrading the pool of human resources for science and technology (HRST). Demand for the highly skilled can also be boosted through support for job openings in academia or in the business sector, especially in small and medium-sized enterprises (SMEs). Mismatches between demand and supply can be addressed by promoting mobility and training and by building knowledge about current and future skills needs.

Innovation culture

It is increasingly recognised that innovation is influenced by the social and cultural values, norms, attitudes and behaviours that inform an innovation culture. Building an innovation culture implies raising public awareness of and interest in S&T, especially among youth, valuing the contribution of S&T to well-being and social welfare, fostering an entrepreneurial spirit through a positive attitude towards risk taking, nurturing a research culture while raising awareness of IPRs in the research community, etc.

STI policy governance

As the portfolio of innovation policy instruments has broadened, STI policy has become increasingly sophisticated. The sedimentation of STI policy initiatives over time has raised the risk of government failures and the dispersal of state power to supra- and sub-national, quasi-state and non-state actors; it has also favoured the emergence of new forms of multi-level and multi-actor governance (Flanagan, 2010) which make the possible side-effects of public intervention increasingly difficult to detect and anticipate. Moreover, in the aftermath of the 2008 financial crisis, governments are under strong pressure to find new sources of growth, to meet social and global challenges and to consolidate their fiscal accounts (OECD, 2010c). Good governance requires identifying strategic priorities, combining the right instruments and making the most of stabilised, or even shrinking, resources.

More detailed information about the rationale for and major aspects of STI policy intervention, as well as recent STI policy trends, can be found in Chapters 5, 6, 7, 8 and 9 of this volume.

Key figures

The table of key figures provides an overview of a country's economic and environmental performance, the size of its national research system and the relative importance of the government's commitment to R&D through public funding. It also shows how these indicators have changed from 2005 to 2010. When data are not available for these years, the nearest years are used. Growth rates are compound annual growth rates* expressed in percentage.

Economic and environmental performance

Innovation is widely acknowledged as a major driver of productivity and economic performance and is seen as a key way to create new business values while also benefiting people and the planet and addressing global challenges.

Labour productivity levels and annual growth: Welfare is traditionally gauged through the GDP per capita indicator. Changes in welfare are explained by changes in labour productivity (GDP per hour worked) and labour utilisation (hours worked per person employed). Labour productivity is defined as the volume of output divided by the volume of labour input, namely GDP per hour worked, in current US dollars at purchasing power parity (PPP). Labour productivity is however a partial productivity measure and reflects the joint influence of a host of factors. It is easily misinterpreted as technical change or as the productivity of the individuals in the labour force. Also, value-added measures based on a double-deflation procedure with fixed-weight Laspeyres indices suffer from several theoretical and practical drawbacks. Data are drawn from the OECD Productivity Database which provides estimates of productivity levels and allows for comparison of standards of living and underlying factors across countries (*www.oecd.org/statistics/productivity*).

Environmental productivity levels and annual growth: Environmental outcomes are important determinants of health status and well-being. A central element of green growth is the environmental and natural resource efficiency of production and consumption. A declining asset base and climate change constitute risks for growth and sustainable development. The main concerns relate to the effects of increasing atmospheric greenhouse gas (GHG) concentrations on global temperatures and the Earth's climate, and the consequences for ecosystems, human settlements, agriculture and other

* Compound annual growth rates are calculated based on values in constant prices, according to the following formula in which CAGR is the compound annual growth rate, I is the value considered over the period of time between t_0 and t_1:

$$\mathrm{CAGR}^{I}_{t_1,t_0} = \left[(I_{t_1} \mid I_{t_0})^{(1 \mid (t_1 - t_0))} \right] - 1$$

socioeconomic activities that can affect global economic output (OECD, 2011e). Carbon dioxide (CO_2) accounts for the largest share of GHG emissions. The main drivers of climate change and GHG emissions include fuel combustion in economic activities and by households. Environmental productivity is production-based CO_2 productivity, *i.e.* GDP generated per unit of CO_2 emitted through fuel consumption. Estimates are computed by the International Energy Agency (IEA) based on the IEA energy balances and the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IEA, 2011).

Size of the research system and public financial commitment to R&D

GERD intensity and annual growth of GERD: GERD is one of the most widely used measures of innovation inputs. It reflects a country's R&D efforts and investments and its potential for generating new knowledge. Many OECD and non-OECD countries "target" a certain level of GERD intensity to help focus policy decisions and public funding (see Chapter 5). Data are drawn from the OECD Main Science and Technology Indicators (MSTI) Database which aims to reflect the level and structure of efforts in the field of science and technology and is based on harmonised national R&D surveys (*www.oecd.org/sti/msti*).

