Public versus private funded business R&D: Sector specific specialisation indices as a tool for policy analysis

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1 Introduction

In the future development of the European Research Area the ability of government policy instruments supporting business research activities to spur private R&D investments and the responsiveness of public and private R&D bases are key issues. The efficient use of public support measures is a precondition in order to contribute to the Barcelona objective of increasing R&D intensity within the EU to 3 percent by 2010 and to increase the private sector's financing share to 66 percent of total R&D spending. Sophisticated and ready to use evaluation tools are needed as there is a growing interest in analyzing the effectiveness of public support.

The discussion hereby is an attempt to provide a methodology for analysing in particular the role of direct public funding of business R&D. Against this background of a steady decline of publicly funded R&D performed by the private business sector we analyse the specialization of public and private funded business R&D by sector of performance in order to investigate the interrelation between them.

For a selection of two large European countries (Germany, United Kingdom) and two smaller ones (Austria, Norway) we pursue an analysis following the major concept of R&D specialisation by means of a revealed comparative advantage analysis (see Grupp, 1997). The article bases upon a feasibility study on public R&D specialisation conducted within the framework of the EU funded ERAWATCH Network[1], which surveys national research policies, structures, programmes and organisations.

Our primary research question is whether and to which extent R&D specialisation indices can be used as a tool for R&D policy analyses ultimately aiming at enhancing the efficiency and effectiveness of public R&D policies so as to support business R&D. We claim that country specific public and private RTD funding specialisation indices based upon data in the OECD Research and Development database provide a thorough and valuable basis for pursuing new approaches and hypotheses of policy analysis in the respective countries.

[1] http://cordis.europa.eu/erawatch/

For the purpose of the analyses the paper is structured as follows: We first review the role of direct public funding of business R&D and underline that the analyses of business R&D funding is crucial in devising efficient policy making geared towards higher private investments in R&D. We then develop a methodology/model for analysing sectoral public and private R&D specialisation and explain how the methodology can be used as a tool for policy analysis. The model is applied to a set of countries in order to illustrate its use. We finally comment on the relevance of the model and outline paths for further research.

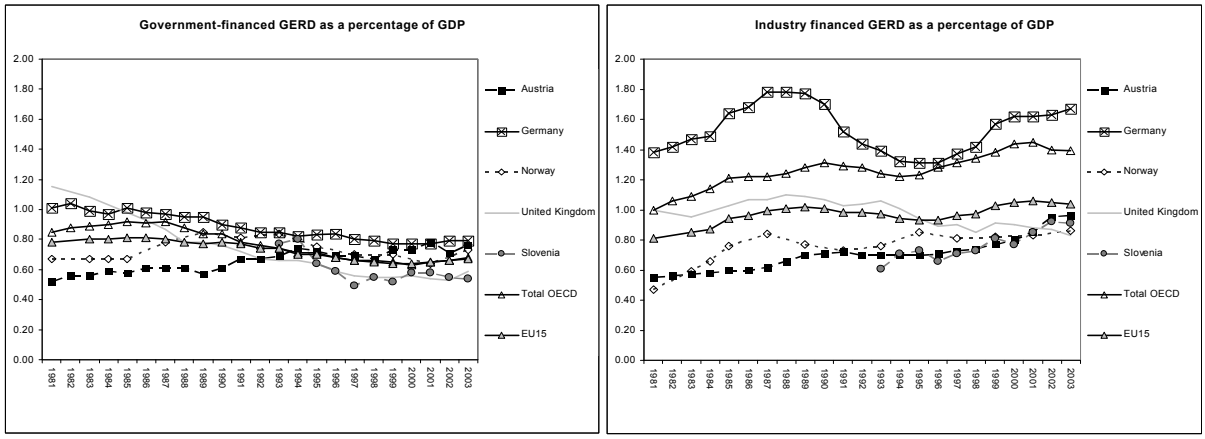
2 The role of direct public funding of business R&D

Governments may have different intentions concerning the public funding of R&D, which results in differing sector, technological or field-specific profiles across countries. What is rather similar is the motivation behind this: the main reasons are a large public interest and/or market failures or market mechanisms respectively, which would result in an underinvestment in certain fields (Arrow, 1962). Companies tend to be reserved/risk aversive in areas of high uncertainty and markets may fail where the necessary investment is too large to be undertaken by one company. Public funding of private R&D may also take place where the competitiveness or other market thresholds are seen to be too high for a national company or institution, but where a public interest is evident. The latter is the classical case of start-up or knock-on financing in new and emerging fields. The system failures rationale (Smith, 1998) such as path-depending developments which cause lock-in problems and transition/adaption problems may rationalise public R&D support to the private sector is another prominent reason which may call for public interventions. Finally, public authorities may just need to "buy" the R&D services from the private sector. This is mainly service project funding directed, for example, to private research institutes or to technical and engineering offices to get expert's opinions and is therefore a matter of public procurement of R&D services.

