B 4 ECONOMIC ASSESSMENT OF PUBLIC R&D FUNDING

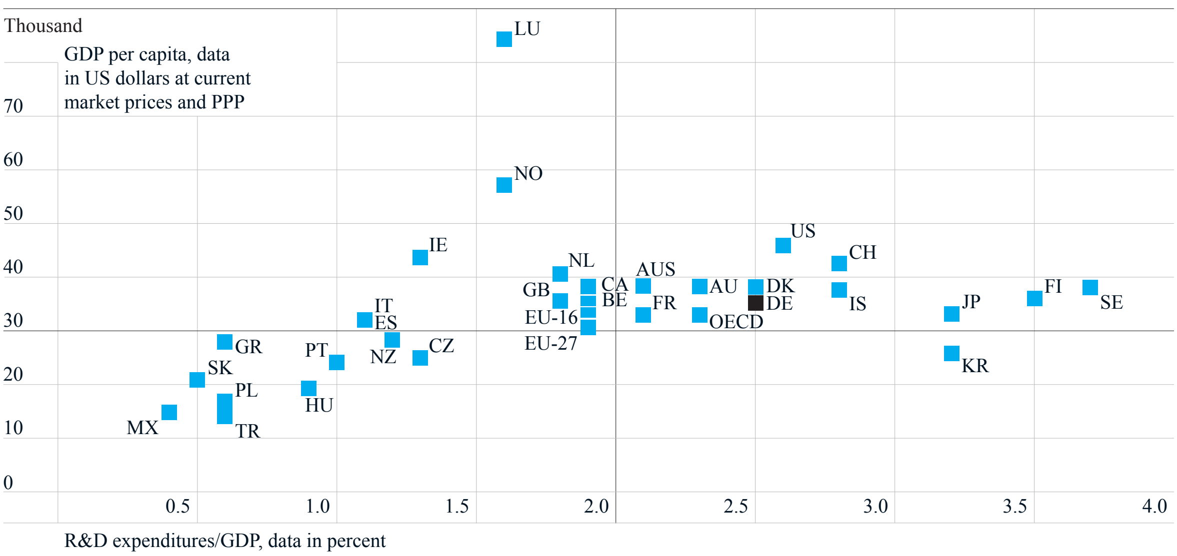
Research and development (R&D) are essential driving forces for an economy's international competitiveness and long-term growth.[286] The R&D process leads to the creation of new knowledge and contributes to the development of innovations. Hence, investment in R&D can be regarded as an instrument for increasing prosperity of knowledge-based industrialised countries. Figure 19 illustrates the link between national R&D expenditures and the gross domestic product (GDP) per capita. Typically, countries with a high GDP per capita display an R&D intensity of 2.0 to 3.6 percent; these are located at the upper right area of the chart. Countries with a low GDP per capita usually invest a smaller proportion of GDP in research and development (0.5 to 1.5 percent according to the diagram at the lower left area of Figure 19). As a general rule, long-term growth and a sustainable increase in productivity can only be achieved via a high level of R&D investment.[287]

On average, 64 percent of R&D funding in the OECD countries is attributable to the private sector, and 28 percent to the public sector.[288] The individual OECD countries pursue different strategies of mixed financing: in some of the economies the proportion of public funding of R&D activities is relatively high; these countries include France (39 percent), Great Britain (31 percent), and Canada (34 percent). In Germany, the proportion of R&D funded by the public sector amounts to 28 percent, thus corresponding to the OECD average. The difference is even more remarkable when one compares the allocation of public R&D expenditures. In the course of the last decade, many countries supported the particularly dynamic expansion of R&D in the private sector with targeted funding measures, while Germany remained largely reluctant in this regard. The major part of Germany's public R&D expenditures is still channeled into public R&D activities – the proportion of financing allocated to private R&D activities is relatively low in Germany.[289]

In light on these figures, the key questions to be asked include the following: why should governments conduct R&D activities, or support R&D activities? How can limited public resources be distributed to different funding measures and priority areas? How can the effectiveness of public measures be systematically monitored?[290]

GDP per capita and proportion of national R&D expenditures of GDP

FIG 19



Annual average values, 2006 – 2008 period.
Source: own chart and calculations based on OECD figures.
For country abbreviations, please refer to the list of abbreviations in the appendix of the report.