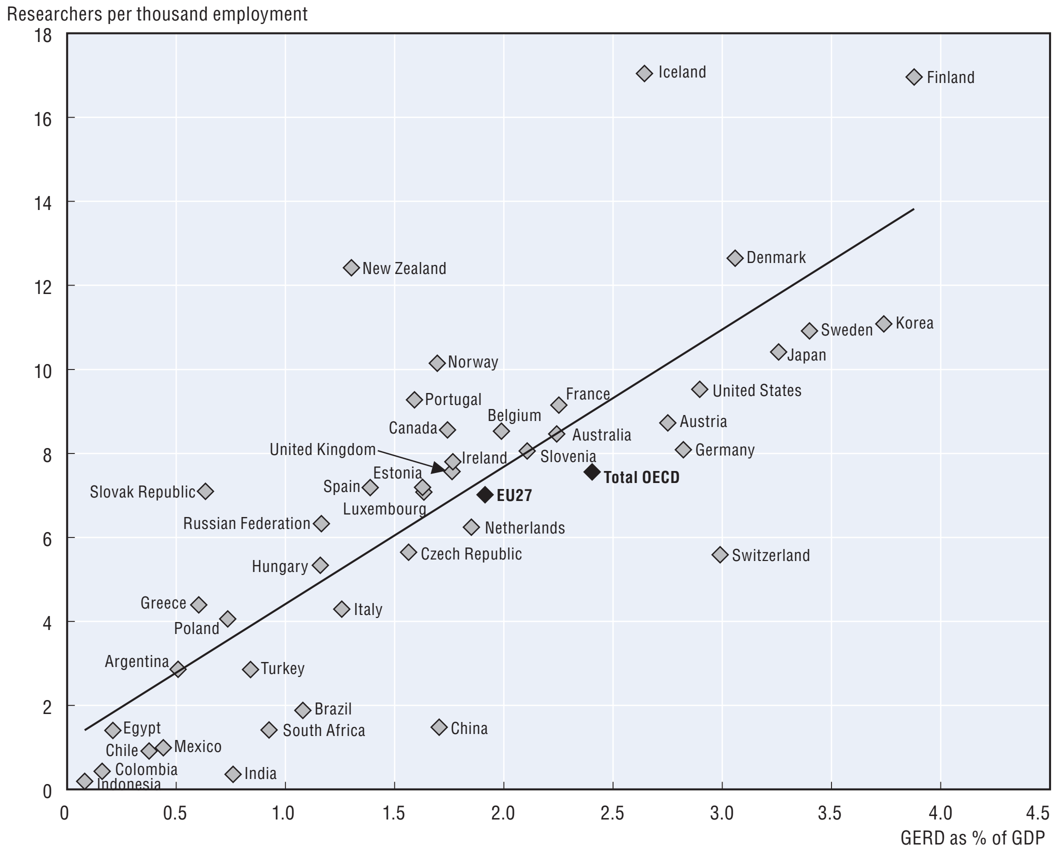
In many economies most R&D expenditures cover personnel costs which includes researcher salaries and compensation. GERD intensity as a percentage of GDP and researchers per thousand employment are therefore closely related (OECD, 2011a). To avoid redundancy, data on researcher density are not always presented in the country profiles but are included when the link between researcher and GERD intensity is more tenuous (*e.g.* Finland, New Zealand) (Figure A.1). The researcher population is estimated in full-time equivalent (FTE). Data are drawn from the OECD MSTI Database.

The size of national research systems in terms of input (GERD) and their relative performance in terms of output (patents and publications) are also reflected in a country's share in OECD totals of GERD, triadic patent families and scientific publications. These data may be used on a case-by-case basis and are drawn from the OECD MSTI Database and the *OECD STI Scoreboard 2011* (OECD, 2011a).

Publicly financed GERD intensity and annual growth: GERD is financed by various sources: business enterprises (industry), government (public), higher education, private non-profit institutions (PNPs) and foreign funds (abroad). In the country profiles, public funding of GERD encompasses financing by the government and higher education sectors. It reflects public commitment to R&D relative to the size of the country. It is expressed as a percentage of GDP. Data are based on harmonised national R&D surveys and drawn from the OECD Research and Development Statistics (RDS) Database which provides detailed information on a range of R&D statistics (*www.oecd.org/sti/rds*).

The relative shares of the funding sectors in total GERD may be included in the text of the profiles. An average 60.7% of GERD is funded by industry in the OECD area, but governments account for around 50% of total R&D funding in Norway, the Slovak Republic and Spain. The R&D funding structure is reversed in the Russian Federation as the government funds over two-thirds of GERD. These shares reflect the extent to which the research system is supported by and may be leveraged by public funding. They also indicate the potential sensitivity or resilience of domestic R&D investments to market shocks as public R&D spending may serve as a stabiliser in times of economic crisis. Data

Figure A.1. **GERD as a percentage of GDP and researchers per thousand employment, 2010 or latest year available**



Source: OECD *MSTI Database*, June 2012. For Mexico, national sources (Conacyt-INEGI R&D survey).

StatLink http://dx.doi.org/10.1787/888932690966

are based on harmonised national R&D surveys and are drawn from the OECD RDS Database (*www.oecd.org/sti/rds*).

Benchmarking national innovation performance (Panel 1 of the country profiles)

The performance of a country's national innovation systems as compared to all OECD countries is represented in Panel 1 of the country profiles. Panel 1 (double graph) reflects the country's strengths and weaknesses in several areas (see the conceptual framework discussed above). A standard set of indicators is used to: *i)* describe the competences and capacity of the science base and the business sector to innovate, as well as the framework conditions for entrepreneurship; *ii)* provide some insights on interactions between STI actors via the deployment and use of the Internet and their participation in domestic and international co-operation networks; and *iii)* depict the status of the HR pool and prospects for increasing human capital further through inflows of new S&T talent.

Indicators are normalised (by GDP or population) to take account of the size of the country. The country's values are compared to the median value observed in the OECD area, *i.e.* the middle position among OECD countries for which data are available. Non-OECD countries are also compared and may appear out of range (*e.g.* lower than the lowest

OECD country). The use of the median avoids a statistical bias towards large players that skew the average, while still reflecting international rankings. The median has also the advantage over a simple ranking that it preserves the deviation between country values. The distance of the country's value from the median value will appear on the chart at a proportional distance from the median. This applies equally to all countries. In a simple ranking, the difference between two successive country values is 1 and the distance to the median is the rank. All indicators are presented in indices and reported on a common scale from 0 to 200 (0 being the lowest OECD value, 100 the median value and 200 the highest) to make them comparable. The benchmark charts also highlight the position and dispersion of the top five and bottom five OECD values. When data are not available, the country's relative position does not figure on the graph (no dot).