The effectiveness of public financing of business R&D has important policy dimensions. Governments need to justify for public expenditures and whereas the above mentioned rationales provide theoretic legitimation of public intervention governments' aims in providing funds for business R&D go far beyond considerations of market and business failure. Public investments in RTD are seen as a key for fostering overall economic performance in the European Union. The Barcelona target calls that overall spending on R&D and innovation in the EU should be increased with the aim of approaching 3% of GDP, where two-thirds of this new investment should come from the private sector. Policy should make Europe more attractive for its best brains and promote new technologies. The Kok report (EC, 2004) recalls that up to 40 % of labour productivity growth is generated by R&D spending and that there are powerful spillover effects into other areas of the economy, depending on the way in which the money is spent. Governments need to choose appropriate public support measures and invest in sectors in which public investments may substantially boost private investments in RTD. But, do/did governments invest in the "right" sectors, and which funding strategies as regards supporting business R&D should be followed?

Figure 1 firstly provides a differentiated picture of government funded research. Changes in total R&D intensity have been accompanied by a structural change in R&D funding. For the OECD area, the level of government financed R&D as a percentage of GDP has decreased in the last two decades whereas the level of industry financed R&D as a percentage of GDP has increased.

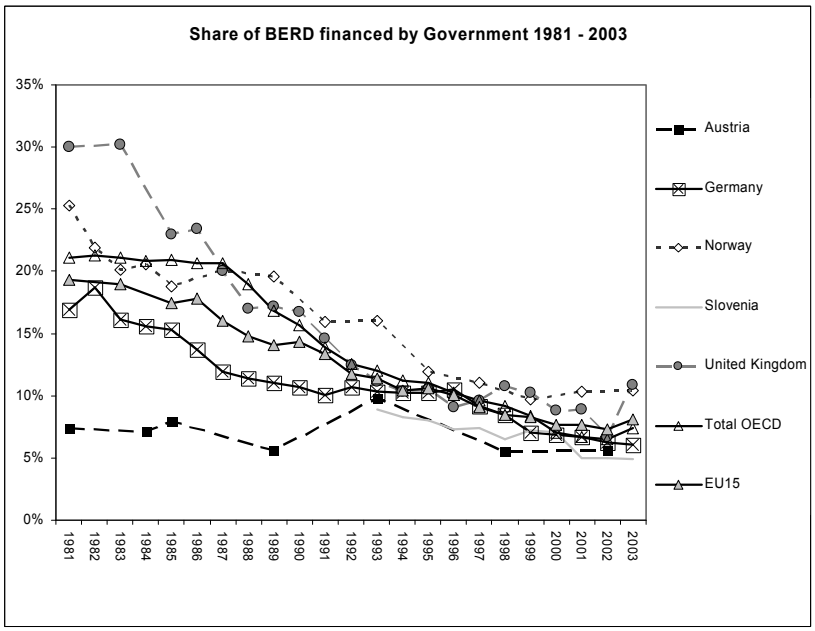
Notable exceptions in the sample countries are the UK where both government and industry financed R&D have decreased, and Austria where financing from both government and industry has increased.



Source: OECD MSTI 2005-2

Figure 1: Industry and Government financed GERD as a percentage of GDP

Furthermore, Figure 2 shows that the development of Business R&D differentiated by funding sources hides an enormous structural change in all OECD countries with the exception of Austria.



Source: OECD MSTI 2005-2

Figure 2: BERD financed by Government 1981 – 2003

In the OECD area the level of government funding in intramural business R&D declined from 23% in 1980, to 17% in 1990, and finally to a mere 7.4% in 2003. The more or less steady decline of BERD financed by government may relate on the one hand to a paradigm change in research

policy moving away from so called “mission oriented” R&D policy, on the other hand data also reflect a long-term reduction of defence R&D for the EU-15 whereas the US have increased considerably R&D expenditures from 2001 onwards (for a detailed discussion see Schibany and Streicher, 2005).

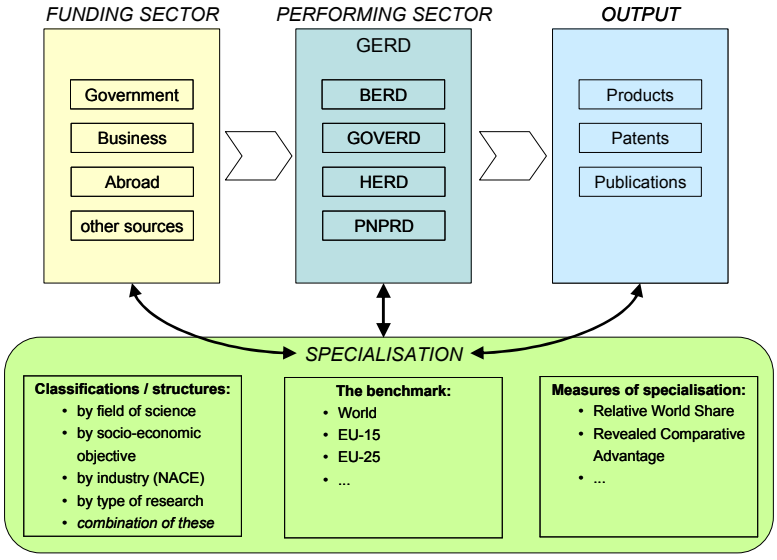
3 A methodology for analysing sector specific R&D investment

Against the outlined background of declining public R&D funding for the business sector, which makes the efficient use of public R&D investments even more important, we analyse the specialization of public and private funding of business R&D in order to investigate the interrelation between them. As the focus is on the analyses of specialisation of government funding of BERD (GBERD) by sectors versus private funding of BERD by sectors, we define BERD and GBERD as follows:

1. BERD is defined as all intramural business R&D financed by the enterprise sector plus all funding from abroad. This means that possible the EU grants for eligible private enterprises are included within BERD, as funding from abroad includes both private and supranational (EU) funds.