Rationale for public R&D funding

From an economic perspective, the implementation of public R&D activities and the funding of private R&D activities by the public sector are fully justifiable.[291] It is often the case that businesses that conduct research are not capable of appropriating the entire returns derived from their R&D activities. Other stakeholders, such as competitors, suppliers and clients, may gratuitously take advantage of the knowledge created in the R&D process and use it for newly developing or advancing their own products and processes (cf. Box 16). When deciding on the level of expenditure for R&D, businesses that strive for profit maximisation take into account only the private returns from their R&D activities. This leads to underinvestment in R&D, since the impact on the knowledge created by R&D on other economic stakeholders is not sufficiently taken into account. Measures on the part of the public sector can at least partially contribute to balancing out this market failure.

When supporting R&D activities, governments may prioritise the expansion of public research, or, alternatively, focus on promoting the implementation of R&D in the private sector. In Germany, the proportion of public R&D expenditures amounts to approximately one third of the total economy's R&D expenditures; the remaining two thirds are attributable to private expenditure. The largest part of public R&D expenditure is allocated to higher education institutions (39 percent) and non-university research institutions (48 percent); 13 percent of public spending go to the promotion of R&D activities in the private sector.

There are two types of public research financing: institutional funding and project funding. Institutional funding comprises basic funding of higher education institutions and non-university research institutions, which also includes federal department research institutions. The Federal Government here largely focusses on the financing of basic research. Due to particularly strong external effects, as described in Box 16, the private sector is engaged in this area only to a limited extent. Because of this, public funding in basic research is particularly important. While basic research in Germany is also supported by means of project funding (e.g. from the German Research Foundation), the largest proportion of resources for project funding is allocated to application-oriented research.

When supporting R&D in the private sector, the focus is primarily on pre-competitive and application-oriented research. Here, several instruments are available to the government. In most cases, project support is granted within the framework of specialised programmes that aim to promote certain technologies. For example, the BMWi's specialised programme ATEM supports research and development on propulsion systems for electrical and hybrid vehicles. As regards funding programmes that are not linked to a particular technological field, the government does not exert an influence on the type or contents of technologies funded. An example for this type of funding would be the Federal Government's "Central Innovation Programme for SMEs" (ZIM), which provides grants and low-interest loans for financing research and innovation projects of small and medium-sized enterprises.

An indirect type of funding is the granting of tax credits for R&D. In economic terms, tax credits reduce the marginal costs of implementing R&D activities. This is an instrument that is available in the majority of OECD and EU member states. To

BOX 16

Non-rivalry and non-exclusivity of knowledge

From an economic point of view, knowledge is characterised by two important features. First, it is characterised by non-rivalry in consumption: if one stakeholder uses knowledge, this does not decrease the utilisation possibilities of another stakeholder. Second, other stakeholders cannot, or only to a limited degree, be excluded from the utilisation of knowledge (non-exclusivity). If the knowledge created by an innovation-generating company comprises these two features, competing stakeholders can make use of the knowledge gratuitously. In economic reality, this situation is most frequently found in the area of basic research. In applied research and development however, businesses can try to keep the knowledge created by R&D confidential, or limit the use of this knowledge by third parties via intellectual property rights such as patents. Yet, in most cases both of these measures can only partially compensate for the existing market failure.

date, Germany has not made any use of this type of funding.

Positive effects of basic research

Despite the fact that the government allocates extensive funding in basic research, it is very challenging indeed to quantify the returns generated from this. One of the reasons for this is that the knowledge generated by basic research is only rarely available in codified form; more often than not, it takes the form of implicit knowledge. Hence, when transferring this type of knowledge, problem solution processes and learning processes based on experience play a major role,[292] which are generally difficult to measure statistically.