Given X_t^c the indicator for country *c* at time *t*, and X_t^{Max}, X_t^{Med} and X_t^{Min} the respective OECD maximum, median and minimum values for this indicator, the country index I_t^c shown in Panel 1 is calculated as follows:

$$\text{If } X_t^c > X_t^{Med} \text{ then } I_t^c = 100 + (X_t^c - X_t^{Med}) / (X_t^{Max} - X_t^{Med})*100$$

$$\text{If } X_t^c < X_t^{Med} \text{ then } I_t^c = 100 + (X_t^c - X_t^{Med}) / (X_t^{Min} - X_t^{Med})*100$$

The standard set of indicators includes the following:

Science base

(a) Public expenditure on R&D (per GDP): Higher education and government research institutions play a key role in the national STI system. Public expenditure on R&D (per GDP) measures the public sector's relative R&D performance. Public expenditure on R&D is the sum of higher education expenditure on R&D (HERD) and government expenditure on R&D (GOVERD) and is expressed as a percentage of GDP. Data are drawn from OECD MSTI Database and based on harmonised national R&D surveys and national accounts.

(b) Top 500 universities (per GDP): Research excellence is often concentrated in a few higher education institutions with strong international impact. The Academic Ranking of World Universities (ARWU), also known as the Shanghai ranking, ranks the world's top universities according to a composite indicator based on number of alumni; staff winning Nobel Prizes and Fields Medals; number of highly cited researchers selected by Thomson Scientific; number of articles published in *Nature* and *Science*; number of articles indexed in the Science Citation Index Expanded and Social Sciences Citation Index; and per capita performance with respect to the size of the institution. More than 1 000 universities are actually ranked by ARWU every year and the list of the leading 500 are published on the web (*www.arwu.org*). This indicator has certain limits however. The ranking is skewed towards large and English-speaking institutions and emphasises the natural sciences over the social sciences or humanities. It also emphasises research excellence over the quality of teaching. The top 500 universities are expressed per million US dollars of GDP at PPP to take into account the size and the relative wealth of the country. Data for GDP are drawn from the OECD MSTI Database and are based on national accounts.

(c) Publications in top-quartile journals (per GDP): Publication is the main means of disseminating and validating research results. Publications in top journals provide a measure of "quality-adjusted" research output and serve as an indicator of the expected impact of institutions' scientific production. Publications in the top-quartile journals are defined as documents published in the most influential 25% of the world's scholarly

journals (in their category, in the reference period, by authors affiliated to an institution, in a given country). This ranking is based on the *SCImago Journal Rank* (SJR) indicator (*www.scimagoir.com*), a size-independent metric that measures the current "average prestige per paper" of journals for use in research evaluation processes and is built on citation data drawn from the *Elsevier's Scopus* database (SCImago, 2007). However, although publications are commonly used as proxies for academic research output, it is worth mentioning that publishing institutions are not necessarily all public-sector research institutions. Publications counts are expressed per million US dollars of GDP at PPP to take into account the size and the relative wealth of the country. Data for GDP are drawn from the OECD MSTI Database and are based on national accounts.

Business R&D and innovation

(d) Business R&D expenditure (per GDP): Business enterprise expenditure on R&D (BERD) accounts for the bulk of R&D activity in most OECD countries. It is frequently used to compare countries' private-sector efforts on innovation since industrial R&D is more closely linked to the creation of new products and production techniques and mirrors market-oriented innovation efforts. Data are drawn from the OECD MSTI Database and are based on harmonised national R&D surveys and national accounts.

(e) Top 500 corporate R&D investors (per GDP): Big companies make an important contribution to R&D and innovation. Large firms tend to introduce innovations of larger scale and bigger impact than SMEs which more frequently tend to be "adopters" and "pioneers" (OECD, 2009). In addition, large firms often drive collaboration, as they play a structuring role in innovation clusters that also include SMEs. Large firms also play the role of "innovation assemblers": by integrating innovations from SMEs in their own products, they bring SMEs' innovations to markets. The *2011 EU Industrial R&D Investment Scoreboard* (*http://iri.jrc.ec.europa.eu/research/docs/2011/SB2011.pdf*) presents economic and financial information about the world's 1 400 largest companies ranked according to the level of their own-funded R&D investments. The top 500 accounted in 2010 for 87% of the 1 400 firms' total R&D investments. Data are based on companies' publicly available audited accounts. The EU Scoreboard is intended to raise awareness of the importance of R&D for businesses and to encourage firms to disclose information about their R&D investments and other intangible assets. It gathers information about a sample of 400 European and 1 000 non-European firms that invested more than EUR 30 million in R&D in 2010. For different reasons (changes in exchange rates, mergers and acquisitions, etc.), the composition of the sample may vary from year to year and data are not fully comparable from one edition of the EU Scoreboard to the next. It is worth noting that companies' accounts do not include information on where R&D is actually performed and that companies' total R&D investment is attributed to the country in which it is registered. The EU Scoreboard's approach to BERD is, therefore, different from that of statistical offices or the OECD which attribute data to a specific territory. The EU Scoreboard data are primarily of interest to those concerned with benchmarking company commitments and performance (*e.g.* companies, investors and policy makers), while BERD data are primarily used by economists, governments and international organisations interested in the R&D performance of territorial units defined by political boundaries (EC, 2011). The two approaches are complementary. The number of top 500 corporate R&D investors is expressed per million US dollars of GDP at PPP to take account of the size of the country. Data for GDP are drawn from the OECD MSTI Database and are based on national accounts.

(f) Triadic patents (per GDP): Patents provide a uniquely detailed source of information on the inventive activity of countries. Triadic patents are typically of relatively high value and eliminate biases arising from home advantage and the influence of geographical location. Triadic patent families are defined as patents applied for at the European Patent Office (EPO), the Japan Patent Office (JPO) and the US Patent and Trademark Office (USPTO) to protect a same invention. Counts are presented according to the priority date and the residence of the inventors. The number of triadic patent families applied for over the 2008-10 period is expressed per billion US dollars of GDP at PPP. Data for patents are drawn from the OECD Patent Database (*www.oecd.org/sti/ipr-statistics*) and data for GDP are drawn from the OECD MSTI Database and are based on national accounts.