2. On the other hand GBERD is defined as all public R&D funding of BERD. Hence it includes all R&D funding from the federal state, federal regions, and municipalities.

Figure 3 displays the general notion of an R&D system in accordance with the OECD Frascati terminology. Several funding sources (left) provide money for R&D which is carried out in different performing sectors (centre). The outcome of this R&D work is mainly new products, patents or publications (right).



Source: Joanneum Research, InTeReg

Figure 3: Conceptualising the specialisation in R&D

Each of these three dimensions and their respective subgroups displays a specific specialisation. Hereby, the term 'specialisation' needs some elaboration:

1. Classifications are needed to answer the question 'what is the area of specialisation?' For this, several classifications are proposed by the OECD Frascati Manual (OECD, 2002) and provided by statistical offices, such as the field of science, the socioeconomic objective or the industry sector (NACE/ISIC) in which R&D funds are invested or the type of research that is sponsored. Especially, as regards classifications on the emphases/orientation of public R&D funding one has to be aware that information on these classifications is scarce. Only GBAORD data is categorized according to some of these subgroups, whereas the remaining funds are not further classified. Similarly, research output is not normally arranged under most of these headings.
2. Since specialisation is a relative term, a benchmark is needed that shows in which areas a given country is specialised compared to this benchmark. The selection of the benchmark has, of course, a severe impact on the result, but at the same time it is heavily influenced by the availability of data.
3. Specialisation needs to be measured with a particular parameter. The most commonly used indicators are related to trade specialisation, namely the revealed comparative advantage (Balassa 1965) even though alternative measures might be available.

In our case the *area of specialisation* under investigation is the relationship of public and private R&D investment at the sector specific NACE 2 digit level of business enterprise. Our data stem from the OECD – Research and Development Statistics database (formerly "Basic Science and Technology Statistics), for which details on national specifications and comparability issues are available in OECD (2004)[2].

Our benchmark is a virtual "world benchmark" consisting of a pool of countries under investigation. Within the ERAWATCH project the focus was on EU-25 plus accession and candidates countries and plus US and Japan[3]. Unfortunately, data availability on government funding of business R&D at a disaggregated level was only available for a limited range of countries. Especially data availability for the United States was too scattered, which prevented us from including the USA in the benchmark. Hence, we decided to construct a benchmark-world consisting of four countries especially tackled in the framework of the ERAWATCH R&D specialisation project (Austria, Norway, Germany and United Kingdom), plus a selection of European Union countries (France, Italy, Spain, Poland, Finland, Sweden) plus Japan. Hence, the benchmark of countries for which the methodology of assessing R&D specialisation consists of a proper mix of large and small countries.

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[3] Japan does not report data for sector "office mach etc." (30). This data seems to be included in sector "electr. equipment" (32). As Japan has a high influence on the benchmark and also some activities in these fields that are not displayed properly, a correction method was applied. The correction method is that 20% of total BERD and GBERD of these two sectors have been assigned to sector 30 and 80% to sector 32. This seems to be a rather arbitrary selection. However, the specialisation profiles especially in sector 30 are closer to reality after this correction. Otherwise the performance of this sector in most countries would have been overestimated.

As parameter or metrics to determine BERD and GBERD specialisation we use the Revealed Comparative Advantage (RCA) methodology according to the formula of Balassa (1965). This RCA value, also known as the Relative World Market Share (RWS) (Grupp 1997) has the following definition:

$$RCA_{ki} = 100 \times \tanh \ln\left((GBERD_{ki} / \sum_i GBERD_k) / (\sum_k GBERD_{ki} / \sum_{ki} GBERD_{ki})\right)$$

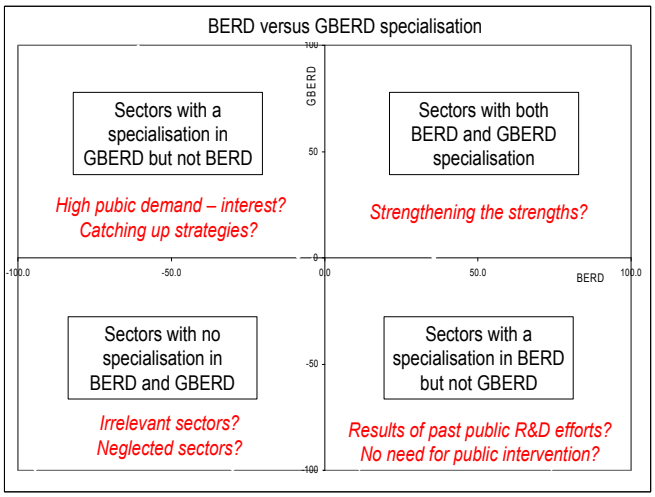
with $GBERD_{ki}$ indicating the amount of government funding of country k in the economic sector i. (Grupp, 1997).