Despite these constraints, numerous studies have been conducted over the last few years that set out to document the impact of publicly-funded basic research on private businesses.[293] Interviews with companies, as well as economic surveys, suggest that collaboration with publicly funded research facilities has a positive impact not only on the development of new products, but also on the companies' revenue. Beyond this, surveys have also shown that stakeholders attach great importance to informal exchange between private businesses and publicly funded research organisations.[294]

Moreover, basic research conducted at higher education institutions and non-university research institutions considerably contributes to the training of highly skilled employees. Following the completion of their training or scientific work, these individuals usually find employment at public research institutes or in the industrial sector. For private companies with complex work processes, the analytical problem-solving skills of these employees are often indispensable. Thus is seems obvious that the personnel transfer of scientists from publicly funded research leads to positive effects; yet it remains difficult to quantify these effects more precisely.[295]

Public R&D funding creates incentives for additional R&D activities in the private sector

Over the last few years, there have been numerous studies analysing the impact of public R&D funding on the R&D expenditure of private enterprises. These studies confirm that public R&D investments result in an increase in R&D expenditure in the private sector.[296] It has been feared that funded businesses would substitute private R&D expenditure by public funding resources. Yet, these concerns can be invalidated as it has been shown that such knock-on effects usually occur to a relatively small extent.[297] To date, scientific research has not yet been able to draw a consistent picture of the exact level of funding effects. It can be observed that privately financed R&D expenditures of publicly funded companies are 15 to 40 percent higher than those of businesses that do not receive public funds.[298]

Macroeconomic effects of public R&D funding

As a rule, not only the research entity itself benefits from knowledge generated through R&D activities; other companies also obtain indirect revenues generated by means of knowledge spillover. Empirical surveys confirm the existence of such indirect revenue and demonstrate that this can reach a similar level as the direct revenue achieved by businesses that have invested in their own R&D.[299]

Yet, these surveys also indicate that the degree of knowledge spillover depends on the extent of the research activities by a business benefitting from external factors. Thus not all companies equally benefit from external knowledge. The important factor here is whether a company possesses sufficient competence to utilise the knowledge that exists in other companies.[300] This competence is usually strengthened by a company's own R&D activities.

Any public funding that aims to create domestic welfare gains also needs to consider the relationship between national knowledge spillover and international flows of knowledge. In some of the cases, research results can be transformed much more swiftly into added value by going abroad. This is an issue that has been explicitly addressed by more recent research on international knowledge spillover. Small, open economies such as Canada or Sweden are particularly affected by these effects.[301] Yet, the following findings also apply to Germany: funding impact cannot be strong if research is not met with a sufficiently strong industrial environment, or if the absorptive capacity of domestic companies is insufficiently developed for innovation. In such cases research might be extensively promoted in Germany, but the industrial implementation of the innovation is largely conducted abroad.

