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Silvia Appelt,

Matej Bajgar,

Chiara Criscuolo,

Fernando Galindo-Rueda

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Micro-data based insights on trends in business R&D performance and funding: findings from the OECD microBeRD+ project

Silvia Appelt, Matej Bajgar, Chiara Criscuolo, and Fernando Galindo-Rueda (OECD)

This report presents new insights on trends in business R&D performance and funding, drawing on the micro-aggregated R&D and tax relief statistics collected for 21 OECD countries as part of the OECD microBeRD project. Micro-aggregated statistics provide an important input for policy analysis, highlighting important variations in business R&D performance and funding across industries and different types of firms that are hard to uncover based on aggregate R&D and tax relief statistics. They shed light on country and industry specific trends in the concentration of R&D activity, business R&D dynamics, the structure of R&D performance among different types of firms and the way that they fund their R&D activities. Such evidence can be relevant in assessing the contribution of different types of firms (e.g. young firms, foreign-controlled affiliates) and individuals (e.g. female R&D staff, doctorate holders) to research and development in the business sector and designing business R&D support policies.

Keywords: Research and development, government support, tax incentives, impacts, additionality

JEL Codes: O38, H25, L25

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The authors would like to thank all the national experts from the microBeRD network which comprised 21 OECD countries in the first phase of the microBeRD project: Australia, Austria, Belgium, Canada, Chile, the Czech Republic, France, Germany, Hungary, Ireland, Israel, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. This project and the results contained in this report would not have been possible without their knowledge, dedication, and patience.

microBeRD expert network – first project phase, 2016-19

Australia	Sasan Bakhtiari, Australian Department of Industry, Innovation and Science
	Rowan Hethey, Australian Bureau of Statistics
	Bucifal Stan, Australian Department of Industry, Innovation and Science
Austria	Andreas Schiefer, Statistics Austria
Belgium	Karl Boosten, Belgian Science Policy
	Michel Dumont, Federal Planning Bureau Belgium
Canada	Ivan Carillo, Statistics Canada
	Ryan Kelly, Innovation, Science and Economic Development Canada
	Haig Mc Carrell, Statistics Canada
	Pierre Therrien, Innovation, Science and Economic Development Canada
Chile	Maria Jose Bravo Pizarro, Ministry of Economy, Development and Tourism Chile
	Heinz Rodrigo Doebbel Aponte, Ministry of Economy, Development and Tourism Chile
	Antonio Martner, Ministry of Economy, Development and Tourism Chile
Czech Republic	Martin Mana, Czech Statistical Office
	Martin Srholec, CERGE-EI and Czech Statistical Office
France	Justin Quemener, French Ministry of Higher Education, Research and Innovation
	Camille Schweitzer, French Ministry of Higher Education, Research and Innovation
	Lisa Kerboul, French Ministry of Higher Education, Research and Innovation
	Geraldine Seroussi, French Ministry of Higher Education, Research and Innovation
Germany	Thu-Van Nguyen, Stifterverband Germany
Hungary	Tibor Keresztély, Hungarian Ministry for National Economy
	Katalin Horváth, Hungarian Ministry for National Economy
	Péter Tóth, Hungarian Ministry for National Economy
	Ilona Cserháti, Hungarian Ministry for National Economy

Ireland	Donough Lawlor, Revenue Commissioners Jean Acheson, Revenue Commissioners Keith Walsh, Revenue Commissioners
Israel	Evyatar Kirschberg, Central Bureau of Statistics of Israel
Italy	Antonella Caiumi, Italian National Institute of Statistics Valeria Mastrostefano, Italian National Institute of Statistics
Japan	Tomohiro Ijichi, Japanese National Institute of Science and Technology Policy Yuya Ikeda, Japanese National Institute of Science and Technology Policy
Netherlands	Piet Donselaar, Ministry of Economic Affairs and Climate Policy Jamie Graham, Statistics Netherlands
New Zealand	Michelle Morris, (independent contractor for New Zealand Ministry of Business, Innovation and Employment) Simon Wakeman, New Zealand Ministry of Business, Innovation and Employment
Norway	Diana-Cristina Iancu, Statistics Norway Arvid Raknerud, Statistics Norway Marina Rybalka, Statistics Norway
Portugal	Filomena Oliveira, Portuguese Directorate General of Education and Science Statistics Alexandre Paredes, Portuguese Directorate General of Education and Science Statistics
Spain	Joseba Sanmartín Sola, Spanish Foundation for Science and Technology Cecilia Cabello Valdés, Spanish Foundation for Science and Technology
Sweden	Petter Ehn Wingårdh, Statistics Sweden
Switzerland	Elisabeth Pastor, Federal Statistical Bureau Switzerland Sandra Plaza, Federal Statistical Bureau Switzerland
United Kingdom	Khalid Khan, UK Department for Business, Energy & Industrial Strategy Joshua Sarracino, UK Department for Business, Energy & Industrial Strategy Armand Viaje-Balog, UK Department for Business, Energy & Industrial Strategy Josh Martin, UK Office for National Statistics Russell Black, UK Office for National Statistics Emma Hickman, UK Office for National Statistics Laura Hill, UK Office for National Statistics

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Executive summary

Investment in research and development (R&D) is a key factor driving innovation and economic growth. Digital technologies, globalisation, economic framework conditions and other factors are changing the organisation of R&D activities (e.g. R&D location and collaboration) and R&D funding. This has important implications for the design of R&D support policies. However, it is hard to observe these changes in aggregate-level cross-country datasets. In order to shed light on the distribution and structure of business R&D (BERD) and the heterogeneity in the use and impact of tax and direct support measures for BERD across different types of firms and countries, the OECD carried out the microBeRD project from 2016 to 2019 with support from the EU Horizon 2020 programme. **microBeRD applies a "distributed" approach** to the analysis of business R&D and tax relief microdata. This approach, characterised by a collaboration between the OECD secretariat and national experts with access to the confidential R&D and public support microdata within participating countries, ensures data confidentiality and facilitates a co-ordinated and harmonised analysis of R&D and tax relief microdata across countries.

With continued support from the European Commission, **microBeRD+** - the second phase of the microBeRD project (2020-23), aims to extend and deepen the existing descriptive and impact-oriented analysis (OECD, 2020a and OECD, 2020b) undertaken in the first phase of the project. This includes a more in-depth, descriptive analysis of business R&D performance (e.g. R&D expenditure, R&D employment) and funding, leveraging the micro-aggregated data collected in the first phase of the project. This report – the **first microBeRD+ project output** – highlights novel and stylised facts about business R&D performance and funding that are hard to uncover based on aggregate R&D and tax relief statistics on a cross-country basis. It provides a detailed description of country- and industry-specific trends in the concentration of R&D activity, the structure of R&D performance (e.g. type of R&D, type of costs) among different types of firms (e.g. firm size and age) and the way that different types of firms fund their R&D activities.

This first descriptive analysis undertaken as part of microBeRD+ covers altogether 21 countries (Australia, Austria, Belgium, Canada, Chile, the Czech Republic, France, Germany, Hungary, Ireland, Israel, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom) and focusses on 12 industry classes (STAN A38 industry classification) that together account for over three quarters of total R&D expenditure in countries on average.

The **key findings** from the **first microBeRD+ analysis** can be summed up as follows:

- **R&D concentration:** business R&D is strongly concentrated at country, and in particular industry level, but there is large variation in the rate of R&D concentration across different industries, whether measured by the share of the 10 largest R&D performers in an industry or by the Herfindahl index. Available results further suggest that the within-industry, within-country concentration of R&D has declined over time and that the decline of R&D concentration at country level is positively correlated with the increasing adoption and generosity of R&D tax incentives. These results, thus, seem to suggest that these incentives encourage R&D investment among existing and new R&D performers (OECD, 2020a).

- **R&D performance and funding of foreign-controlled affiliates**: While foreign-controlled firms account for a significant share of business R&D expenditure in many OECD economies, they tend to receive proportionally less R&D support through direct funding (e.g. R&D grants, government procurement of R&D services) compared to their share in total R&D expenditure.

- **R&D performance and funding of small and young firms**: SMEs tend to account for a disproportionally higher share in direct funding compared to their contribution to business R&D expenditure in most industries, but the difference is particularly large in Mining and Pharmaceuticals. As expected for market-based and less discretionary support measures, the SME share in R&D tax relief tends to match more closely the SME share in R&D expenditure across different industries. In terms of the relative importance of public support for R&D for firms of different size, smaller firms rely to a larger extent on public support for financing their R&D investments, both in terms of direct and tax support. An interesting difference also exists between young and old small firms in this context: while young small firms rely, more than any other type of firms, on direct support almost as much as on tax support, for older small firms tax incentives are noticeably more important than direct support. The stronger reliance of young firms on direct support might be related to the earlier timing with which firms typically receive direct vis-à-vis tax support or demonstration effects connected to the receipt of direct funding.
- **Orientation of R&D by industry**: Overall, although there are some cross-industry differences in the share of basic and applied research versus experimental development, they do not tend to be particularly large. Research (basic and applied) accounts for close to 40% to 60% of all R&D expenditure in all main R&D industries except for Transport equipment, where it accounts for less than 30% of total R&D. Basic research represents a minor share of total R&D in all industries. It is most important in Scientific R&D and Pharmaceuticals, with a share in total intramural R&D expenditure of close to 10%.
- **Female R&D employees and R&D staff with a doctorate degree by industry:** Large differences are found in the share of female R&D employees and share of R&D staff with a doctorate degree in R&D employment across industries. Women represent over one third of R&D employees in Chemicals, Scientific R&D and Food & beverages and more than 50% of R&D employees in Pharmaceuticals. However, 10% or less of R&D employees in Transport equipment, Metal products and Machinery and equipment are women. Likewise, a high share of doctorate holders among R&D staff can be found in science-based industries such as Pharmaceuticals, Scientific R&D and Chemicals.

The new micro-aggregated statistics provide an important input for policy analysis, pointing out important variations in business R&D performance and funding across industries and different types of firms that are hard to uncover based on aggregate R&D statistics. These can reveal stylised facts that either confirm or challenge assumptions about how policies work, helping refine policy research questions for analysis. The microBeRD approach enables the exploration of different data perspectives beyond established tabulations that countries regularly submit to the OECD. The latter, as the implementation of the Frascati Manual 2015 has shown, are difficult to change in a sufficiently responsive fashion due to a combination of factors. microBeRD helps demonstrate how it is possible to enhance the range of policy relevant indicators while protecting business respondent confidentiality.

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1. Introduction and background

Investment in research and development (R&D) is a key factor driving innovation and economic growth. Digital technologies, globalisation, economic framework conditions and other factors are changing the organisation of R&D activities (e.g. R&D location and collaboration) and R&D funding. This has important implications for the design of R&D support policies. However, it is hard to observe these changes in aggregate-level cross-country datasets. In order to shed light on the distribution and structure of business R&D (BERD) and the heterogeneity in the use and impact of tax and direct support measures for BERD across different types of firms and countries, the OECD carried out the microBeRD project from 2016 to 2019 with support from the EU Horizon 2020 programme.

MicroBeRD is a joint project of the OECD Committee on Industry, Innovation and Entrepreneurship (CIIE) and the Committee for Scientific and Technological Policy (CSTP) carried out under the lead of its Working Party of National Experts on Science and Technology Indicators (NESTI). microBeRD relies on a "distributed" approach for the empirical analysis of micro-data, undertaken in collaboration with national experts with access to confidential R&D and public support micro-data. This approach facilitates a co-ordinated statistical analysis of the impact of tax relief design features and their interaction with direct forms of public R&D funding by exploiting variation in support within and across countries, while preserving the confidentiality of the business-level microdata that remain secure within national databases.