LN centres the data around zero and the hyperbolic tangent multiplied by 100 limits the RCA values to a range of +100 to -100. Positive values for sector i point to the fact that the sector has a higher weight in the portfolio of the country than its weight in the world (all government funding from all countries taken together). Negative values indicate specialisation of government funding below the average, respectively. The RCA indicator allows the assessment of the relative position of an economic sector in a country beyond any size effects. Neither the size of the technological field nor the size of the country has an impact on the outcome of this indicator. Therefore, it is possible to directly compare countries and technologies.

4 A tool for policy analysis

The performance of the analyses according to the concept of public and private business R&D specialisation results in four distinct specialisation quadrants portrayed in Figure 4:

1. Sectors with **neither specialisation in BERD nor in GBERD** (lower left quadrant)
2. Sectors with **a specialisation in BERD and GBERD** (upper right quadrant)
3. Sectors with a **specialisation in BERD but none in GBERD** (lower right quadrant)
4. Sectors that display a **specialisation in GBERD but not in BERD** (upper left quadrant)



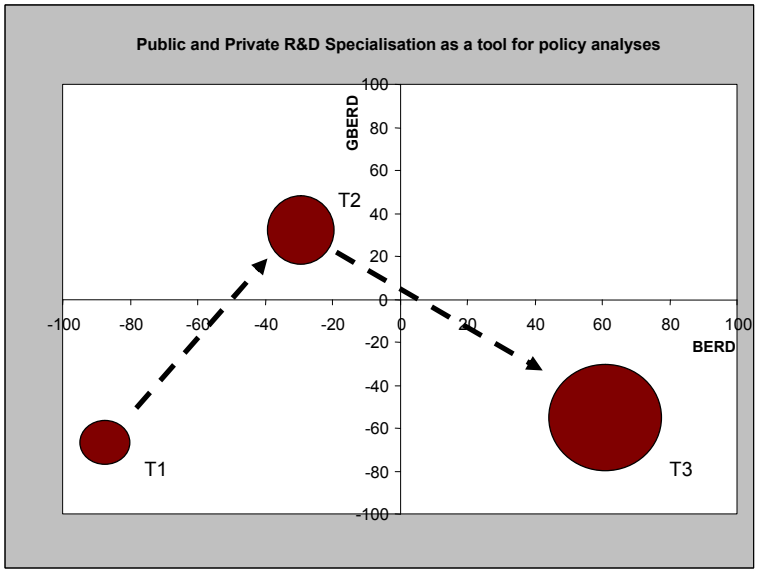
Source: Joanneum Research

Figure 4: BERD and GBERD specialisation

The resulting picture firstly shows the extent of correlation between public R&D specialisation and private R&D specialisation. Secondly, it allows distinguishing between sectors of higher and lower public interest. For example, the upper right quadrant may be interpreted as a sector of "strengthening the strengths". The lower right quadrant may be interpreted either as the results of public R&D efforts (needs to be proved), sectors with no need for public specialisation, or sectors for which public support mechanisms other than R&D funding apply. The upper left quadrant could point to sectors with high public demand/interest. It may also reflect public catching up strategies or sectors with market restrictions.

Though the interpretation is not straightforward one may link public and private specialisation patterns of business R&D with institutional aspects of business R&D funding or national thematic research policies geared towards the business sector in order to find evidence on the interrelation of public and private R&D.

We have to be aware that the analysis has its limitations as it is cross-sectional, thus it ignores issues related to dynamics: present business R&D specialisation may be the result of past funds provided by government, and current public specialisation may result in BERD specialisation in the future. This could result for instance in patterns in which the constructed variables of BERD specialisation and Government funding of BERD specialisation (GBERD) specialisation move independently from each other. On the other hand, the issue of dynamics makes this easy to use methodological tool also interesting, as the concept allows tracing changing patterns of public and private R&D investments benchmarked against of the international context. Figure 5 exemplifies the 'movement' of a sector through the diagram, indicating its overall growth (size of the circle), its relative private specialisation (the horizontal axis) and the relative public specialisation (vertical axis) over time. Hence, the tool could be used as a method to survey the effects of public investments in specific sectors of private R&D as well as a 'warning system' or monitoring device which indicates increasing specialisation or de-specialisation of sectors.