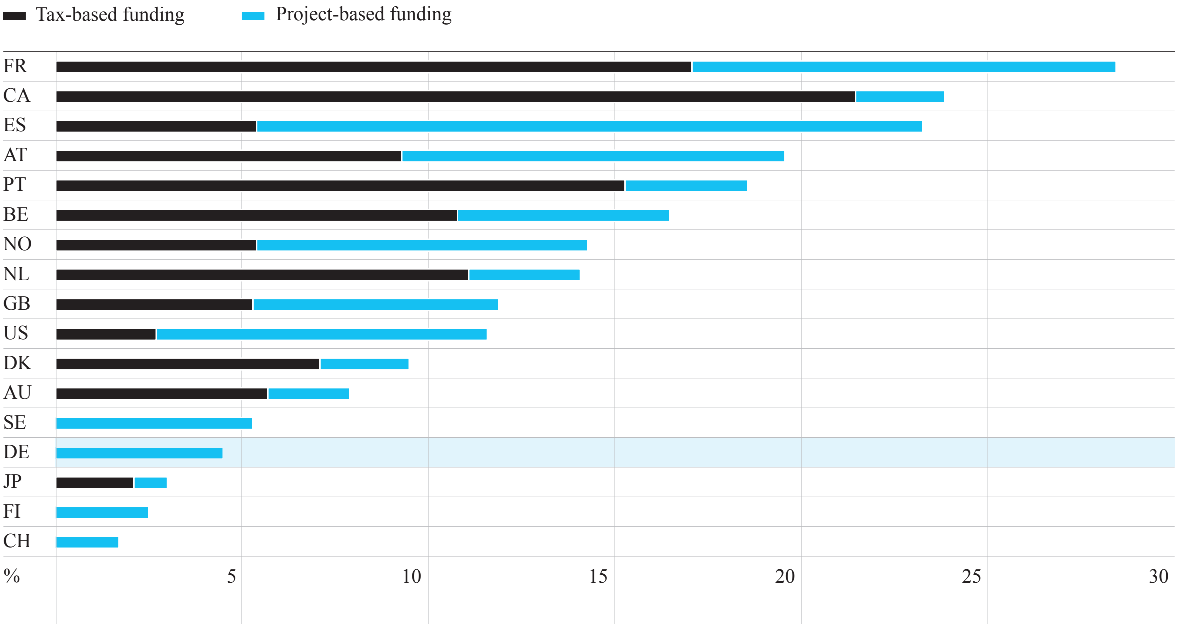
Because of this, the main focus of public research funding should be on areas that already have a highly developed national innovation system, or those areas where chances that such a system can be built up successfully are sufficiently high. This is also known as the ecology of innovation.[302] In addition to highly developed scientific research, ecology of innovation also includes effective collaboration between higher education institutions and industry, the existence of companies with onsite R&D facilities, the availability of venture capital, a highly developed patent system, as well as state regulations that support the innovation process in the respective field. All of these elements create reinforcement mechanisms and contribute to a strong domestic impact of publicly funded research.

R&D tax credits generate additional R&D expenditure in the private sector

Today, 26 of the 34 OECD countries and 15 of the 27 EU member states offer tax credits for R&D. In several OECD countries, the proportion of tax-based R&D funding already exceeds the proportion of direct public funding (cf. Figure 20).

Yet, the structuring of R&D support differs considerably across countries.[303] Regardless of these differences, several evaluation studies have confirmed[304] that tax-based R&D funding leads to an increase in private R&D expenditures.[305] The Industrial Research and Innovation Council (IRIC), a Canadian expert committee, recently presented a comprehensive assessment of tax-based R&D funding.[306] The report stresses the key importance of R&D tax credits as a measure that benefits SMEs in particular.[307] Moreover, many countries successfully use R&D tax credits as an instrument for attracting foreign investment.[308] Thus tax-related R&D funding has long become an instrument for competing business locations.[309] If Germany refrains from introducing tax credits for R&D, it will run the risk of fading into the background in the global competition for locations for multinationals and research-intensive industries.[310]

FIG 20 **Proportion of R&D expenditures in the economic sector that are directly or indirectly funded by the government, 2008** (figures in percent)



Source: OECD Main Science and Technology Indicators 2011-1 and OECD STI Scoreboard 2011.
Calculations by ZEW.

BOX 17

Tax-based R&D funding

A recent study[311] analyses the organisational options and the anticipated effects of introducing fiscal R&D support measures in Germany. The authors of the study point out that the current German tax law contains a number of innovation-hampering provisions. These include the discrimination of self-financing as opposed to external financing, limited options for offsetting losses, as well as the treatment of intangible assets in terms of trade tax and cross-border function relocation.

The authors of the study further state that the aim of fiscal R&D support is to directly strengthen economic growth. To implement the measure planned in the Federal Government's coalition agreement, the study recommends volume-based funding that grants a tax credit that is proportional to the level of a company's R&D expenditure. A funding rate of 10 percent (for all companies)[312] would result in initial tax losses of approximately EUR 4.75 billion. A funding rate of 5 percent would result in tax losses of approximately EUR 2.38 billion. A particularly interesting approach according to the authors is the granting of tax credits for R&D personnel expenses, which could then be set against the wage tax that is payable on a monthly basis. This would result in immediate liquidity effects for the respective companies.