(g) Trademarks (per GDP): A trademark is a sign that distinguishes the goods and services of one undertaking from those of other undertakings. Firms use trademarks to launch new products on the market in order to signal novelty, promote their brand and appropriate the benefits of their innovations. Trademarks convey information not only on product innovations, but also on marketing innovations and innovations in the services sector. The number of trademark applications is highly correlated with other innovation indicators (OECD, 2011a). Because the data relating to trademark applications are publicly available immediately after filing, trademark-based indicators can provide timely information on the level of innovative activity (OECD, 2011a). Trademark-based indicators are therefore a good predictor of economic downturns (OECD, 2010c). However, trademarks counts are subject to home bias as firms tend to file trademarks in their home country first. Trademarks abroad correspond to the number of applications filed at the USPTO, the Office for Harmonization in the Internal Market (OHIM), and the JPO, by application date and country of residence of the applicant. For the United States, EU members and Japan, counts exclude applications in their domestic market (USPTO, OHIM and JPO, respectively). Counts are rescaled by taking into account the relative average propensity of other countries to file in these three offices. The number of trademarks applied for over the 2007-09 period is expressed per billion US dollars of GDP at PPP. Data for trademarks are drawn from OECD calculations based on World Intellectual Property Organization (WIPO) Trademark Statistics and data for GDP are drawn from the OECD MSTI Database and are based on national accounts.

Entrepreneurship

(h) Venture capital (per GDP): A financial and policy environment that fosters the start-up and growth of new firms is essential for innovation to flourish. Access to finance for new and innovative small firms is vital but banks may be reluctant to lend to risky ventures. For entrepreneurial firms, especially if they are young, technology-based and have high growth potential, venture capital is an important source of funding during the seed, start-up and growth phases. Venture capital (VC) is private equity provided by specialised firms acting as intermediaries between primary sources of finance (insurance, pension funds, banks, etc.) and private companies whose shares are not freely traded on any stock market. Data for VC investments are drawn from the OECD Entrepreneurship Financing Database (OECD, 2011b) and data for GDP are drawn from the OECD MSTI Database and are based on national accounts.

(i) Patenting firms less than 5 years old (per GDP): The presence of young firms among patent applicants underlines the inventive dynamics of firms early in their development. Young firms are defined as firms less than five years old with an incorporation date in

business registers (ORBIS©) between 2004 and 2010. Patenting firms are those filing patent applications at the European Patent Office (EPO), at the US Patent and Trademark Office (USPTO) or through the Patent Cooperation Treaty (PCT) between 2007 and 2010. It should be stressed that this experimental indicator is obtained by matching patent (EPO/USPTO/PCT patent filings) and business (listed in the ORBIS database) data: the names of applicants as they appear in the patent were linked with those of firms listed in business registers. Counts are limited to a set of patent applicants which have been successfully matched with business register data. In addition, only countries with average matching rates over 70% over the period are included. Counts of young patenting firms are expressed per billion USD GDP using PPPs. Data for young patenting firms are based on the OECD Patent Database and the ORBIS Database (Bureau Van Dijk Electronic Publishing). Data for GDP are drawn from the OECD MSTI Database based on national accounts.

(j) Ease of entrepreneurship index: For businesses to enter the market and grow they need a suitable regulatory framework. Most OECD countries have lowered barriers to entrepreneurship during the last decade (OECD, 2010c). The "barriers to entrepreneurship" indicator is one of the OECD Indicators of Product Market Regulation (PMR) and measures regulations affecting entrepreneurship. The index uses a scale of zero to six to evaluate barriers to competition (*e.g.* legal barriers, antitrust exemptions, barriers in network sectors and in retail and professional services); regulatory and administrative opacity (*e.g.* licences, permits, simplicity of procedures); and administrative burdens for creating new firms. However, the PMR indicators were last updated in 2008 and the data may no longer fully reflect the situation in rapidly reforming countries. As lower values suggest lower barriers, the barriers to entrepreneurship index is reversed so as to be read in the same way as other indicators used in this international benchmark. The ease of entrepreneurship index is calculated as 6 minus the barriers to entrepreneurship index. Calculations are made with data drawn from the OECD Product Market Regulation Database (*www.oecd.org/economy/pmr*).

Internet for innovation

The Internet has become a critical infrastructure for businesses, consumers/users and the public sector (OECD, 2011a). In terms of data transmission, traffic levels have increased exponentially and are expected to continue to do so. New network applications and the expected migration of mobile users to more advanced 3G networks place larger demands on existing infrastructures by generating more traffic flow.

(k) Fixed broadband subscribers (per population): Broadband provides high-speed Internet access and enables the broader participation of customers, suppliers, competitors, government laboratories and universities in the innovation process. It makes outsourcing and off-shoring more efficient and has changed personal and business practices dramatically (OECD, 2010c). Recent OECD work also indicates a strong correlation between the penetration of broadband and the use of e-government services by citizens (OECD, 2009). While mobile broadband is developing rapidly and has become the dominant broadband access channel in OECD countries, fixed wired broadband connections are still the foundation of high-speed data transport (OECD, 2012b). Fixed broadband includes all subscriptions to DSL lines offering Internet connectivity (the DSL line is excluded if it is not used for Internet connectivity, *e.g.* leased lines), cable modem, fibre-to-the-premises (*e.g.* house, apartment) and fibre-to-the-building (*e.g.* apartment LAN) and other broadband over power lines capable of download speeds of at least 256 kbit/s. It does not include 3G

mobile technologies and Wi-Fi. The number of fixed broadband subscribers includes business and residential connections and is expressed per 100 inhabitants. Data for fixed broadband subscriptions are drawn from the OECD Broadband Statistics (*www.oecd.org/sti/ict/broadband*) which are compiled from information collected directly from telecommunications firms and national regulators twice a year. For non-OECD countries, data come from the ITU World Telecommunication/ICT Indicators 2011 Database and population data come from the UNESCO Institute for Statistics.