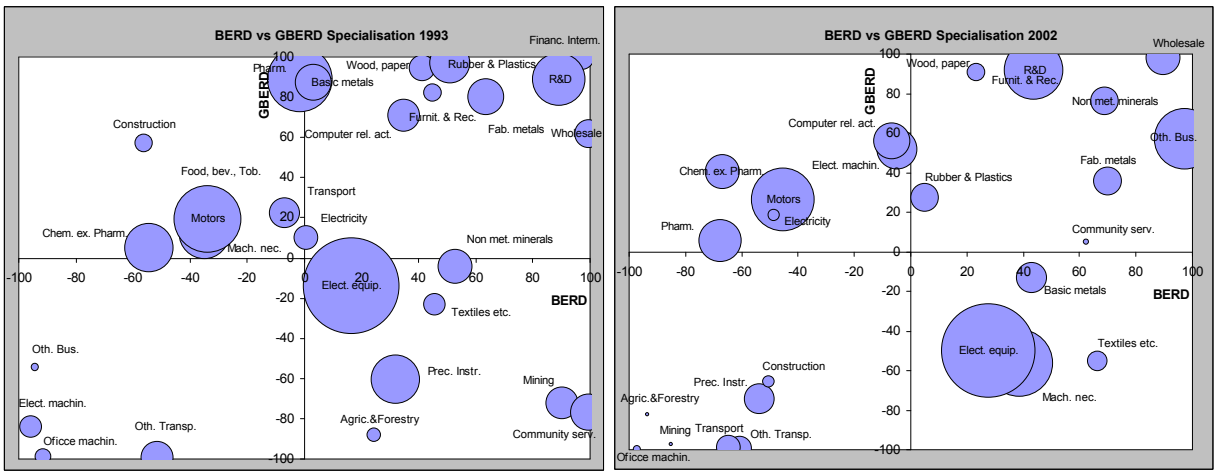


Source: Joanneum Research

Figure 5: BERD and GBERD specialisation as a monitoring tool for public policy

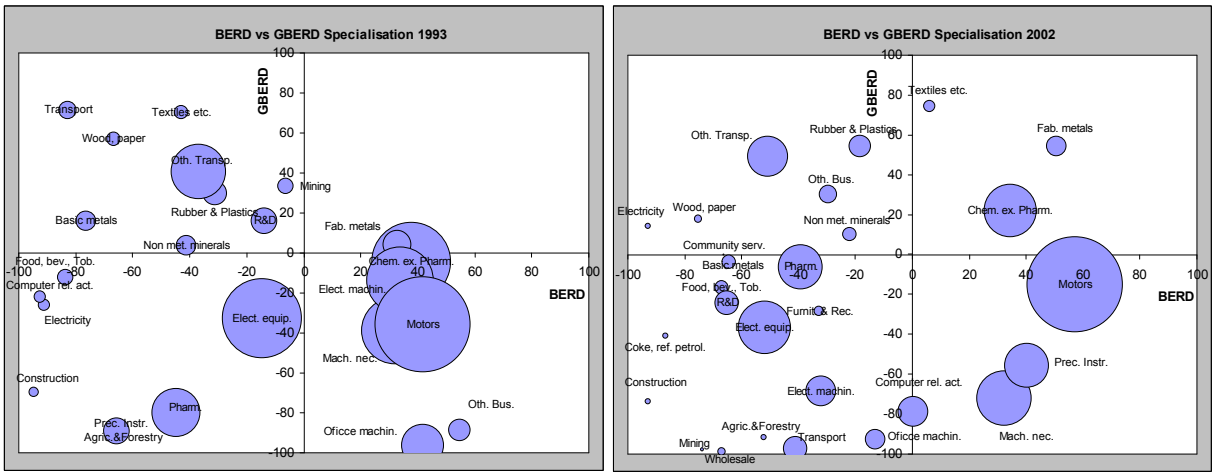
5 Results for the sample countries

For Austria, Germany, Norway and the United Kingdom the results of the specialisation analyses are presented in figures 3 – 6 for 1993 and 2002. The total amount of R&D expenditures of the specific sectors is represented by the area of the circles.



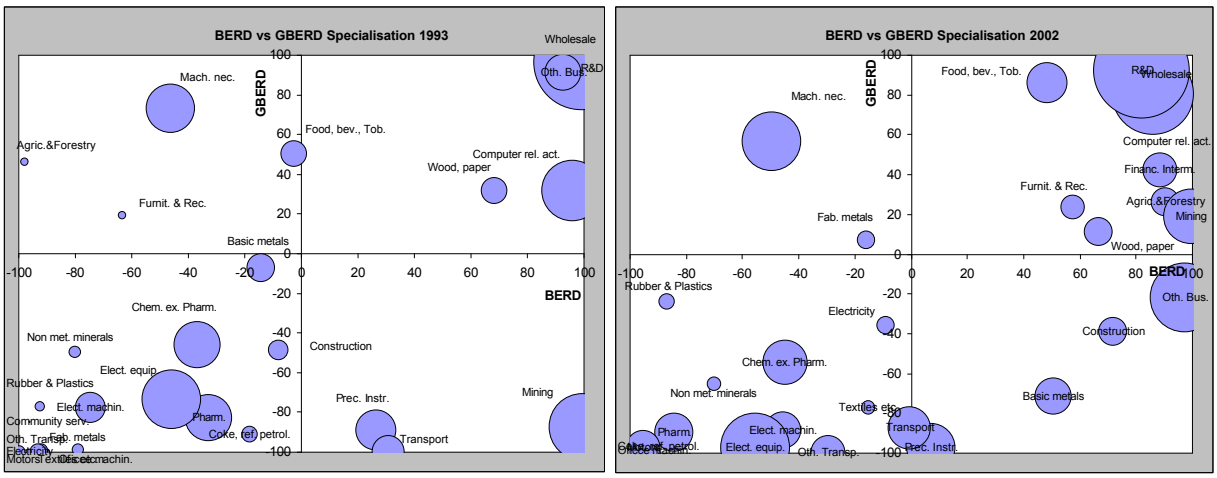
Source: Joanneum Research - based on OECD RDS Database