With continued support from the European Commission, the second phase of the microBeRD project (microBeRD+, 2020-23) aims to extend and deepen the existing descriptive and impact-oriented analysis (OECD, 2020a) undertaken in the first phase of the project. microBeRD+ envisages:

a) a more in-depth, descriptive analysis of business R&D performance (i.e. R&D performed by companies) and funding, leveraging the micro-aggregated data collected in the first phase of the project, and

b) an extension of the existing micro-data based analysis of the effect of R&D support policies on business R&D investment to further explore the impact of direct funding and R&D tax support on innovation outputs (e.g. introducing new products and services, filing patents) and economic outcomes (e.g. employment and productivity growth).

This report – the first microBeRD+ project output – explores possible applications of R&D and tax relief microdata to complement and extend existing evidence based on official R&D statistics as those found in the OECD R&D Statistics (RDS), OECD ANBERD and OECD R&D Tax Incentives databases. It provides a detailed description of country and industry specific trends in the concentration of R&D activity, the structure of R&D performance (e.g. type of R&D, type of costs) among different types of firms (e.g. firm size and age) and the way that different types of firms fund their R&D activities. Using micro-aggregated data, this descriptive analysis helps highlight not only average trends across countries and the heterogeneity of country experiences but also within-country and within-industry heterogeneity in business R&D performance and funding across different types of firms. It further provides a number of new insights on structural aspects of business R&D dynamics that are important for policy makers and researchers alike. Such evidence can be relevant in assessing the contribution of different types of firms (e.g. young firms, foreign-controlled affiliates) and individuals (e.g. female R&D staff, doctorate holders) to research and development in the business sector and effectively designing business R&D support policies with a view to potentially directing government support towards certain types of firms and industries.

The remainder of the report is structured as follows. **Section 2.** introduces the distributed approach to microdata analysis, describes the R&D microdata used within the microBeRD project and summarises the micro-aggregated indicators generated through the microBeRD distributed code. **Section 3.** explores the coverage and representativeness of the micro-aggregated data, using aggregated business R&D and tax relief statistics as benchmark. **Section 4.** highlights the new insights that micro-aggregated data can deliver about the concentration, structure and distribution of business R&D performance and funding. **Section 5.** concludes by summarising the main findings of the report, highlighting their practical significance for policy analysis and R&D statistics, and points out potential avenues for future work.

2. The distributed approach explained

In recent years, the policy and research communities' interest in the use of harmonised cross-country business microdata has increased significantly. This has been partly driven by improvements in computing power and storage capacity but, fundamentally, reflects the recognition that microdata are needed for understanding the growing complexity in the way economies work and the heterogeneity in economic outcomes. Significant access obstacles remain, however, that prevent the transnational use of official microdata. As a result, and with few exceptions, cross-country studies based on the analysis of official business microdata are rare, particularly in the area of science, technology and innovation.

The microBeRD project adopts a distributed approach towards the analysis of business R&D microdata, characterised by a collaboration between the OECD secretariat and national experts with access to the confidential R&D and public support microdata within participating countries. This unique arrangement allows the implementation of a common and centrally-developed code which provides the basis for the harmonised analysis of cross-country microdata while respecting access conditions to nationally held, confidential business microdata.

2.1. Distributed microdata analysis

The distributed microdata analysis is a method of analysing microdata held in separate locations by means of a common, centrally designed routine. This routine is automated and flexible enough to run on different data sources in different countries and take into account some of their idiosyncrasies. It relies on the collaboration of an international network of national experts, with each national team having legal access to their respective national microdata. The use of harmonised cleaning, statistical and estimation routines ensures the generation of harmonised, microdata-based outputs which, designed and checked to be non-disclosive, do not present disclosure concerns. Examples include the custom production of summary statistics for the relevant population and subgroups, as well as statistical inference indicators, for example, regression coefficients and related measures of precision.

The harmonisation procedures ensure that sample composition (e.g. coverage of firm size classes and industries)[1] and methodological choices will be identical or at least mutually consistent, thus ensuring, to the extent possible, the cross-country comparability of results. The generic microdata approach for the analysis of business data was pioneered in the beginning of the 2000s in a series of cross-country projects on firm demographics and productivity (Bartelsman, Scarpetta, et al., 2005; Bartelsman, Haltiwanger, et al., 2009). Over recent years, the OECD has built expertise in implementing distributed microdata approach through the Innovation in firms project (OECD, 2009), the DynEmp (Criscuolo et al., 2014) and MultiProd (Berlingieri et al., 2017) projects.[2]

The distributed method, ensuring a high degree of cross-country harmonisation and comparability, also yields considerable benefits to aggregate R&D data producers and users as it provides an additional and highly complementary source of validation and data quality assessment. Compared to issuing generic requests for indicators from countries, this approach places a lower burden on national statistical agencies and limits the running costs of data collection endeavours. Moreover, it highlights hitherto unidentified cross-country differences in data coverage (e.g. firm age and ownership) and methodology which can help spur further harmonisation and statistical development. For example, microBeRD has been particularly useful in exploring avenues for implementing the recommendations in the latest edition of the OECD Frascati Manual (OECD, 2015) on key areas of public support for R&D and R&D globalisation. The use of a distributed approach in the analysis of R&D statistics has also contributed to promote awareness of the existence of rich microdata sources and their potential utility for domestic research and policy analysis. The use of organisational microdata is recommended in both the Frascati and Oslo Manuals (OECD, 2015 and OECD/Eurostat, 2018), especially in the latter which outlines the possible use of distributed approaches to examine the impact of R&D and innovation policies, as presented in the first microBeRD project publication (OECD, 2020a).

2.2. Microdata inputs

The microdata approach depends on the availability of sufficiently comparable microdata, containing variables following the same definitions and based on populations with a sufficient degree of commonality. MicroBeRD relies on official business R&D survey data, complemented for some countries with administrative R&D tax relief microdata wherever available and accessible for analytical purposes.

Microdata on business R&D are collected through national business R&D surveys in line with the international standards and guidelines for measuring and reporting R&D as laid out in the OECD Frascati Manual (OECD, 2015).[3] They serve as a basis for official statistics of R&D carried out within countries. For each firm[4], they contain basic demographic information (employment, industry of main activity and, where available, also age, sales and type of ownership) together with detailed information on the firm's R&D. This includes, most importantly, information on R&D performed (intramurally) and funded (extramurally-performed), the type of R&D performed (basic research, applied research, experimental development), sources of funding (e.g. own, other business, government), the structure of R&D costs (e.g. labour, current consumption of goods and services, capital) and R&D employment (expressed in headcount and full-time equivalents).

Business R&D surveys are generally designed to be representative of the population of R&D performing and funding firms in each country. Some countries do not collect information on R&D performers with fewer than 5 or 10 employees, applying another minimum firm-size criterion or exclude certain industries (e.g. agriculture). BERD surveys tend to combine census and sampling survey features to ensure near exhaustive coverage at the aggregate level of an activity which is rather asymmetrically distributed, i.e. a few companies tend to account for a large share of BERD and therefore, known large R&D performers tend to be sampled with certainty. Countries with a sampling framework generally provide ex-ante or ex-post (adjusted for survey-non-response) sampling weights. These allow for the computation of suitably weighted R&D statistics.

Several steps are undertaken in the data preparation phase to ensure data harmonisation and support a robust analysis across countries. Firstly, only firms that actually filled in the R&D survey are kept in the dataset; imputed observations are dropped and the remaining observations are reweighted accordingly. Secondly, micro-firms with fewer than 10 employees, which several countries do not cover in their BERD surveys, are dropped from the analysis. Thirdly, country-level statistics focus on industries which are generally covered in the R&D surveys of all countries: ISIC Rev.4 industries 5-72, excluding 45, 47, 55-56 and 68-69. [5] Automated checks are carried out to identify and drop outliers.[6]

Administrative microdata on tax relief provide information on the amount of R&D tax benefits received by corporate tax relief recipients, a subset of the population of R&D performing firms. In some cases, they also include information about the total amount of qualifying R&D expenditure (by type of cost) which may encompass both intramural and extramural R&D. In addition, these administrative data sources typically contain some information about the characteristics of firms (e.g. employment, sales). Prior to applying the microBeRD code, the tax relief microdata are matched by experts within countries to the R&D survey data at the firm-level using unique firm identifiers. By matching business R&D and tax relief microdata, it is possible to identify the corporate R&D performers that make use of R&D tax incentive support and exploit information on the uptake of R&D tax incentives in the analysis.

2.3. Micro-aggregated statistics

The microBeRD code prepared by the OECD secretariat and implemented by national experts within the OECD microBeRD network generates two types of harmonised, non-confidential, microdata-based outputs. This includes micro-aggregated statistics and regression outputs from firm-level analyses within countries (OECD, 2020a).

Micro-aggregated indicators capture rich information on R&D performance, funding and employment, the theoretical implied marginal R&D tax subsidy rates (based on the B-Index) and actual amounts of R&D tax relief received by firms, where relevant tax relief microdata are available. They mainly consist of statistical moments – counts, means and percentiles (10th, 25th, 50th, 75th and 90th) – of the underlying variables. These can apply to the primary variables collected in surveys, or derived ratios thereof, such as firm-level R&D intensity (R&D as percentage of sales). The micro-aggregated indicators also include measures of dispersion (standard deviation) and concentration.

The statistics are calculated for all firms and various subgroups of firms defined, for example, by STAN A38 industry classification,[7] size class (small, medium-sized, large), age (young, old), ownership (part of group, foreign-owned) or various interactions of these characteristics**.** Table 1 provides an overview of the status of data availability across countries, distinguishing between the two types of microdata sources employed in the distributed analysis.

Table 1. Availability of micro-aggregated statistics by source of data

		Micro-aggregated indicators
Source of microdata	R&D survey	8 countries AUT, CHE, DEU, ESP, GBR, ISR, JPN, NZL
	R&D survey + tax relief data	12 countries AUS, BEL, CAN, CHL, CZE, FRA, HUN, ITA, NLD, NOR, PRT, SWE
	Tax relief data	1 country IRL

Note: This table reports the status of data availability across microBeRD member countries, drawing on the micro-aggregated data collected in the latest distributed analysis carried out as part of the first phase of the microBeRD project.
Source: OECD microBeRD project, http://oe.cd/microberd, November 2021.

Twenty countries completed the final round of distributed analysis undertaken as part of the first phase of the microBeRD project (2016-19), and one country (Ireland) additionally completed the distributed analysis in 2021. These 21 countries are included in the descriptive analysis, based on micro-aggregated data, reported in **Section 4.** , namely: Australia, Austria, Belgium, Canada, Chile, the Czech Republic, France, Germany, Hungary, Ireland, Israel, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. All of the countries provided financial support for business R&D through a combination of direct funding and R&D tax incentive support during the time period considered in this study (2000-2016), with the exception of two countries (Germany and Switzerland) that did not provide R&D tax incentives during these years. Table A A.1 in Annex A shows the countries and years which are included in the analysis based on micro-aggregated R&D and tax relief data. Thirteen out of the nineteen countries that offered R&D tax support during the 2000-16 period were able to extend the analysis to R&D tax relief microdata. As Ireland is currently not able to additionally include R&D survey data in the distributed analysis, statistics have been calculated exclusively based on tax relief data. For this reason, the results for Ireland should be treated as experimental and not directly comparable with the R&D microdata-based results reported for other countries participating in the microBeRD project.

3. Coverage and representativeness of micro-aggregated statistics

This section explores the coverage and representativeness of the micro-aggregated statistics compiled as part of the microBeRD analysis by benchmarking the implied total R&D expenditure and total R&D tax support from the microBeRD results against corresponding aggregate statistics collected by the OECD, which are used as benchmarks. For the microdata-based analysis to serve its analytical purposes, the relevant micro-aggregated indicators need to be as representative of the population of R&D performing firms as possible. For several coverage and procedural reasons, the analytical microBeRD indicators may not perfectly match national official figures. The purpose of the exercise presented in this section is to document the coverage and overall representativeness of the microBeRD data and to inform about possible data quality improvements in the future.