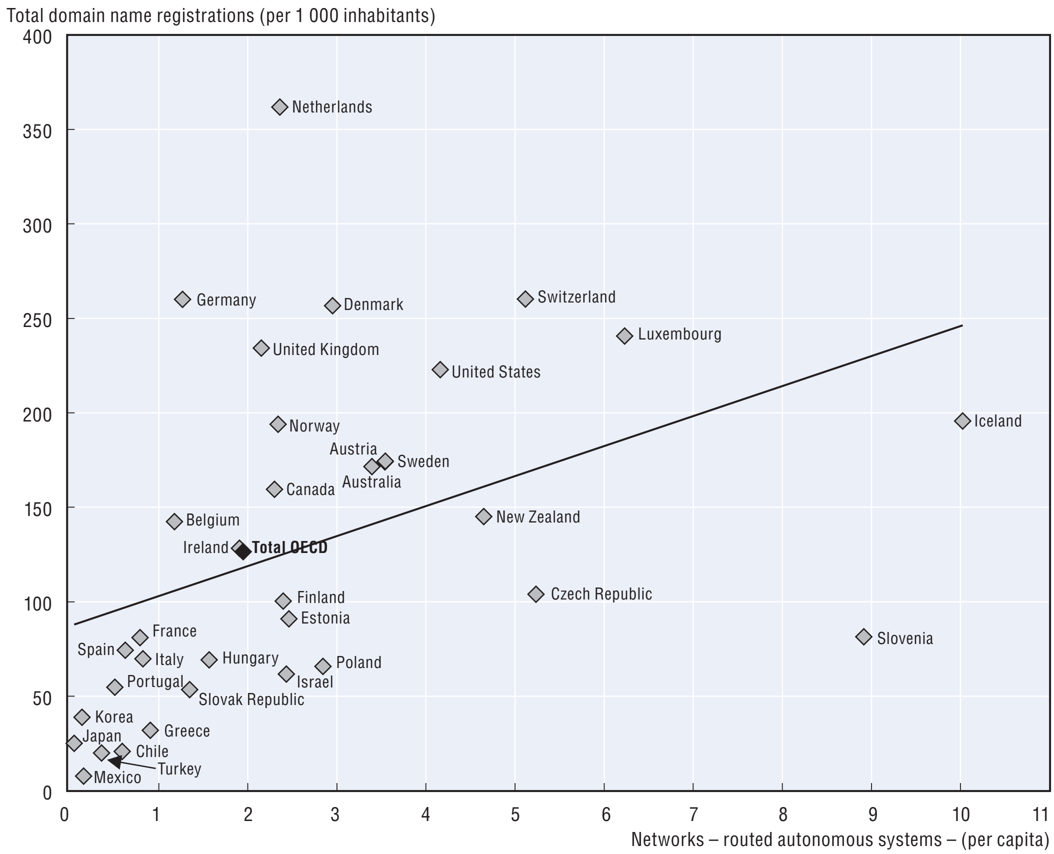
(l) Wireless broadband subscribers (per population): Wireless broadband includes subscriptions with advertised download speeds of at least 256 kbit/s through satellites, terrestrial fixed wireless, terrestrial mobile wireless (including standard mobile subscriptions and dedicated data subscriptions). It does not include Wi-Fi. The number of wireless broadband subscribers includes business and residential connections and is expressed per 100 inhabitants. Data for wireless broadband subscriptions are drawn from the OECD Broadband Statistics which are compiled from information collected directly from telecommunications firms and national regulators twice a year. For non-OECD countries, data come from the ITU World Telecommunication/ICT Indicators 2011 Database and population data come from the UNESCO Institute for Statistics. Satellite subscriptions which tend to be null are not included.

(m) Networks (autonomous systems) (per population): The deployment of Internet infrastructures, *e.g.* individual networks, is linked to the use made of them, *e.g.* the registration of new domain names (Figure A.2). The Internet is composed of individual networks under single administrative control. These networks are called autonomous systems (AS). They can be Internet service providers (ISPs), academic or government networks, or firms with a particular need for some independence of networking (*e.g.* AT&T, France Telecom, Google, NTT). A unique number is assigned to each autonomous system in order to identify it and each AS is given an aggregated block of Internet Protocol (IP) addresses. Regional Internet registries (RIRs) are non-profit corporations which administer and register Internet Protocol (IP) address space and AS networks. ASs use the Border Gateway Protocol (BGP) routing protocol to announce (*i.e.* advertise) the aggregated IP addresses to which they can deliver traffic.

Domain names are one of the best available indicators of the spread of the Internet and e-commerce (OECD, 2011c). The domain name system (DNS) translates user-friendly domain names into IP addresses. The DNS servers handle billions of requests daily and are essential for the smooth functioning of the Internet. Top-level domains (TLDs) are divided into two classes: generic top-level domains (gTLDs) such as ".com" or ".org", and country code top-level domains (ccTLDs) which consist of two-letter codes generally reserved for a country or dependent territory (*e.g.* ".au" for Australia or ".fr" for France). Between 2000 and 2010, registrations under all ccTLDs worldwide grew by 24.3% a year and registrations under major gTLDs grew by 19.8% a year. Domain name registrations are an indicator of interest in having a web presence. Creating a new TLD can be attractive for brand holders and organisations potentially interested in managing their own name as a top-level domain for branding purposes.

The number of routed/advertised autonomous systems (RAS) is expressed per million inhabitants. Data from the *OECD Communications Outlook 2011* (OECD, 2011c) have been updated based on information compiled by *www.zooknic.com*. For non-OECD countries, population data come from the UNESCO Institute for Statistics.