Figure 6: BERD vs GBERD Specialisation in Austria, 1993 & 2002



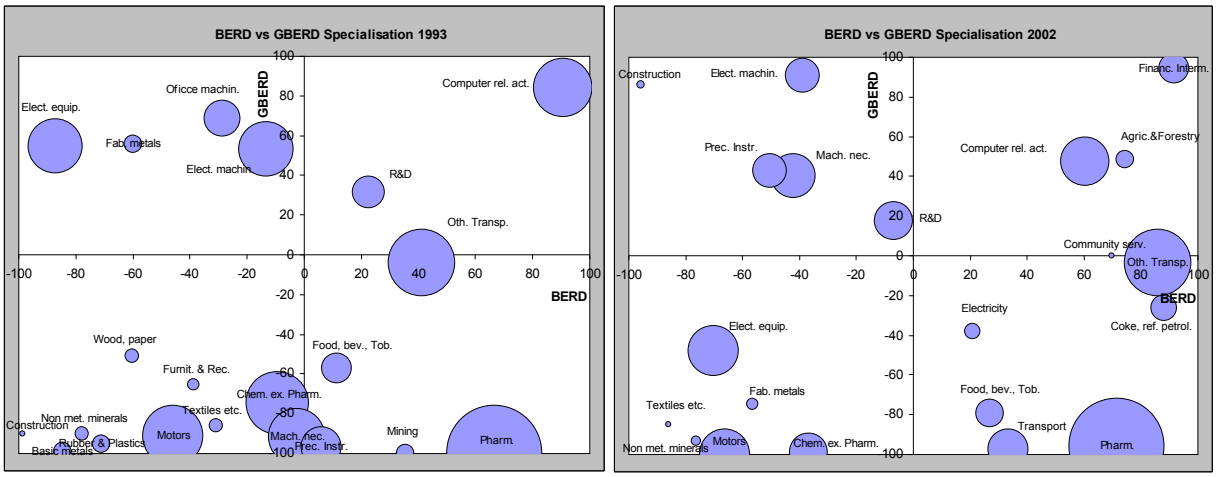
Source: Joanneum Research - based on OECD RDS Database

Figure 7: BERD vs GBERD Specialisation in Germany, 1993 & 2002



Source: Joanneum Research - based on OECD RDS Database

Figure 8: BERD vs GBERD Specialisation in Norway, 1993 & 2002



Source: Joanneum Research - based on OECD RDS Database

Figure 9: BERD vs GBERD Specialisation in United Kingdom, 1993 & 2002

The figures show that the extent of correlation between public R&D specialisation and private R&D specialisation varies considerably between the countries under consideration. In 2002 the smaller countries in the sample have a medium positive correlation between public and private R&D specialisation: Norway (0.68) and Austria (0.59). On the other hand Germany (0.25) and the UK (0.15) have a low correlation between BERD specialisation and GBERD specialisation.

The reasons for this are as follows: First, there seems to be a size effect at place. By the definition of the specialisation index, larger countries (UK, Germany) have a high impact on the benchmark, which will result in values close to the centre of the specialisation index. Secondly, large countries have a much more scattered profile and are active in more fields than smaller countries which tend to focus or specialise in a few selected fields.

Apart from the correlation aspect, the resulting picture on BERD and GBERD specialisation allows distinguishing between sectors of higher and lower public interest. Sectors with both public and private BERD funding specialisation may be interpreted as a policy of "strengthening the strengths", whereas sectors with high GBERD specialisation and low BERD specialisation could point to sectors with high public demand/interest and may also reflect public catching up strategies or sectors with market restrictions.

The cases of the UK and Germany show that the disparities between public and private R&D funding specialisation are largely due to the strong government emphasis on sectors related to defence and aerospace. For Germany the inspection of government funding of business R&D reveals that aerospace (other transport NACE 35) still receives only slightly more than 5% of the total spending on R&D of the German government (GOVERD), but it receives more than 55% of the total funding of business R&D (GBERD). This means, within the intramural business funding activities of the government it plays a very prominent role. The reasons here are a strong public interest and an expected market failure that justifies these massive investments, coming along with the state being the most important customer of aerospace goods and services. Also in the United Kingdom a large amount of public R&D funding to the private sector (26%) are reserved for the aerospace sector. But whereas the UK the aerospace sector also shows an increasing specialisation in private R&D funding in this sector this does not hold true for Germany, where only public R&D expenditures in the sector show a positive specialisation.