Table 2 shows total R&D expenditure derived from microBeRD statistics as a ratio of total R&D expenditure as reported in the OECD R&D Statistics (RDS) and OECD ANBERD databases[8] for each country and year covered in the descriptive analysis (2000-2016). For most countries, the microdata-based figures match official statistics rather well. In 13 out of 20 countries, the ratio of microdata based to aggregate R&D figures ranges on average between 0.95 and 1.05 (i.e. within 5% difference). For Australia, total R&D expenditure estimated by microBeRD is below the official figures in the first two to three years but the match improves substantially over time. For Belgium, microBeRD estimates are around 20% greater than their official counterparts which is related to the differences in the reweighting of observations for unknown R&D performers where imputation is required.[9] In the case of Japan, microBeRD underestimates total R&D expenditure by about 20% on average; this is due to the fact that the microBeRD data for small firms in Japan are based on a sample where no weights are available. microBeRD also somewhat underestimates total R&D expenditure for Norway and New Zealand and slightly overestimates it in the case of the Netherlands.[10]

Table 2. Business R&D expenditure totals derived by microBeRD relative to aggregate data

Year	AUS	AUT	BEL	CAN	CHE	CHL	CZE	DEU	ESP	FRA	HUN	IRL	ISR	ITA	JPN	NLD	NOR	NZL	PRT	SWE
2000				100			98								92					
2001			116	99			97	98							87		77		99	
2002		100		99			98						100		78		82			
2003			101	99			98	100					98		69		82		100	
2004		100		99			100						98		72		82	86		
2005	59		99	99			98	99					99		79		80		100	
2006	75	101		100			100						102		82		86	82		
2007	79	101	137	100			101	98	100	96			102	96	74		85		102	
2008	82			100	99		101		100	97			100	98	69	107	89	86	97	
2009	89	100	129	100		100	102	100		101		50	97	94	80	100	78		99	
2010	89			99		91	104			100		58	98	94	77	105	87	86	102	
2011	94	99	138	99		83	103	101		97		65	99	97	88	108	79		101	97
2012	96			99	100	101	103			101		64	99	94	73	111	86	89	102	
2013		100	113	98		101	90	101		103		114	96	96	73	111	81			97
2014	102					93	95			99	100	123	97	94	83	113	81	81		
2015		99			99	100	101		100	101	94	102	100		80	112	87			95
2016	92					99	100		100		100	72	95		73			80		
Average	***86***	***100***	***119***	***99***	***99***	***96***	***99***	***99***	***100***	***100***	***98***	***81***	***99***	***95***	***78***	***108***	***83***	***84***	***100***	***96***

Note: For each country and year, the table shows the ratio of the total R&D expenditure derived by microBeRD based on weighted micro-aggregated data and the total R&D expenditure as reported in the OECD R&D Statistics.

Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

Table A B.1 (Annex B) provides a similar comparison to Table 2 based on a decomposition by firm size. Overall, there is not much evidence of systematic differences in the coverage of microBeRD across firm size classes. Exceptions include Japan and Ireland. In the case of Japan, the lack of weights for the sample of small R&D performers leads to a stronger underestimation of R&D expenditure for small and medium-sized firms than for large firms, and to an underestimation of total R&D expenditure in Japan by around 20% as aforementioned. In the case of Ireland, the use of tax relief data to approximate information on R&D performance leads to a severe underestimation of R&D expenditure by small and medium-sized firms and a significant overestimation of R&D expenditure by large firms.

Table 3 documents the coverage of microBeRD in terms of public funding for business R&D – government-financed BERD (direct funding), as reported in national R&D surveys, and R&D tax support, based on administrative tax relief microdata. For most countries, total direct funding by government is similarly well captured as total R&D expenditure. In the case of Switzerland, total direct funding derived based on microBeRD statistics fall below official R&D estimates in 2008 but come close to official figures in the next two years for which relevant data are available. In other countries, the microdata based R&D figures match official data well but direct funding falls below its official counterpart to some extent. This includes France, Hungary and Norway, where microBeRD direct support figures fall short of official figures more strongly than those based on R&D expenditure. In the case of the Netherlands, the relative magnitude of the microBeRD direct support figures is very volatile, falling short of official statistics in some years and surpassing them in others.

R&D tax relief figures are derived by microBeRD in two ways. The first approach compiles total tax relief figures for the population of R&D-performing firms as targeted by the R&D survey. It focuses on firms that appear in the survey and applies weights where appropriate. The second approach fully focuses on the administrative corporate tax relief data and estimates total tax relief for all corporate tax relief recipients. As the data should in principle cover all firms receiving R&D tax relief, no weights are applied. The first approach – based on the R&D survey population –underestimates the total R&D tax relief in a majority of countries, and overestimates it for Australia, Belgium, Canada and Ireland. The second approach based on corporate tax relief microdata leads to accurate estimates for France, Norway and Portugal, but keeps underestimating total R&D tax support in the case of Hungary and Italy and overestimating it in the case of Australia, Ireland and, to a lesser extent, Canada. This may be explained, at least in part, by differences in the scope of R&D tax incentives covered in the micro-data based analysis (e.g. exclusion of social security exemptions in case of Hungary) and the aggregate R&D tax relief statistics. Also, in some cases (e.g. Ireland) micro-aggregated tax relief statistics refer to R&D tax incentive claims (i.e. earned credits, including carry-forwards from previous periods) rather than the actual cost of R&D tax support (sum of tax offsets and refunds, where applicable) to government in the accounting period, leading to a deviation of micro-aggregated from official R&D tax relief statistics.

Table 3. Public funding for business R&D expenditure in microBeRD relative to aggregate data

	AUS	AUT	BEL	CAN	CHE	CHL	CZE	DEU	ESP	FRA	HUN	IRL	ISR	ITA	JPN	NLD	NOR	PRT	SWE
Direct support																			
2000							85								63				
2001			147				82	68		116					93		70	101	
2002		108					82			100					89				
2003			128				83	76		81					96		64	100	
2004		116					91			81					92				
2005	80		104				102	97		92					88		45	100	
2006	82	102					107			50					86		36		
2007	111	104	106				111	94	100	64				99	88		55	100	
2008	119				65		107		100	46				99	87		52	98	
2009	101	140	134			100	108	101		78				101	82		37	101	
2010	100					64	112			69			108	102	85		40	100	
2011	89	86	69			107	109	108		75			119	104	96	91	32	100	104
2012					100	106	114			96				102	87	653	44	101	
2013		79	123			100	109	106		94			100	98	91	104	38		100
2014						98	114			88	73		98	97	84	47	40		
2015		98			100	99	100		100	87	49		100		84	31	51		
2016						100	104		100		64		96		86				
Average	***97***	***104***	***116***		***88***	***97***	***101***	***93***	***100***	***81***	***62***		***103***	***100***	***87***	***185***	***46***	***100***	***102***
Tax support (BERD population)																			
2000				118															
2001				115															
2002				118													38		
2003				120						84							45		
2004				107						60							51		
2005	173		114	119						60							39		
2006	223			126						66							53		
2007	261		159	109			67			66				0			45	52	
2008	250			115			75			62				47		42	59	60	
2009	199		156	108			70			70				63		37	53	68	
2010	228			113			62			73						42	59	62	
2011	239		163	112			56			76						47	44	65	
2012	139			101			59			82						44	58	65	
2013			191	99			49			81						47	45		
2014	184						56			75	71					66	48		
2015							65				81					93	65		64
2016	129						68				42								
Average	***202***		***157***	***112***			***62***			***71***	***65***			***37***		***52***	***51***	***62***	***64***
Tax support (tax population)																			
2000				132															
2001				127															
2002				129													100		
2003				131						105							99		
2004				114						84							105		
2005	389			127						83							89		
2006	368			129						88							92	99	
2007	406			114						88				0			98	99	
2008	409			116						94		100		46			96	97	
2009	315			110						91		179		62			98	97	
2010	350			113						92		204					98	95	
2011	346			110						92		212					98	99	
2012	170			102						100		216					98	98	
2013				98						92		214					98		
2014	260									89	77	207					98		
2015											83	168					98		
2016	210										50	146							
Average	***322***			***115***						***92***	***70***	***183***		***36***			***97***	***98***	

Note: For each country and year, this table shows the ratio of microdata-based (microBeRD) to official aggregated R&D and tax relief statistics as reported in the OECD R&D Statistics and R&D Tax Incentives database. Ratios are presented for total R&D expenditure, direct funding of business R&D and R&D tax support. The microBeRD figures of “R&D tax support (BERD population)” are calculated as weighted statistics based on the records of firms that appear in both the R&D survey and corporate tax data. The microBeRD figures of “R&D tax support (tax population)” are calculated as unweighted statistics based on the records of all firms listed in the corporate tax relief microdata.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

4. R&D performance and funding: new findings based on micro-data

The distributed analysis facilitates the production of a range of new types of descriptive R&D statistics. While selected micro-data based indicators such as country-level indicators on the concentration of business R&D feature on the OECD microBeRD website (https://oe.cd/microberd), in the latest OECD microBeRD project publication (OECD, 2020a) and OECD flagship publications such as 2017 OECD Science, Technology and Industry Scoreboard (OECD, 2017), this report presents the most comprehensive selection of microdata-based indicators to date. Leveraging the power of micro-aggregated data, this document highlights novel and stylised facts about business R&D performance and funding that have not been previously documented on a cross-country basis.

The statistics contained in this report represent average values over the period 2011-2016, with the exception of time-series figures that show the evolution of business R&D performance and funding over time. This period has been chosen to include countries for which the more recent years are not available. , and the averaging helps make the documented patterns more robust. To account for the role of sample composition – not all statistics and decompositions (e.g. by industry and firm size, age etc.) are available for all countries -, country specific effects are controlled for, subtracting the country-specific means from each micro-aggregated statistic and adding back its population mean.[11]

Those statistics that are decomposed by industry are shown for a group of altogether 12 industry classes defined based on the STAN A38 industry classifications that, on average across countries, contribute most to national business R&D performance. These 12 industries taken together account for over three quarters of total R&D expenditure in microBeRD data in countries on average.[12]

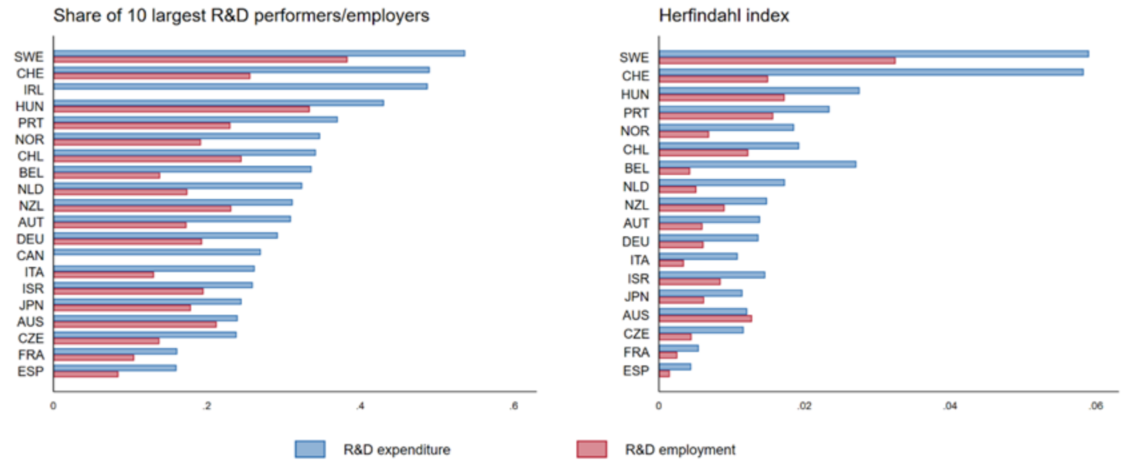
4.1. R&D concentration at country and industry levels

Indicators on the concentration of R&D performance can be helpful for understanding the role of competition, for example by comparing them with other measures of economic concentration (e.g. labour or product market concentration) at industry or country level which may display different patterns in reflection of the extent of specialisation, internalisation and economies of scale and scope in a particular market segments. These indicators may also help shed light on recent and expected trends in R&D concentration. This section examines the concentration of business R&D performance and employment, comparing concentration levels and trends across countries and industries.