Figure A.2. **Networks infrastructures and spread of the Internet use, 2010**



Source: OECD (2011), *OECD Communications Outlook 2011*, OECD, Paris. Based on *www.zooknic.com* and *www.potaroo.net/reports/oecd*.

StatLink http://dx.doi.org/10.1787/888932690985

(n) E-government readiness index: Governments increasingly use the Internet to improve their interaction with citizens by making it easier for them to obtain information, fill out necessary forms and file taxes (OECD, 2012b). ICTs support changes in public services delivery by allowing more personalised, better-quality services, changes in work organisation and management through greater back-office coherence and efficiency; this improves the transparency of government activities as well as citizen engagement. OECD countries are transforming government through the use of ICT and ICT-enabled governance structures, new collaboration models (*i.e.* sharing data, processes and portals), and networked or joined-up administrations. ICTs increasingly drive public-sector innovation. The e-government readiness index is a composite index which shows how prepared a country is to use ICT-enabled public administrations for greater efficiency and measures its capacity to develop and implement e-government services. The index ranges from 0 (low level of readiness) to 1 (high level). Data are drawn from the UN e-government survey 2012.

Knowledge flows and commercialisation

Public research is the source of significant scientific and technological breakthroughs. To optimise the economic and social benefits from public research and the return on public R&D investments, effective linkages are needed between academia and industry.

Knowledge flows between public research institutions and industry are channelled through spin-offs, joint research projects, training, consultancy and contract work, the commercialisation of public research output, staff mobility between workplaces and informal co-operation by researchers.

(o) Industry-financed public R&D expenditures (per GDP): Direct funding of public research by industry takes the form of grants, donations and contracts and influences the scope and orientation of public research, generally steering it towards more applied and commercial activities. The share of public R&D expenditure financed by industry is the domestic business enterprise sector's contribution to the intramural R&D expenditures of the higher education (HERD) and government (GOVERD) sectors. Data are drawn from the OECD MSTI Database and are based on harmonised national R&D surveys and national accounts.

(p) Patents filed by universities and public labs (per GDP): The pool of available public research output can be diffused and commercialised via patenting and licensing. Patents applications by universities and public research institutions cover the government sector, higher education and hospitals. They include patent applications filed between 2005 and 2009 under the PCT, at international phase, by priority date and applicant's country of residence. Patent applicant names are allocated to institutional sectors using a methodology developed by Eurostat and Katholieke Universiteit Leuven (KUL). Only countries having filed at least 250 patents over the period are included. Because there are important variations in the names recorded in patent documents, misallocations to sectors may occur and thus introduce biases in the resulting indicator. Data are drawn from the OECD Patent Database. Patent counts by universities and PRIs are expressed per billion USD GDP (PPPs). GDP data are drawn from OECD MSTI Database based on OECD National Accounts.

(q) International co-authorship in total scientific articles (%): The growing specialisation of scientific disciplines and the increasing complexity of research encourage scientists to engage in collaborative research. Production of scientific knowledge is shifting from individuals to groups, from single to multiple institutions, and from a national to an international focus. Researchers increasingly network across national and organisational borders (OECD, 2009). International co-authorship of research publications provides a direct measure of international collaboration in science. International co-authorship is measured as the share of scientific articles produced in collaboration by two or more authors from different countries between 2008 and 2010. The values are computed on the basis of the share of an institution's output which includes addresses in more than one country over the period. Data are drawn from the *SCImago Journal and Country Rank (SJR)* (*www.scimagojr.com*) by the SCImago Research Group (CSIC).

(r) International co-invention in PCT patent applications (%): International co-invention of patents is a measure of the internationalisation of research and illustrates formal R&D co-operation and knowledge exchange among inventors in different countries. International collaboration by researchers can take place either within a multinational corporation (with research facilities in several countries) or through a research joint venture among several firms or institutions (*e.g.* universities or public research institutions). International co-operation is less widespread for patented inventions than for scientific publications (OECD, 2011a). International co-invention is measured as the share in total patents invented domestically of patent applications filed under the PCT between 2007 and 2009 with at least one co-inventor located abroad. Data are drawn from the OECD Patent Database.

Human resources for innovation

Education systems play a broad role in supporting innovation because knowledge-based societies rely on a highly qualified and flexible labour force. While basic competences are generally considered important for absorbing new technologies, high-level competences are essential for the creation of new knowledge and technologies.

(s) Adult population at tertiary education level (%): The adult population with tertiary educational attainment is a measure of a country's pool of workers with advanced, specialised knowledge and skills. It indicates its potential to absorb, develop and diffuse knowledge and shows its capacity to upgrade continuously its high-end skills supply. Educational attainment affects all aspects of adult learning. Adults with higher levels of educational attainment are more likely to participate in formal and non-formal education during their working lives than adults with lower levels of attainment. Tertiary graduates are those with a university degree, vocational qualifications, or advanced research degrees of doctorate standard, at a minimum at Level 5 of the International Standard Classification of Education (ISCED) 1997. The adult population is defined as those aged from 25 to 64 years old. Data on population and educational attainment are compiled from national labour force surveys (LFS). For European countries, Iceland, Norway, Switzerland and Turkey, data are from Eurostat. Otherwise they are drawn from *OECD Education at a Glance 2011* (*www.oecd.org/edu/eag2011*) (OECD, 2011d).

(t) 15-year-old top performers in science (%): Demand for skills increasingly emphasises capabilities for adapting and combining multidisciplinary knowledge and solving complex problems. The acquisition of such skills starts at a very early age. The top performers in science are the students who reach the two highest levels of proficiency (levels 5 and 6) in the OECD Programme for International Student Assessment (PISA) 2009 science assessment (*i.e.* they have obtained scores of more than 633.33 points). The number of top performers is expressed as a percentage of 15-year-olds. Data are drawn from the OECD PISA 2009 Database (*www.pisa.oecd.org*).