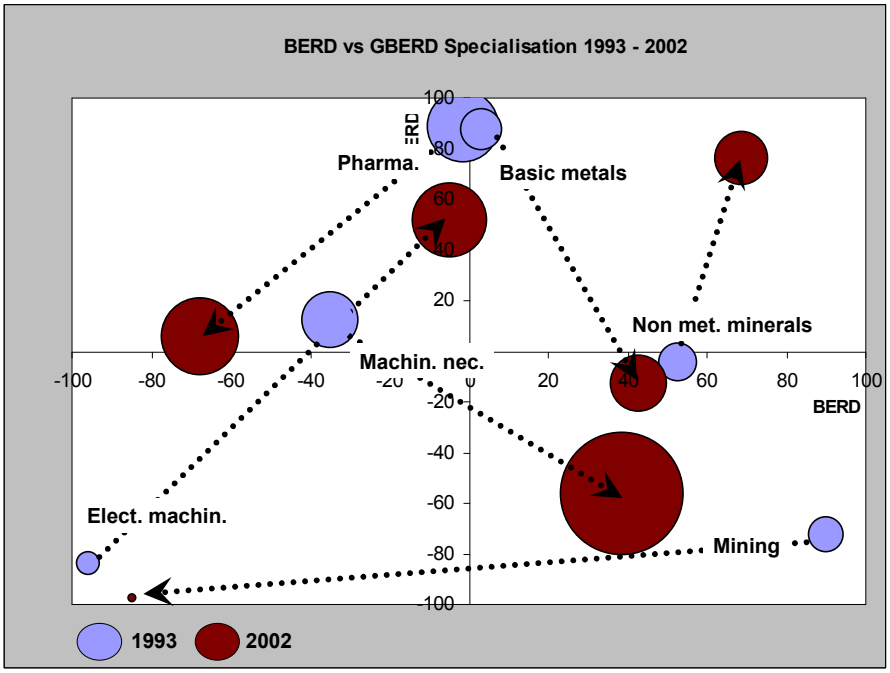
Another example for high specialisation in GBERD but no specialisation in BERD can be found in Austria for chemicals and pharmaceuticals and motors (NACE 34). Here, the support scheme General Programmes of the Austrian Research Promotion Agency (FFG), which provides about 2/3 of total Business R&D support via a bottom-up funding scheme, play a prominent role as they show high shares of funding for these sectors: In 2003, of the 127 million the Euros cash value of total funding 18.5% were provided for chemicals and chemical products, 13.4% for computer related activities, and 6.6% for motor vehicles (BMBWK, 2005). Whereas the motors sector has generally gained momentum in the Austrian economy, the chemicals/pharmaceutical sector is internationally compared rather small but relatively competitive in terms of performed research. The Austrian chemicals sector is also a very important sector as regards manufacturing employment (approx. 10.85% in 2003) and manufacturing production (11.4%) (Aiginger and Novak, 2004).

On the other hand, there are sectors in which countries have a strong BERD specialisation but no GBERD specialisation. This is for instance the case for pharmaceuticals in the UK, and for the motor vehicles sector in Germany. Here, the strong private R&D specialisation is not accompanied by a strong GBERD specialisation. Reasons for this might be that the private R&D investment (and specialisation) in the sector seems to be so strong, that either no public intervention is justified or that the public intervention may operate through other mechanisms than R&D funding for the private sector. For example, in the case of the UK we've seen that a large increase of public research funding in the life sciences has been channelled through the higher education institutions. Furthermore, especially in the pharmaceutical sector, other indirect public support mechanisms as price regulations and tax incentives might be at work.

As regards strong public and private R&D specialisation the R&D sector (NACE 73) of Norway and Austria stands out. This, however, might be due to peculiarities in the official R&D statistics.

For example, in Austria business sector comprises a private business sector and a co-operative sector, which includes large semi-publicly owned research companies as for example ARC-Seibersdorf Research GmbH and Joanneum Research – GmbH. According to the Frascati Manual (OECD, 2002), the business enterprise sector (and hence BERD) "includes public enterprises mainly engaged in market production and sale of the kind of goods and services which are often produced by private enterprises …" In Austria, of all public R&D funding for the business sector (176 million the Euros in 2002), 73 million the Euros were devoted to this so called co-operative sector (BMBWK, 2005) – whereas in other countries likewise organisations are to be found within the state sector.

Finally, for the case of Austria Figure 10 illustrates movement of public and private R&D specialisation over time. The figure confirms that not only private R&D specialisation changes over time, but also the public attitude towards investments in private sectors. The figure shows a mix of increasing specialisation and de-specialisation processes over time, of which the most interesting one are the sectors electrical machinery and machinery necessities: Whereas in 1993 the electrical machinery sector in Austria was characterised by below average public and private RTD investment, the sector shows nowadays a distinct public specialisation and private investments close to the "world" average. The Machinery necessity sector already showed a slight public specialisation in 1993, but as private investments increased dramatically public de-specialisation processes took place. Public and private de-specialisation processes also occurred in pharmaceuticals: whereas in 1993 funding for pharmaceutical industry was highly specialised, public RTD specialisation is nowadays just about at the average of the sample countries.



Source: Joanneum Research - based on OECD RDS Database

Figure 10: Moving specialisation patterns – the case of Austria, 1993 - 2002

6 Relevance and paths for future research

The BERD versus GBERD specialisation analysis provides a simple quantitative framework to analyze coherence and emphasis of direct financial measures devoted to the private sector. The international databases on R&D funding and performance allow us to measure national specialisation indices in terms of government funding for business R&D as well as BERD for a majority of ERA countries. Whereas there is a positive correlation between BERD and government funding of BERD specialization in smaller countries, this does not hold true for the larger European countries considered in the sample.

As the main objective of the R&D specialisation project was to identify indicators and aggregation levels for future data analysis purposes, these indicators must provide additional and complementary information compared to those provided by other sources, such as EUROSTAT, EC or the European Innovation Scoreboard (EIS) indicators under the TrendChart scheme. In an attempt to test whether the figures and tables with specialisation profiles of BERD and GBERD from the respective country reports of Austria and Norway (see Technical Report concerning information collection and analysis on R&D specialisation in Europe, 2006, IPTS) are a useful tool for national policy experts, 11 interviews with national experts from research councils and ministries in charge of S&T policy were conducted.

The policy experts held the opinion that specialisation indices seem to provide information valuable for pursuing new approaches and hypotheses of policy analysis in their countries. Many suggested alternative methods for combining these thus rendering them more user-friendly and more vigorous as analytical tools; Many interviewees mentioned that since specialisation indices are relative indicators, both the choice of metrics and benchmark is an issue requiring further research.