The results from the latest distributed analysis undertaken in the first phase of the microBeRD project provide a picture of the degree of the R&D concentration both in terms of business R&D performance (intramural R&D) and R&D employment (headcounts). The microdata-based indicators (Figure 1) quantify the extent to which aggregate R&D performance (left Panel) is driven by a small number of top R&D performers and the rate of concentration in the market for research and development as measured by the Herfindahl index (right panel)[13], also known as Herfindahl-Hirschman Index, which ranges from 0 to 1 (or 0 to 10 000 points if the calculation is based on percentage points).

Figure 1. Concentration of business R&D performance across OECD countries

2011-2016 average



Note: The figure shows R&D concentration across firms (establishments in the case of Israel) in the entire economy. It displays average values across all years available for a given country in the period 2011-2016. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries. For Canada, only the measure of R&D concentration is available at the time of reporting.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

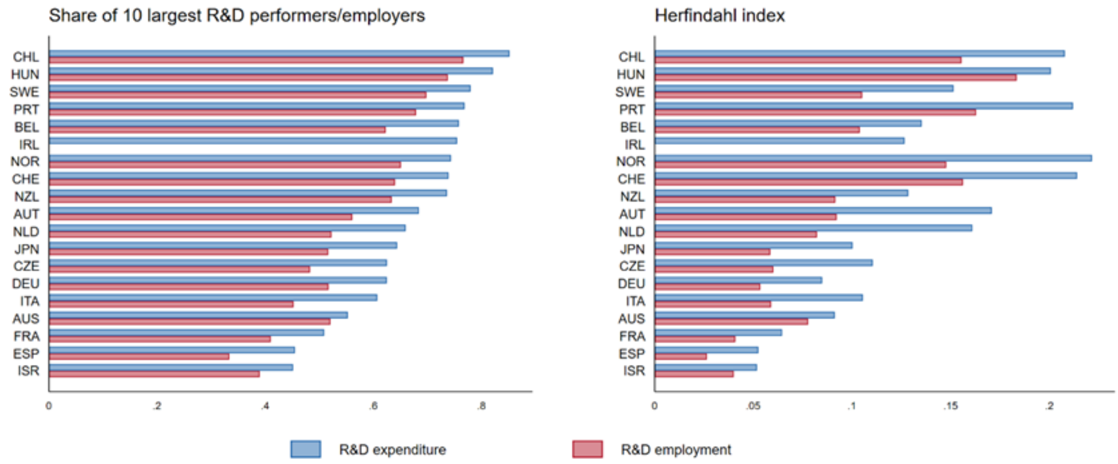
As Figure 1 (left panel) shows, R&D is highly concentrated, with the 10 largest R&D performers accounting for around one third of total R&D expenditure and a fifth of total R&D employment in most countries. However, significant differences exist across countries. While the 10 largest performers account for more than half of all R&D expenditure in Sweden and Switzerland, they account for less than one fifth in France and Spain. This is an interesting pattern worth investigating. R&D employment generally tends to be significantly less concentrated than R&D expenditure, indicating that the largest R&D performers tend to spend more on R&D for each R&D employee, either because of higher wages paid to R&D workers, potentially reflecting their higher average skills, or because of complementary non-labour related expenditure for R&D.

The Herfindahl index (Figure 1, right panel) similarly displays a large variation in the concentration of business R&D and R&D employment across countries, whereby the former again exceeds the latter. The ranking of countries remains consistent across the two measures of concentration used. Indeed, it only changes slightly, when comparing the rate of R&D concentration based on the share of the 10 largest R&D performers vis-à-vis Herfindahl index. The Herfindahl index for business R&D expenditure (R&D employment) varies from 0.02 (0.004) in Spain to close to 0.06 (0.032) in Sweden. For comparison, in the context of sales concentration in a well-defined market, a Herfindahl index below 0.01 indicates a highly competitive market while an index between 0.15 and 0.25 points to a moderate rate of concentration; finally an index above 0.25 points to a high rate of concentration.

R&D is even more concentrated at the level of individual industries within each country (Figure 2). In most countries, the 10 largest R&D performers account on average for about 60% of total R&D expenditure within a 2-digit industry. The Herfindahl index computed at country-industry level similarly exceeds the one at the level of the entire economy (Figure 1), with an average value of 0.14 (0.09) for R&D expenditure (R&D employment) across countries.

Figure 2. Within-industry concentration of business R&D

Weighted mean across industries (2011-2016 average)



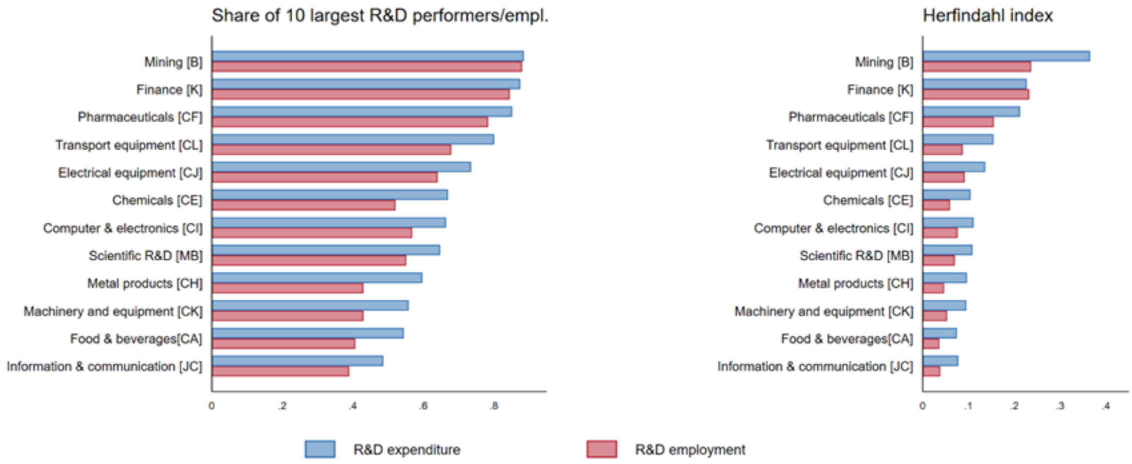
Note: The figure shows R&D concentration across firms (establishments in the case of Israel) within A38 industries. For each country, it displays weighted averages across industries, using each industry's share in the total R&D expenditure of the country as weight. It is based on average values across all years available for a given country-industry in the period 2011-2016. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

Figure 3 provides insights into the concentration of business R&D across 12 industries that on average contribute most to national business R&D performance. It shows the average share of R&D expenditure (R&D employment) accounted for by the 10 largest R&D performers (R&D employers) by industry, and the corresponding Herfindahl Index for R&D expenditure and R&D employment.

As Figure 3 (left and right panel) shows, R&D in Mining, Finance and Pharmaceuticals is noticeably more concentrated than in other industries, looking at R&D investment or R&D employment. By contrast, Food & beverages and Information & communication are among those industries that show the least concentration of R&D investment and employment.

Figure 3. Concentration of business R&D by industry

Mean values across countries adjusted for country compositional effects (2011-2016 average)



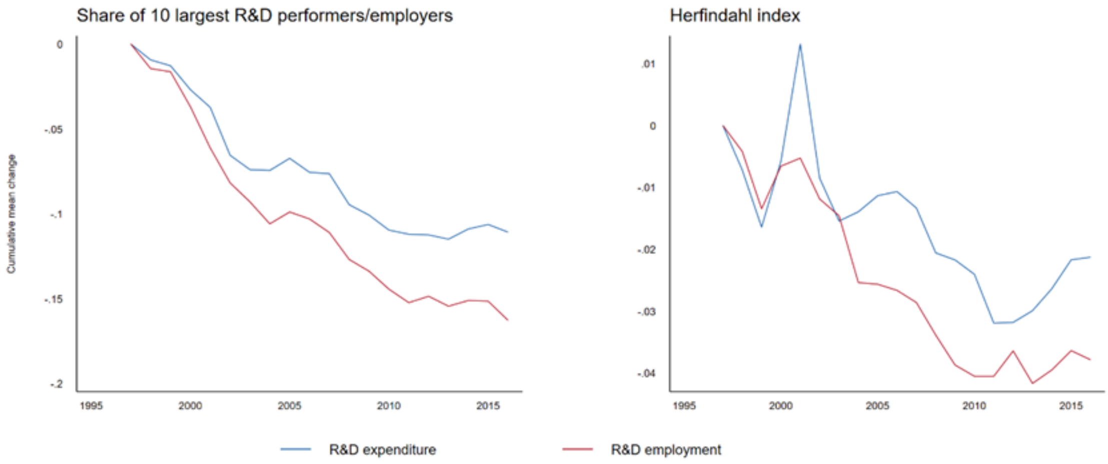
Note: The figure shows R&D concentration across firms (establishments in the case of Israel) for selected A38 industries. For each industry, it displays averages across countries. Country-specific effects have been removed by subtracting country-specific means and replacing them with the overall population mean. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. Countries: AUS, AUT, BEL, CHE, CHL, CZE, DEU, ESP, FRA, HUN, IRL, ISR, ITA, JPN, NLD, NOR, NZL, PRT, SWE. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

In recent years, a lot of attention has been given to rising industry concentration (in terms of sales) in some countries. Recent evidence for an increase in industry sales concentration in some OECD countries is provided by Bajgar *et al.* (2019). The microBeRD data offer a unique opportunity to see if similar trends can also be observed in terms of R&D concentration. Figure 4 indicates that, on average, within both countries and industries, R&D concentration has actually steadily decreased over time, whether measured by the share of the 10 largest R&D performers in an industry or by the Herfindahl index.

However, at least three important qualifications are warranted. Firstly, the “firms” or economic units in the microBeRD data are enterprises (establishments in the case of Israel).[14] If R&D performing firms increasingly form part of enterprise groups, concentration measured at the group level could be flat or even increasing while enterprise-level concentration is declining. Secondly, the metrics presented here show R&D concentration within individual countries. Global business concentration of R&D could follow very different trends, as the largest global groups can own R&D performing enterprises within many different countries. Thirdly, the distinction between R&D performance and ownership is important. In the presence of intense takeover activity and markets for IP as well as R&D outsourcing, a decline in the concentration of R&D performance could run in parallel with a rising concentration of ownership if the rights to use outcomes of R&D are ultimately acquired by a small group of companies. Subject to the availability and linkability of relevant patent microdata, microBeRD+ may further explore and provide additional insights into the concentration of R&D activity vs. IP ownership over time.