In addition to assessing the fiscal costs of tax-based R&D funding in Germany, the study also assesses the macroeconomic impact of R&D funding. When transferring relatively reliable results from international surveys to the German context, it can be assumed that for each euro of tax income that is lost to the public sector, EUR 1.25 of additional R&D expenditure is being generated. Based on fairly conservative parameter assumptions[313], the survey identifies the economic net benefits of this measure as approximately EUR 750 million.[314] This corresponds to approximately 15 percent of the financial volume invested. R&D funding of 10 percent would correspond to an increase in growth of 0.1 percentage points of GDP. Alongside its economic effectiveness, a major advantage of this measure is that businesses can decide if, when and how to invest in R&D – irrespective of government decisions and application procedures.

Already in its earlier reports, the Expert Commission indicated that the instrument of fiscal R&D support can be flexibly adapted. Should the government wish to use the instrument for limiting tax losses, tax credits could be capped, or, alternatively, large companies could be subjected to lower funding rates. This would concentrate the effect of funding on small and medium-sized enterprises, which is justifiable seeing that restrictions on financing have a stronger impact on SMEs than they have on large-scale enterprises. Yet, such an adaptation of the measure would contribute to securing the location only to a lesser extent, since it is primarily large-scale enterprises that relocate their R&D facilities. Thus it has been the case that major German car manufacturers have relocated large parts of their R&D activities to Austria to benefit from R&D tax credits there.

Improving impact analysis

Improved efficiency of fiscal R&D support can also be expected from strengthening and qualitatively advancing impact analysis. The last few years have seen the development of scientifically founded procedures for improving the evaluation of R&D funding measures. Yet, innovation research is far from systematically using impact analysis as a method of evaluation. In contrast to this, labour market research has made substantial progress in analysing the impact of public support ever since the 1990s. The integration of systematic evaluation standards has established a robust basis for analysing measures conclusively. In this regard, the specification of control groups has been particularly important.[315] Surveys in innovation research that integrated control groups into their analysis have also achieved significant initial results. This has been the case e.g. in the context of evaluating the *High-Tech Gründerfonds*[316] programme, and also in the context of evaluating the promotion of technology and innovation among medium-sized companies.[317]

Developing a suitable data infrastructure

Even at this stage, the Federal Government collects data that are essential for an impact analysis in their R&D funding databases. Yet, there is no provision for allowing unlimited use of data for the purpose of academic research. The Expert Commission therefore asks the Federal Government to provide scholars with unbureaucratic access to the data available in its R&D funding databases.[318]

In addition to merely making existing data available, it is also vital to develop a reliable, coherent data infrastructure. Other countries have already made initial achievements in this field. Belgium and Brazil, and most notably the United States, can be regarded as pioneers in the development of databases that consolidate information on public research funding, while also documenting scientific results and the effects of funding measures (cf. Box 18). Since the establishment of such databases has proved positive in several other countries, the Expert Commission recommends introducing comparable projects in Germany.

BOX 18

The STAR METRICS programme

STAR METRICS (Science and Technology for America's Reinvestment: Measuring the Effects of Research on Innovation, Competitiveness and Science) is a collaboration between the White House Office of Science and Technology Policy (OSTP), the National Science Foundation (NSF) and the National Institutes of Health. The programme aims to develop a single data infrastructure that will provide a basis for a standardised evaluation of research projects in the United States. By bundling administrative tasks in reporting, the programme will soon allow for a comprehensive cost-benefit analysis of research projects. STAR METRICS was launched in 2009 with a total of seven research institutes involved. In 2010, as many as 60 research institutes were participating in the programme, while another 50 institutes have expressed an interest in future collaboration.

The development of the STAR METRICS programme can be divided into two phases. The first phase aims to record the direct impact that public-sector investment in research has on the employment situation in the science sector. Since the required data are collected in the participating research facilities themselves, this first phase primarily allows for a systematic impact analysis of existing data. In the second phase, it is attempted to broadly document the scientific, social and economic effect of investment in research. Prior to the start of the survey, representatives from the government and the research institutes are integrated in order to decide on the reporting form and establish uniform evaluation indicators and methods. To date, numerous pilot projects have been initiated within the framework of STAR METRICS. With this programme, innovation research is following successful examples that have been set in education, labour and health research.[319]