(u) Graduation rate in science and engineering at doctoral level: Doctoral graduates are those with the highest educational level and are key players in research and innovation. They have been specifically trained to conduct research and are considered best qualified to create and diffuse knowledge (OECD, 2010c). They have attained the second stage of university education and obtain a degree at ISCED Level 6. They have successfully completed an advanced research programme and gained an advanced research qualification (*e.g.* Ph.D.). Graduation rates represent the estimated percentage of an age cohort that will complete the corresponding level of education during its lifetime (the number of graduates, regardless of their age, is divided by the population at the typical age of graduation). However, in some countries, graduation rates at the doctoral level are inflated by a high proportion of international students (*e.g.* Germany, Sweden and Switzerland). Science degrees include: life sciences; physical sciences; mathematics and statistics; and computing. Engineering degrees comprise: engineering and engineering trades; manufacturing and processing; and architecture and building. The rates presented combine graduation rates at doctoral level and the share of doctorate graduates by field of study. They constitute a good proxy of graduation rates in science and engineering at doctoral level. Data are drawn from *OECD Education at a Glance 2011* (OECD, 2011d) and the OECD Education Database (*www.oecd.org/education/database*).

(v) S&T occupations in total employment (%): Human resources in science and technology are major actors in innovation. HRST are defined as persons having graduated at the tertiary level of education (ISCED Level 5 or 6) or employed in a science and technology occupation for which a high qualification is normally required and the innovation potential is high. HRST occupations refer to professionals and technicians. Professionals include: physical, mathematical and engineering science professionals (physicists, chemists, mathematicians, statisticians, computing professionals, architects, engineers); life science and health professionals (biologists, agronomists, doctors, dentist, veterinarians, pharmacists, nursing); teaching professionals; and other professionals (business, legal, information, social science, creative, religious, public service administrative). Technicians and associate professionals include: physical and engineering science associate professionals; life science and health associate professionals; teaching associate professionals; other associate professionals (finance, sales, business services, trade brokers, administrative, government, police inspectors, social work, artistic entertainment and sport, religious). Data are drawn from the OECD ANSKILL Database.

Structural composition of BERD (Panel 2 of the country profiles)

A country's industrial structure determines the composition of its BERD and affects the growth prospects of its business research system.

Industrial structure

Industries and services are defined on the basis of the International Standard Industrial Classification (ISIC) Rev. 3. The sectors are classified according to their R&D intensity (R&D expenditures relative to output). Data are drawn from the OECD ANBERD Database (*www.oecd.org/sti/anberd*). ANBERD is in the process of moving to the new sectoral classification, ISIC Rev. 4, in line with the OECD STAN family of sectoral databases. In the meantime, for some countries, despite the fact that more recent data are available according to the new classification, sectoral grouping refer to earlier years.

The sectoral groupings are defined as:

Industry includes Mining (ISIC 10-14), Manufacturing (ISIC 15-37) and Utilities (ISIC 40-41) while *Services* include market sector services (ISIC 50-74) and non-market sector services (ISIC 75-99).

High-technology manufacturing include Pharmaceuticals (ISIC 2423), Office, accounting and computing machinery (ISIC 30), radio, TV and communication equipments (ISIC 32), Medical, precision and optical instruments, watches and clocks (ISIC 33), while *medium- to low-technology industries* include all other manufacturing industries.

High-knowledge market services include Post and telecommunications (ISIC 642), Financial intermediation (ISIC 65-67) and some knowledge-intensive business activities (ISIC 72-74), including Computer and related activities (ISIC 72) and Research and development (ISIC 73). *Low-knowledge services* include all other market services.

Primary-resource-based industries are those that involve the harvesting, extraction and processing of natural resources. This aggregate includes Agriculture, hunting, forestry and fishing (ISIC 01-05), Mining and quarrying (ISIC 10-14), Food products, beverages and tobacco (ISIC 15-16), Wood and products of wood and cork (ISIC 20), Pulp, paper and paper products (ISIC 21), Coke, refined petroleum products and nuclear fuel (ISIC 23), Other non-metallic mineral products (ISIC 26), Basic metals (ISIC 27) and Electricity, gas and water supply (ISIC 40-41). Owing to their low contribution to total BERD and issues of data availability, Wearing apparel, dressing and dying of fur (ISIC 18) and Leather, leather products and footwear (ISIC 19) are not included. This sectoral grouping is not represented in the charts for countries in which these industries contribute marginally to business R&D expenditure.

Firm population

Firm size: SMEs play a key role in the R&D and innovation system. They are defined as firms with fewer than 250 employees; large firms have 250 employees and more. BERD data by firm size come from the OECD RDS Database.

Role of multinationals

Foreign affiliates contribute in many ways to a host country's international competitiveness by providing domestic firms with access to new markets, introducing new technologies and generating knowledge spillovers. In particular, foreign affiliates invest a higher share of their revenue in R&D than domestic firms (OECD, 2009). In addition, in the search for new technological competences, larger local market opportunities and lower R&D costs, companies are moving their research activities abroad. The geographical origin of a foreign affiliate is the country of residence of the ultimate controller. An investor (company or individual) is considered to be the investor of ultimate control if it is at the head of a chain of companies and controls directly or indirectly all the enterprises in the chain without itself being controlled by any other company or individual. The notion of control implies the ability to appoint a majority of administrators empowered to direct an enterprise, to guide its activities and determine its strategy. In most cases, this ability can be exercised by a single investor holding more than 50% of the shares with voting rights. Data come from the OECD AFA and FATS Databases.