Figure 4. Trends in business R&D concentration within 2-digit industries

Weighted mean across industries and countries



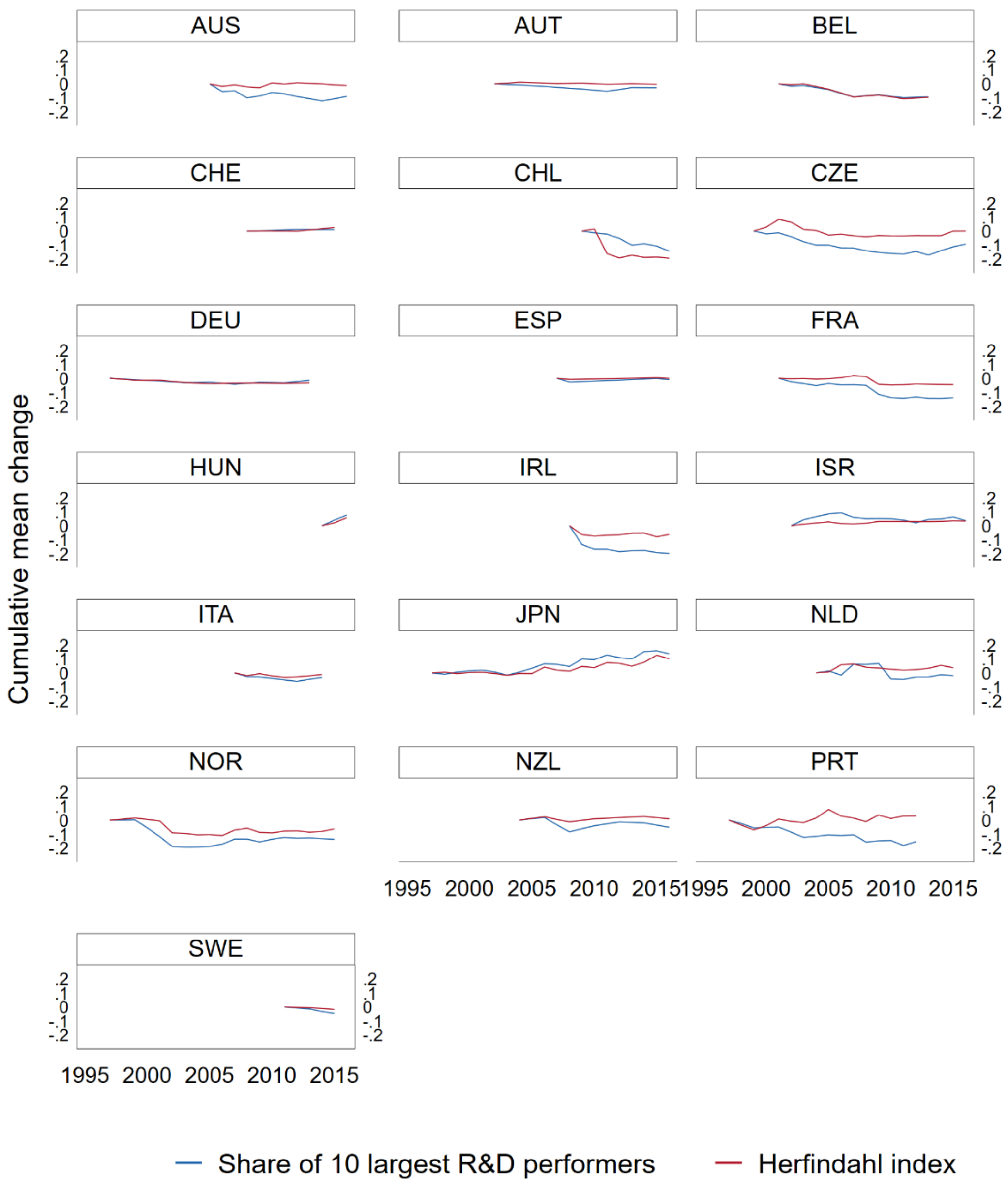
Note: The figure shows R&D concentration across firms (establishments in the case of Israel) within A38 industries. It displays the cumulative average change in concentration across countries and industries. In each year, a weighted average annual change in concentration is calculated across all country-industries with the change observed in a given year, using each industry's share in the total R&D of a given country as weight. The average annual changes are then cumulatively added over time. Countries: AUS, AUT, BEL, CHE, CHL, CZE, DEU, ESP, FRA, HUN, IRL, ISR, ITA, JPN, NLD, NOR, NZL, PRT, SWE. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

For several countries – Belgium, Chile, the Czech Republic, France and Norway – a decline in the concentration of R&D performance (intramural R&D expenditure) can be witnessed (Figure 5), while R&D concentration is flat in most other countries. The only country with a clearly increasing trend in R&D concentration is Japan. However, this result should be taken with some caution given the incomplete coverage of SMEs in the data (see Section 3.).

As Figure 6 shows, the decline in R&D performance concentration has been primarily driven by the Information & communication industry, where the share of the largest 10 R&D performing firms within countries has declined by about 40 percentage points between 1997 and 2016. Other important R&D industries that have witnessed a substantial decline in industry concentration are Finance and Scientific R&D. In most other industries, industry concentration has been flat or mildly declining, with the exception of Machinery & equipment where a noticeable increase in the share of R&D held by the ten largest performers can be observed.

Figure 5. Trends in business R&D concentration within countries

Weighted mean across industries

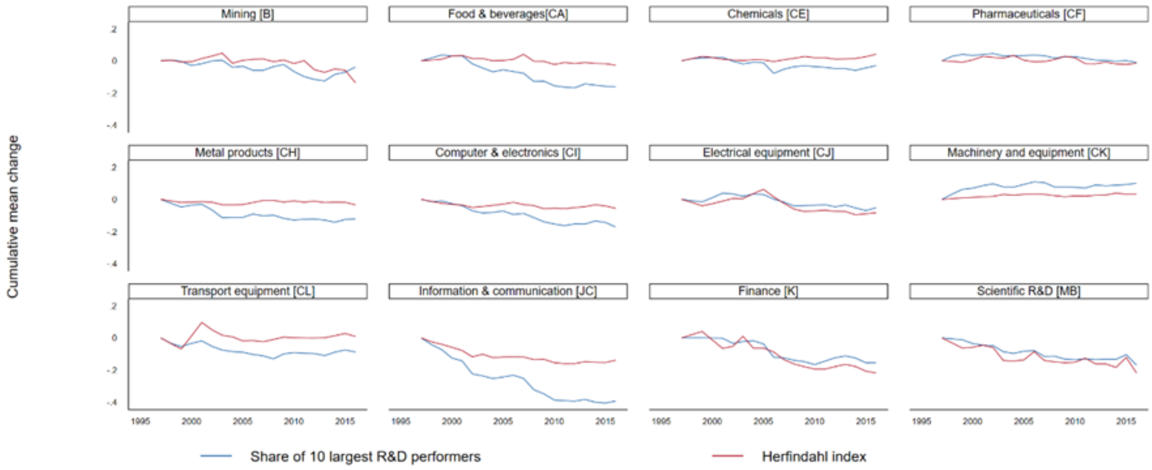


Note: The figure shows R&D concentration across firms (establishments in the case of Israel) within A38 industries. For each country, it displays the cumulative average change in concentration across industries. In each year, a weighted average annual change in concentration is calculated across all industries with the change observed in a given year, using each industry's share in the total R&D of a given country as weight. The average annual changes are then cumulatively added over time. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.

Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

Figure 6. Trends in business R&D concentration by industry

Mean across countries



Note: The figure shows R&D concentration across firms (establishments in the case of Israel) within A38 industries. For each industry, it displays the cumulative average change in concentration across countries. In each year, an average annual change in concentration is calculated across all countries with the change observed in a given year. The average annual changes are then cumulatively added over time. Countries: AUS, AUT, BEL, CHE, CHL, CZE, DEU, ESP, FRA, HUN, IRL, ISR, ITA, JPN, NLD, NOR, NZL, PRT, SWE. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

An important question is to what extent the observed trends in R&D concentration might have been influenced by R&D support policies, and R&D tax incentives more specifically. To explore this question, Figure 7 plots for each country the change in R&D concentration over the entire period for which relevant data available against the log change in the average B-Index over the same period. The approach adopted in the microBeRD project is to estimate the implications of R&D tax relief provisions through the calculation of the B-Index at the level of each firm (OECD, 2020a). The B-Index is a key R&D tax incentive indicator (Appelt et al., 2019) that specifies the cost of R&D to business when investing one additional monetary unit in R&D.

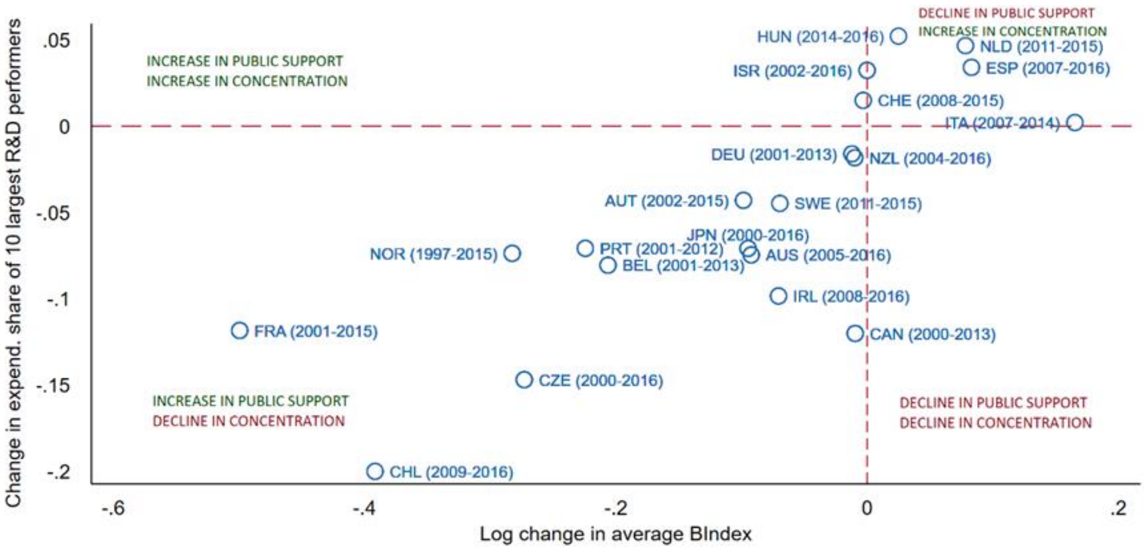
Figure 7 shows a link between a decrease in tax relief related cost of R&D and a decrease in R&D concentration: countries that have seen the largest increases in tax support (i.e. the strongest declines in B-Index) have also seen the sharpest declines in R&D concentration. In a specular way, the few countries that have seen a decline in support, and therefore an increase in the B-Index, such as Netherlands, Spain, Hungary, and to a lesser extent Italy, have seen an increase in R&D concentration. This is in line with evidence from the initial microBeRD cross-country study (OECD, 2020a), which showed that tax incentives induce additional entry into R&D performance as well as additional R&D investment among existing R&D performers whereby smaller firms respond more strongly to R&D tax incentives than larger firms.

This stylised correlation does not have direct policy implications since there are multiple mechanisms that connect public support and the observed R&D concentration patterns. The design features of tax support may in some instances induce different R&D funding and performance arrangements. In addition, measurement and sampling concerns can also arise if the introduction of R&D tax incentives helps R&D surveys identify smaller R&D-

performing firms. This would reduce the measured R&D concentration even if the actual R&D concentration remains unchanged.

Figure 7. Changes in business R&D concentration and the cost of R&D (B-Index)

Change between the first and the last year for each country



Note: For each country, the figure plots a change in national R&D concentration across firms (establishments in the case of Israel) against the log change in the average B-Index. The changes are calculated between the first and last year available in the data for each country. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

4.2. Performance and funding of R&D by foreign-controlled affiliates

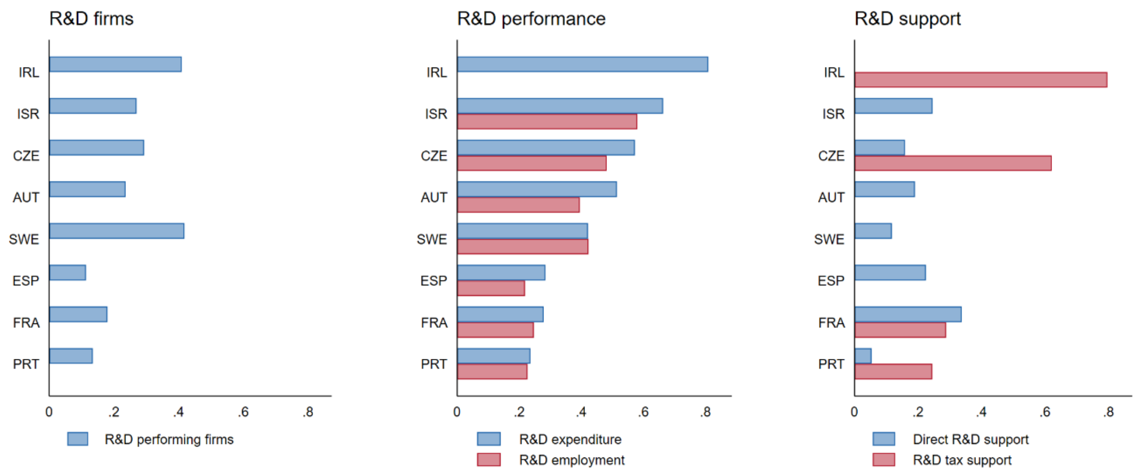
The microBeRD analysis also provides insights into the role that foreign-controlled affiliates[15] play as R&D performers in different countries. Figure 8 describes the share of foreign-owned firms in the R&D sector – relative to the population of R&D performing firms, total R&D expenditure, and R&D employment as well as direct and tax support for business R&D – for each country where foreign ownership information is available.