The availability of time series was also considered to be important as this allows to follow one sectors 'movement' through the diagram over time and could hence also provide a 'warning system' if sectors move from one quadrant to another, indicating increasing specialisation or de-specialisation. Furthermore one interviewee mentioned that we should not underestimate the difficulties faced when communicating the specialisation profiles to a more general audience of policy actors with no specialist background. By and large, the response from the policy experts lead us to state that the specialisation profiles is a successful monitoring device.

However, there is no doubt that there is also a need for more detailed interpretations of the specialisation profiles since the specialisation profiles provide large quantities of concentrated information. The BERD versus GBERD specialisation analysis only provides a simple quantitative framework to analyse the coherence and emphasis of direct financial measures devoted to the private sector. It needs to be combined with qualitative information on R&D support schemes in the respective countries as one has to keep in mind that direct R&D funding measures are but one promotion mechanism. For example, an important limitation of our analysis performed herein is that it does not distinguish between different channels or sources of direct and indirect government funding of R&D in the business sector. Another aspect is, that the analysis does not consider the relevant policy distinction between foreign and national public funding (such as EU-funds). Therefore, rather than regarding GBERD funding as a total, one should distinguish

between three domestic and one foreign (i.e. EU) instruments to deliver public R&D funds to private firms (see Figure 11).

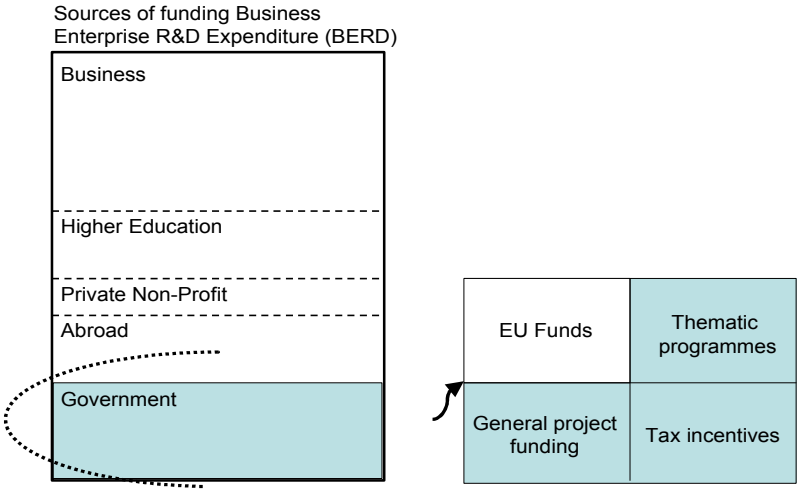


Figure 11: The policy mix in funding private R&D

More specifically the following structural indicators of public funding of BERD should be considered in future analysis:

1. General project funding (national): These are free/open schemes, i.e. any company/ research consortia may apply for R&D funding and its R&D project will be granted on specific rules such as scientific quality.
2. Thematic/Mission oriented programmes (national): These are programmes where the funding agency targets a specific group of firms and has consequently stated certain requirements which the applicant needs to meet. These can relate either to thematic fields (e.g. nanotechnology), to characteristics of the company (e.g. SMEs). It can also include the requirement to form new networks or other types of formal or informal collaborations (e.g. research networks with public research institutions).
3. EU funds for R&D: In some countries a significant share of R&D funds for private firms is provided via EU-funds (e.g. Framework Programmes). This funding is reported in the OECD and EUROSTAT statistics along with all other types of R&D funding from abroad. It would be, however, relevant to know what is the exact distribution of EU-funding by Member States and by sectors as government funding from abroad.
4. Tax incentives for R&D activities: While the first three instruments provide direct support/ funds to firms, this is an indirect instrument, and includes the total amount of money companies deduct from their taxable income as approved R&D expenditure, new R&D-activities, etc. for tax incentives international comparable data is limited although tax incentives are used in a number of countries with higher levels of business R&D intensity, including Korea, Japan, France and the United States (OECD, 2005a; OECD, 2005b,European Commission, 2003). So far the so-called “b-index” (Warda 1996) gives a synthetic view of tax-generosity.
5. Other direct but not competitive funding of R&D activities (often supporting business R&D expenditures in defence, agriculture and other mature industries)

6. Other support measures not necessarily targeted to R&D activities in the business sector but which nevertheless seem to be important for the level or the direction of research activities in the business sector.

Though for all above mentioned categories official R&D statistics are poor, methods can be employed to for example the evolution of project funding and its different dissemination mechanism and beneficiaries in various countries are a category of central concern for the analysis of public research policies. Furthermore In the framework of ENIP a small group of countries (Austria, Italy, France, Norway, Netherlands, and Switzerland) tested an approach to analyse the evolution of project funding by using data from funding agencies (Lepori et al., 2005). Basically, the methodology applied for these countries allows gathering information on the first three categories mentioned above – as it concentrates on the identification of funds from research councils, programmes managed by ministries and by European research programmes. Four national reports on Austria, France, Italy and Switzerland have been published (Dinges, 2006, Theves, 2006, Lepori, 2005, Poti and Reale 2005). But contrary to the analysis presented in this paper the methodology used has the limitation that it does not allow for a NACE 2-digit disaggregation level.

7 Relevant Literature

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