Revealed technology advantage in selected fields (Panel 3 of the country profiles)

The revealed technology advantage (RTA) index provides an indication of the relative specialisation of a given country in selected technological domains and is based on patent applications filed under the Patent Cooperation Treaty. It is defined as a country's share of patents in a particular technology field divided by the country's share in all patent fields. The index is equal to zero when the country holds no patents in a given sector; is equal to 1 when the country's share in the sector equals its share in all fields (no specialisation); and above 1 when a positive specialisation is observed. Only economies with more than 500 patents over the period reviewed are included. Data are drawn from the OECD Patent Database.

Overview of national research and innovation policy mix (Panel 4 of the country profiles)

This figure shows several features of national research and innovation systems that are areas of direct or indirect public intervention.

Public research

By sector of performance: Public research is traditionally performed by universities and PRIs. Although there is a general trend in the OECD area towards reinforcing the role of universities, PRIs still make a major contribution in several countries (*e.g.* China, Luxembourg, the Russian Federation). The figure shows the balance between R&D performed by universities (university-centred public research) and R&D performed by PRIs (public lab-centred public research), as a percentage of total public expenditure on R&D. Public expenditure on R&D is the sum of HERD and GOVERD. Data are drawn from the OECD MSTI Database and are based on harmonised national R&D surveys.

By mission/orientation: Most basic research is performed by universities and PRIs. Basic research is essential for developing new scientific and technological knowledge and builds the long-term foundations of knowledge societies. It is experimental or theoretical work undertaken primarily to acquire new knowledge, without any particular application or use in view. The figure shows the balance between public expenditure on R&D for basic research (basic-research-oriented public research) and public expenditure on R&D for the purpose of applied research and experimental development. Total public expenditure on R&D is the sum of HERD and GOVERD. Data are drawn from the OECD RDS Database and are based on harmonised national R&D surveys.

By socioeconomic objective: Government budget appropriations or outlays for R&D (GBAORD) by socioeconomic objective indicate the relative importance of various socioeconomic objectives, such as defence, health and the environment, in public R&D spending. These are the funds committed by the federal/central government for R&D (GBAORD generally covers only the federal or central government). Programmes are allocated according to socioeconomic objectives on the basis of intentions when the funds are committed and may not reflect the actual content of the projects implemented. They reflect policies at a given moment in time. The classification used is the European Commission's Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets – NABS (see the OECD *Frascati Manual*). The GBAORD data are based on funders' reports; they are less accurate than "performer-reported" data, but they are more timely and can be linked back to policy issues by means of a classification by "objectives" or "goals". Data are drawn from the OECD RDS Database and based on budget data assembled by national authorities using statistics collected for budgets.

Civil GBAORD includes total GBAORD less defence. Defence R&D financed by government includes military nuclear and space but excludes civilian R&D financed by ministries of defence (*e.g.* meteorology).

Generic public research includes: general university funds (GUF), a block grant which includes an estimated R&D content, granted by government to the higher education sector; and non-oriented GBAORD, which covers research programmes financed with a view to the advancement of knowledge. Thematic public research includes all other GBAORD.

By funding mechanism: Governments support public research by means of institutional and project-based funding. Institutional block grants provide stable long-run funding of research, while project-based funding can promote competition within the research system and target strategic areas. Project funding is defined as funding attributed on the basis of a project submission by a group or individuals for an R&D activity that is limited in scope, budget and time. Institutional funding is defined as the general funding of institutions with no direct selection of R&D projects or programmes (OECD, 2010c). The figure shows the balance between institutional funding and project funding for selected OECD countries. Data are based on an exploratory project carried out by NESTI on public R&D funding (Van Steen, 2012).

Public support to business R&D and innovation

Private investment in R&D and innovation may be below a socially optimal level, mainly because returns are uncertain or the innovator cannot appropriate all of the benefits. Governments therefore play an important role in fostering investment in R&D and innovation. They can choose among various tools to leverage private-sector R&D. They can offer firms direct support via grants, loans or procurement or they can use fiscal incentives, such as R&D tax incentives (R&D tax credits, R&D allowances, reductions in R&D workers' wage taxes and social security contributions, and accelerated depreciation of R&D capital) (Colecchia, 2007).

In relative terms with public research: Governments support both public-sector research and business R&D and innovation but in different proportions. Most public money spent on R&D goes to universities and PRIs. However, public support to business R&D seems to have gained ground in many countries over the past five years. The figure shows the relative balance between government funding to universities and PRIs and government funding to business R&D. The former is defined as the sum of HERD and GOVERD funded by both government and higher education. The latter is defined as the sum of government-funded BERD and the estimated cost of R&D tax incentives, if any. The balance is expressed as a percentage of the sum of the two. Data are drawn from the OECD RDS Database and data on R&D tax incentives collected by NESTI in 2010 and 2011.

By funding mechanism: Direct R&D grants or subsidies target specific projects with high potential social returns. Tax credits reduce the marginal cost of R&D activities and allow private firms to choose which projects to fund. The optimal balance of direct and indirect R&D support varies from country to country, as each tool addresses different market failures and stimulates different types of R&D. For instance, tax credits mostly encourage short-term applied research, while direct subsidies foster more long-term research. Direct government funding of R&D is the amount of business R&D funded by the government as reported by firms. It is the sum of different components (contracts, loans, grants/subsidies) with different impacts on the cost of performing R&D. R&D grants and loans decrease the cost of performing R&D, but contracts (usually awarded through competitive bidding) do not directly affect the cost of performing R&D. Foregone revenues on R&D and innovation tax incentives are an estimated cost of the R&D tax concession. As the cost of tax incentives is estimated and reported in different ways across counties, these indicators are experimental. Eligible R&D expenditures can differ, and companies may use R&D tax incentives in some circumstances to fund intramural or extramural R&D, some of which may take place in other sectors. Tax incentives are excluded from the definition of government-funded BERD to minimise the risk of double counting. Data are drawn from the OECD RDS Database and from data on R&D tax incentives collected by NESTI in 2010 and 2011.

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