Figure 8 (left panel) shows that more than 40% of R&D-performing firms in Sweden are foreign-owned, whereas less than 20% of R&D-performing firms are foreign-owned in the case of Spain, Portugal, and France. However, the share of foreign-owned firms in the total number of R&D performing firms is not necessarily very informative about the overall importance of foreign-owned firms in terms of total R&D expenditure because foreign-owned firms tend to be disproportionally large companies (see middle panel) and in many cases (e.g. Portugal; Ireland; Israel) foreign-controlled firms account for double the share in terms of R&D expenditure or R&D employment than in terms of number of R&D performing firms. Indeed, their share in total business R&D expenditure is more than 40% in the median country (Sweden) and ranges from just above 20% in Portugal to around 70% in Israel. Foreign-owned firms also account for a large share of business R&D expenditure in the Czech Republic and Austria, whereas they play a comparatively more limited role in Spain, Portugal, and France. The corresponding figures for R&D employment support this finding.

Interestingly, foreign-owned firms tend to receive proportionally less R&D support through direct funding (Figure 8 right panel) compared to their share in total R&D expenditure, with the exception of France and, to a lesser extent, Spain. By contrast, in all three countries (Czech Republic, France, Portugal) where matched R&D and tax data are available together with foreign ownership information, foreign-owned firms account for a slightly greater share of R&D tax relief than R&D expenditure. This might be due to foreign-owned firms being more likely to actually apply for R&D tax relief or being more likely to receive support (e.g. more likely to be profitable). Other factors such as the presence and relative magnitude of ceilings on the amount of qualifying R&D expenditure or value of R&D tax benefits may also play a role. In the case of Ireland, where micro-aggregated statistics rely exclusively on tax relief data, foreign-owned firms account for over 80% of qualifying R&D expenditure and over 40% of R&D tax support claimed (i.e. earned credits, including carry-forwards from previous periods). This figure differs from the actual value of R&D tax support paid out to firms (sum of tax offsets and refunds, where applicable) in the accounting period.

Figure 8. Share of foreign-owned firms in business R&D expenditure and funding

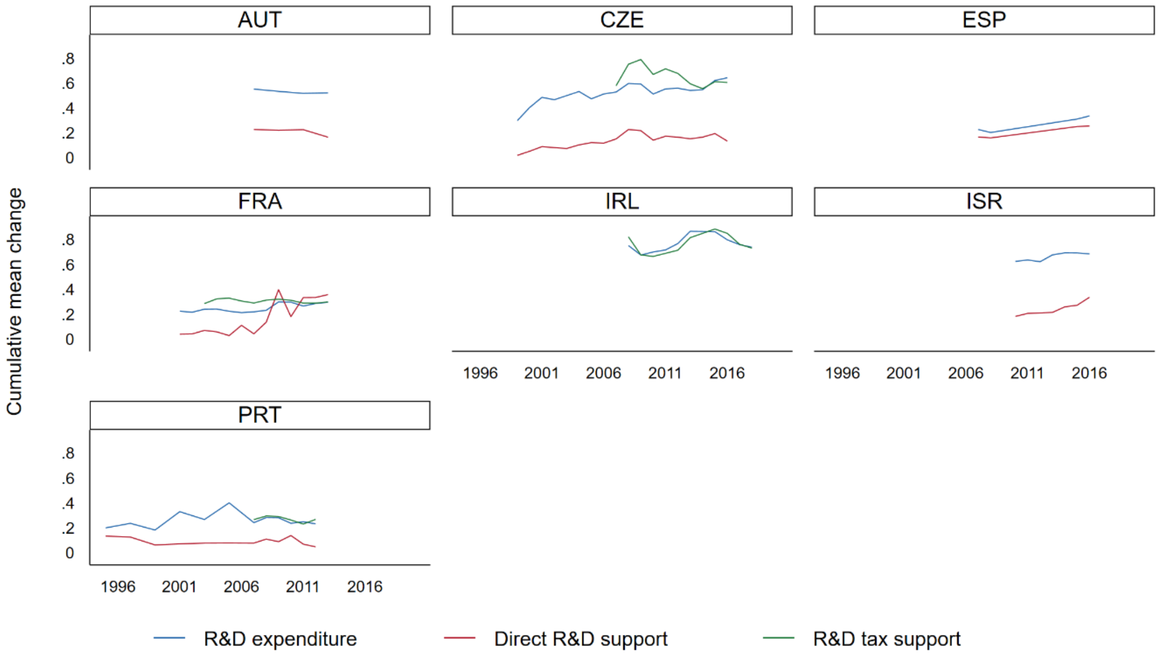
2011-2016 average



Note: For each country, the figure shows the share of foreign-owned firms in business R&D in terms of R&D performing firms, performance and funding. It displays average values across all years available for a given country in the period 2011-2016. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

Figure 9 displays how the share of foreign-owned firms in business R&D expenditure and R&D funding – direct vs tax support – has evolved over time in different countries. In the Czech Republic and Spain, the importance of foreign-owned firms as corporate R&D performers has seen a steady increase over time, while their importance has been relatively stable in France and Portugal.[16]

Figure 9. Trends in the share of foreign-owned firms in business R&D expenditure and funding



Note: For each country, the figure shows the evolution of the share of foreign-owned firms in business R&D in terms of R&D expenditure and funding of business R&D. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

4.3. Business R&D activity and funding across industries

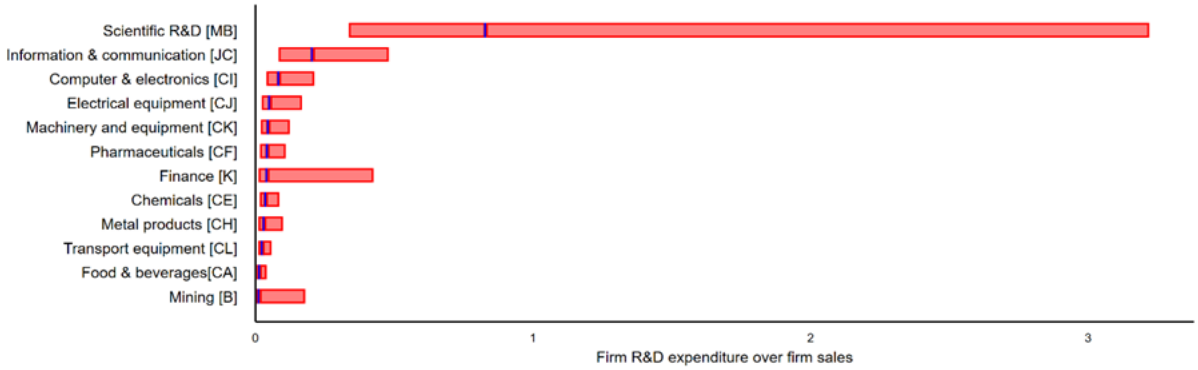
This section uses the rich detail of the micro-aggregated data produced by microBeRD to offer new insights into differences in the distribution, structure and orientation of business R&D across industries. As Figure 10 shows, there are substantial differences in the R&D intensity of R&D-performing firms across industries, with R&D intensity being defined as the ratio of R&D expenditure to sales.

Importantly, Figure 10 documents R&D intensity of firms *conditional* on these firms having a strictly positive R&D expenditure. R&D performers in the Scientific R&D industry tend to have a much higher R&D intensity (median at 70%, 75th percentile at 270%) than R&D performers in any other industry. This is because R&D service providers are likely to reflect in their scope and type of R&D activity the dominant use industry (e.g. pharma) in a given country.

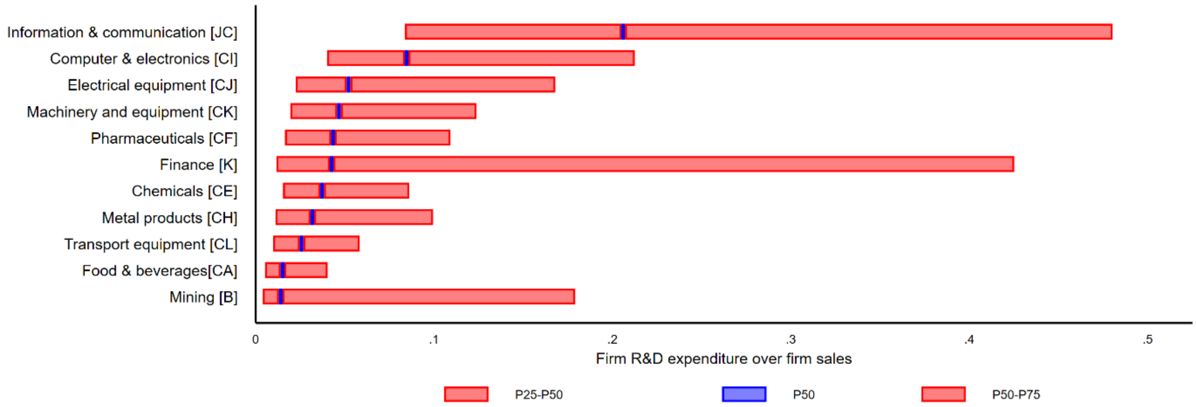
The R&D intensity of a median R&D performing firm is highest in Information & communication with 21% and Computer & electronics with about 8%. In most other industries, the median R&D intensity is below 5%, and it is lowest in Food & beverages and Mining (1.5%). However, there are also important differences beyond the median firm. In particular, in Finance and in Mining, firms at the 75th percentile of R&D intensity are highly R&D-intensive even though the median firm has, relative to all other sectors, average R&D intensity in Finance and low R&D intensity in Mining.

Figure 10. Distribution of R&D intensity (among R&D performers) by industry

Panel 1: Average of percentiles across countries (2011-2016 average).



Panel 2: The same as Panel 1 but excluding Scientific R&D.

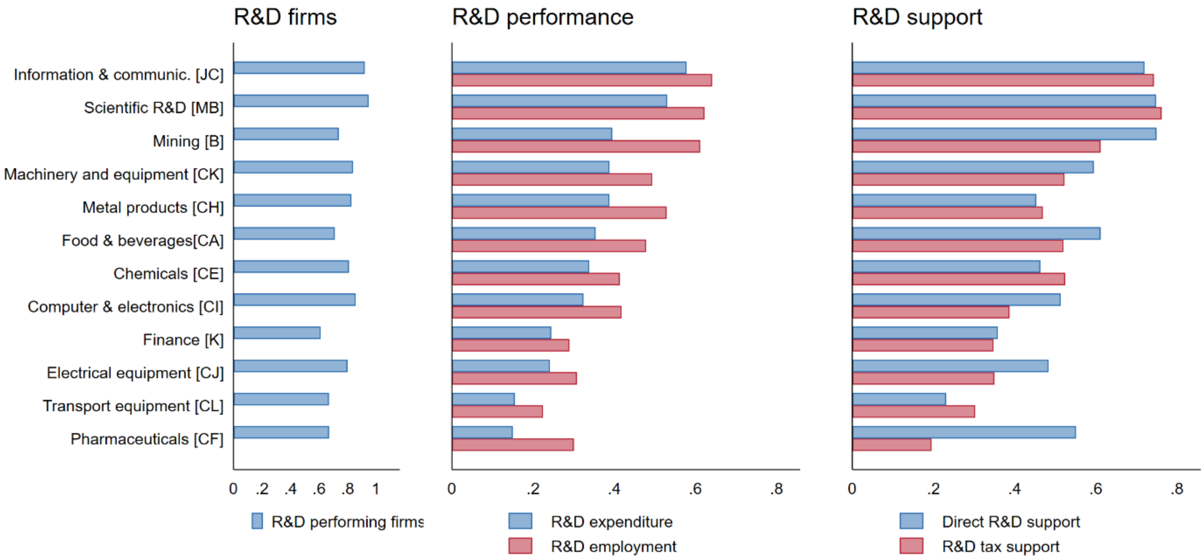


Note: The figure shows the distribution (25th, 50th and 75th percentile across firms) of R&D intensity (R&D expenditure divided by sales and profits in the case of Ireland) for selected A38 industries (two-digit A38 codes in squared brackets). For each industry, it displays (unweighted) averages across countries. It is based on average values across all years available for a given country-industry in the period 2011-2016. Countries: AUS, AUT, BEL, CHL, CZE, DEU, ESP, FRA, IRL, ISR, JPN, NZL, PRT, SWE. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

Industries also differ widely in terms of the contribution that SMEs make to national business R&D performance (Figure 11). As with the share of foreign-owned firms, the differences are not so important in terms of the number of R&D performers as the majority of R&D-performing firms are SMEs in all industries, but they become significant when focusing on the share of R&D expenditure and R&D employment accounted for by SMEs. SMEs account for around half of total business R&D expenditure and R&D employment in Scientific R&D and Information & communication, but for only around 10% of total business R&D expenditure and about 20-25% of R&D employment in Pharmaceuticals and Transport equipment.

Figure 11. SME share in R&D firms, R&D performance and R&D support by industry

Mean across countries adjusted for country compositional effects (2011-2016 average)



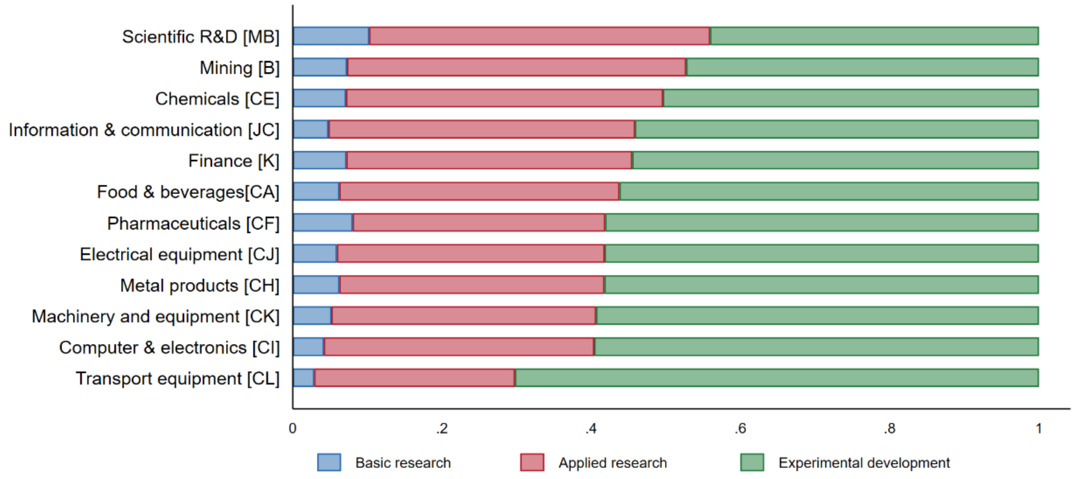
Note: For selected A38 industries, the figure shows the share of SMEs (10-249 employees) in business R&D in terms of firm count, performance and funding. For each industry, it displays averages across countries. Country-specific effects have been removed by subtracting country-specific means and replacing them with the overall population mean. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. Countries: AUS, AUT, BEL, CAN, CHE, CHL, CZE, DEU, ESP, FRA, GBR, IRL, ISR, ITA, JPN, NLD, NOR, NZL, PRT, SWE. Countries (direct support): AUS, AUT, BEL, CHE, CHL, CZE, DEU, ESP, FRA, HUN, ISR, ITA, JPN, NLD, NOR, NZL, PRT, SWE. Countries (tax support): AUS, BEL, CAN, CZE, FRA, HUN, IRL, NLD, NOR, PRT, SWE The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

SMEs tend to account for a disproportionally higher share of direct funding, reflecting the more discretionary nature of this form of support, compared to their contribution to business R&D performance in most industries, but the difference is particularly large in Mining and Pharmaceuticals. As expected for market-based and less discretionary support measures, such as R&D tax credits, the SME share in R&D tax relief tends to match more closely the SME share in R&D expenditure across all industries. Figure A B.1 provides complementary, country specific information on the SME shares in population of R&D firms, R&D performance and support by industry for the subset of countries that offer R&D tax incentives and have available matched R&D and tax relief microdata.

Although the industry composition of R&D differs in terms of basic and applied research versus experimental development, the cross-sectoral differences are on average of a moderate scale (Figure 12). Basic and applied research accounts for between 40% and 60% of all R&D expenditure in all main R&D industries except for Transport equipment, where it accounts for less than 30% of total R&D. Basic research represents a minor share of total R&D in all industries, and it is most important in Scientific R&D and Pharmaceuticals. Compared to official R&D statistics by the US National Science Foundation on business R&D in the United States by industry and type of R&D for 2018,[17] the micro-data based industry-level shares of experimental development (Figure 12) averaged across countries where relevant data are available, are somewhat lower (around 60%) than those found for the United States (60-85%), although the overall pattern looks qualitatively similar.

Figure 12. Intramural R&D expenditure by industry and type of R&D

Mean across countries adjusted for country compositional effects (2011-2016 average)



Note: For selected A38 industries, the figure shows the orientation of R&D. For each industry, it displays unweighted averages across countries. Country-specific effects have been removed by subtracting country-specific means and replacing them with the overall population mean. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. Countries: AUS, AUT, BEL, CHE, CHL, CZE, DEU, ESP, FRA, ISR, ITA, JPN, NLD, NOR, PRT, SWE.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

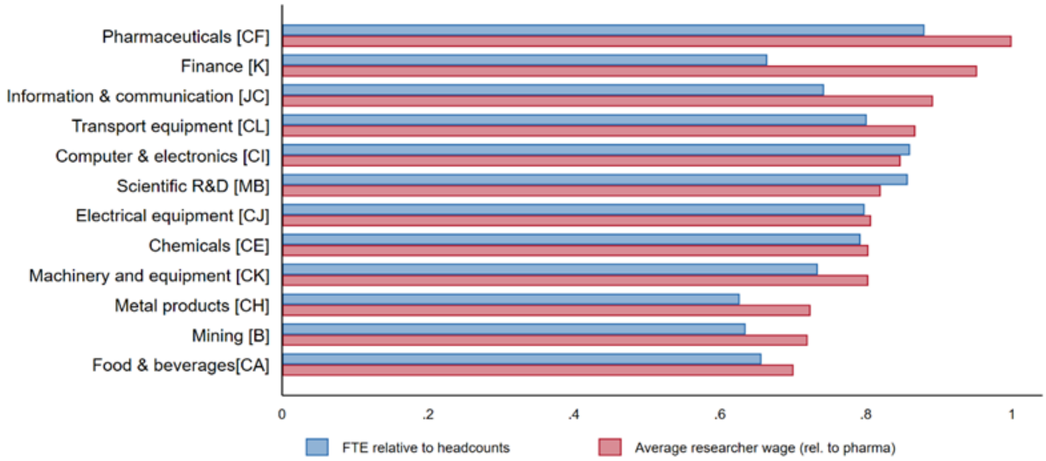
The nature of R&D in different industries can also be characterised according to the type of R&D employment (Figure 13). For instance, the ratio of R&D employment measured in full-time equivalents to R&D employment measured in headcounts indicates whether most R&D employees in a given industry work on R&D projects on a full-term basis or devote only a part of their working time to R&D (or work only part-time). In Scientific R&D, Computer & electronics and Pharmaceuticals, employees involved in R&D seem more likely to be fully dedicated to work on R&D projects. In Finance, Mining and Metal products, by contrast, it seems relatively common for employees to devote only part of their time to R&D.

Another way to characterise R&D employment in different industries is to look at the relative wages of R&D workers, as approximated by R&D unit labour costs, i.e. the ratio of total labour R&D expenditure to total number of R&D employees. To abstract from differences in labour costs across countries and look only at relative differences within countries, R&D wages are normalised to one in the Pharmaceuticals industry in each country. Figure 13 documents that researchers in Pharmaceuticals, Finance and Information and Communication are paid 40-50% more than researchers in Metal products and Food & beverages.

Finally, the share of female R&D employees and share of R&D staff with a doctorate degree can also provide important insights into industry specific differences in R&D employment (Figure 14). Women represent over one third of R&D employees in Chemicals, Scientific R&D and Food & beverages and more than 50% of R&D employees in Pharmaceuticals. By contracts, 10% or fewer of R&D employees in Transport equipment, Metal products and Machinery and equipment are women. Likewise, a high share of doctorate holders among R&D staff can be found in science-based industries such as Pharmaceuticals, Scientific R&D and Chemicals.

Figure 13. Full time engagement in R&D and R&D unit labour costs by industry

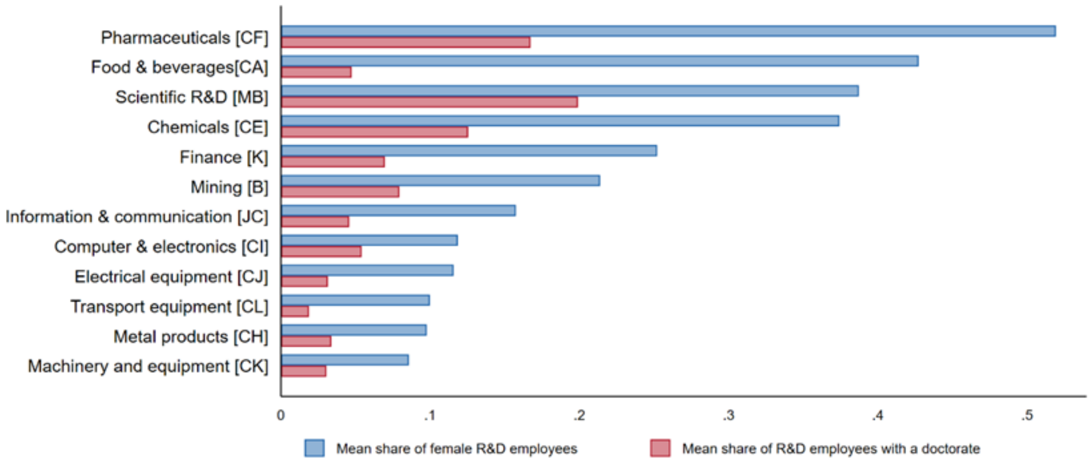
Mean across countries adjusted for country compositional effects (2011-2016 average)



Note: For selected A38 industries, the figure documents the characteristics of R&D employment. The first measure is calculated as the ratio of R&D employment defined in full-time equivalents and R&D employment defined in headcounts. The second measure is calculated as the ratio of total labour R&D expenditure to total number of R&D employees, normalised to be 1 in pharmaceuticals. For each industry, the figure displays averages across countries. Country-specific effects have been removed by subtracting country-specific means and replacing them with the overall population mean. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. Countries: AUT, BEL, CHE, CHL, CZE, DEU, ESP, FRA, HUN, ITA, NLD, NOR, PRT.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

Figure 14. Share of female R&D employees and R&D staff with doctorate degree by industry

Mean across countries adjusted for country compositional effects (2011-2016 average)

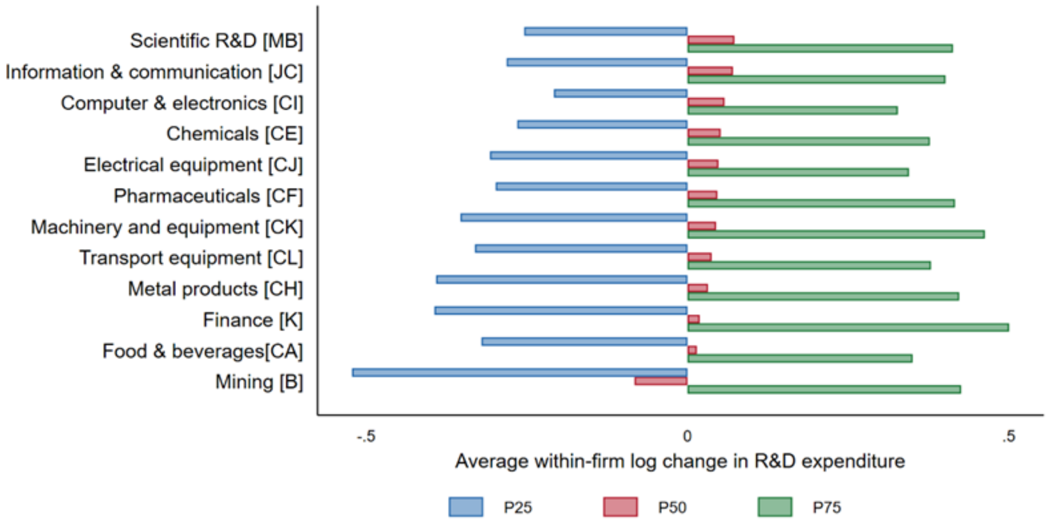


Note: For selected A38 industries, the figure shows the share of women and of doctorate-level workers among R&D employees. For each industry, the figure displays averages across countries. Country-specific effects have been removed by subtracting country-specific means and replacing them with the overall population mean. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. Countries: AUT, BEL, CHL, CZE, ESP, ISR, ITA, JPN, PRT.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

The micro-aggregated structure of the microBeRD data also permits looking at the distribution of within-firm growth in R&D expenditure. Figure 15 shows that in all industries, R&D expenditure is highly volatile from year to year, with an annual growth rate of around -35% at the 25th percentile and around 50% at the 75th percentile. With the exception of Mining, a positive within-firm annual growth rate in R&D expenditure can be observed for the median firm (50th percentile) in all industries, ranging from 1.6% in Food & beverages to 7.6% in Scientific R&D.

Figure 15. Within-firm growth in R&D performance by industry

Means of R&D expenditure growth percentiles across countries (2011-2016 average)

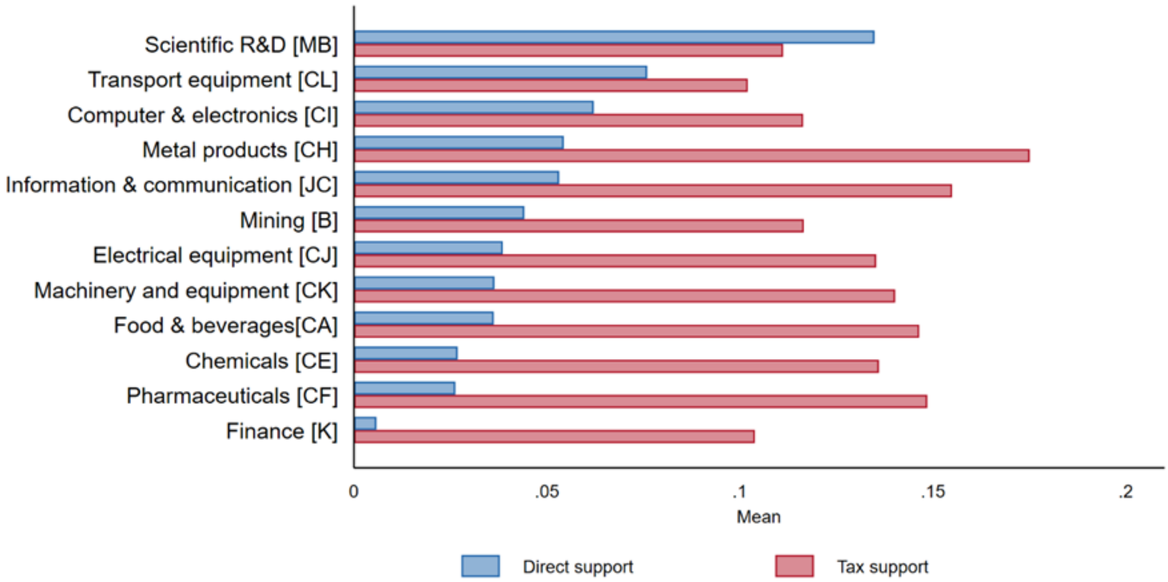


Note: For selected A38 industries, the figure shows the 25th, 50th and 75th percentile of the distribution of the within-firm annual growth (log change) in R&D expenditure across firms. For each industry, it displays averages across countries. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. Countries: AUS, AUT, BEL, CAN, CHL, CZE, DEU, FRA, HUN, IRL, ISR, ITA, JPN, NLD, NOR, NZL, PRT, SWE. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

Industries also differ in the amount of direct funding and tax support that R&D performing firms receive. Figure 16 shows the average ratios of direct and tax support R&D to business R&D expenditure by industry. Firms in the Scientific R&D sector benefit comparatively most from direct funding with a direct funding to R&D expenditure ratio close to 13%. Scientific R&D is the only sector where firms rely more on direct funding than R&D tax incentives on average (across the countries included in the sample). By contrast, only a very small fraction of business R&D is financially supported through direct funding in the Finance sector. The industries that rely most on R&D tax support according to the ratio of R&D tax support to business R&D expenditure – a proxy measure for the average R&D tax subsidy – include Metal products (16%), Food & beverages (14%) and Pharmaceuticals (14%). Figure A B.2 (Annex B) provides complementary information on the relative importance of direct funding and tax support for business R&D separately for each industry and country, pointing to a large variation in the amount of direct and tax support that R&D performers in different industries receive on average across countries (relying on differences in average ratios of direct and tax support for R&D relative to business R&D expenditure).

Figure 16. Direct and tax support for business R&D as a share of R&D expenditure by industry

Mean across countries adjusted for country compositional effects (2011-2016 average)



Note: For selected A38 industries, the figure shows the ratios of direct and tax support to business R&D expenditure. For each industry, the figure displays averages across countries. Country-specific composition effects have been removed by subtracting country-specific means and replacing them with the overall population mean. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. Countries (direct support): AUS, AUT, BEL, CHE, CHL, CZE, DEU, ESP, FRA, HUN, ISR, ITA, JPN, NLD, NOR, NZL, PRT, SWE. Countries (tax support): AUS, BEL, CAN, CZE, FRA, HUN, IRL, NLD, NOR, PRT, SWE. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

How public support for business R&D is distributed across industries does not only depend on the share of government-financed R&D in each industry but also on each industry's share in total business R&D expenditure. Table 4 documents large cross-country differences in how direct support is distributed across industries. In Belgium, for example, the distribution of direct funding of business R&D across the main R&D industries is remarkably even. By contrast, in several countries, a large proportion of direct support is concentrated in Scientific R&D or Transport equipment. The distribution of R&D tax relief across industries in each country is shown in Table 4, based on matched R&D and tax relief microdata. Compared to direct funding, R&D tax relief tends to be more evenly distributed across industries and better reflect industry shares in the total R&D expenditure, which is to be expected given the non-discretionary, market-based nature of R&D tax incentives. Table 4 also presents a micro-data based version of the official R&D statistics on intramural business R&D by industry, as found in the OECD ANBERD database. As discussed in Section 3. , such analytical microBeRD indicators may not perfectly match national official figures for several reasons.

Table 4. Distribution of intramural R&D and direct and tax support for BERD by industry

Mean across countries (2011-2016 average)

Country	Variable	Mining	Food & beverages	Chemicals	Pharmaceuticals	Metal products	Computer & electronics	Electrical equipment	Machinery & equipment	Transport equipment	Information & communicatio	Finance	Scientific R&D	Other
AUS	**Intramural R&D**	20%	4%	5%		4%			8%	6%	10%	20%		23%
	Direct support	2%	2%	2%		4%			8%	52%	11%	2%		16%
	Tax support	17%	7%	4%		9%			8%	2%	11%	14%		28%
AUT	**Intramural R&D**	0%	1%	3%	4%	5%	10%	11%	14%	9%	5%	0%	14%	25%
	Direct support	0%	0%	1%	0%	3%	7%	5%	6%	3%	4%	0%	52%	19%
BEL	**Intramural R&D**	0%	1%	5%	31%	3%	4%	3%	5%	4%	8%	3%	9%	23%
	Direct support	0%	2%	5%	3%	4%	9%	6%	5%	6%	10%	0%	10%	40%
	Tax support	0%	1%	9%	34%	3%	5%	5%	3%	1%	13%	1%	8%	17%
CAN	**Intramural R&D**	10%	1%	1%	4%	4%	19%	1%	3%	12%	9%	2%	8%	25%
	Tax support	5%	1%	1%	4%	5%	17%	1%	4%	11%	14%	2%	7%	28%
CHE	**Intramural R&D**		0%	3%	36%	3%	13%	2%	8%	2%	2%		13%	17%
	Direct support		0%	1%	1%	4%	3%	1%	2%	12%	2%		65%	9%
CHL	**Intramural R&D**	2%	12%	9%	7%	3%		0%	1%		8%	7%	9%	40%
	Direct support	0%	10%	3%	4%	2%		0%	1%		7%	1%	28%	44%
CZE	**Intramural R&D**	0%	1%	3%	3%	3%	3%	6%	9%	18%	15%	2%	14%	24%
	Direct support	0%	0%	2%	2%	4%	5%	2%	8%	6%	18%	0%	31%	22%
	Tax support	0%	1%	3%	2%	5%	4%	9%	16%	30%	11%	6%	3%	9%
DEU	**Intramural R&D**	0%	1%	6%	8%	2%	14%	3%	10%	37%	5%	1%	3%	10%
	Direct support	0%	0%	3%	1%	5%	12%	2%	5%	27%	6%	0%	19%	20%
ESP	**Intramural R&D**	0%	3%	4%	9%	3%	3%	3%	3%	13%	9%	2%	22%	26%
	Direct support	0%	2%	1%	1%	3%	2%	1%	3%	19%	9%	0%	40%	17%
FRA	**Intramural R&D**	0%	1%	5%	4%	2%	12%	3%	3%	18%	6%	1%	11%	33%
	Direct support	0%	0%	4%	0%	1%	23%	1%	2%	47%	3%	0%	7%	10%
	Tax support	0%	2%	6%	5%	3%	12%	3%	3%	12%	8%	2%	14%	30%
HUN	**Intramural R&D**		1%	1%	18%	1%		2%	6%	13%	7%		23%	28%
	Direct support		2%	1%	6%	2%		1%	9%	3%	15%		31%	30%
	Tax support		0%	0%	29%	0%		2%	2%	42%	2%		4%	19%

Country	Variable	Mining	Food & beverages	Chemicals	Pharmaceuticals	Metal products	Computer & electronics	Electrical equipment	Machinery & equipment	Transport equipment	Information & communicatio	Finance	Scientific R&D	Other
IRL	Intramural R&D		2%	1%	13%	1%	15%	1%	2%		11%	1%	5%	47%
	Tax support		2%	2%	11%	1%	14%	1%	3%		15%	1%	6%	45%
ISR	Intramural R&D		0%	1%		1%	17%	0%	2%		37%		36%	6%
	Direct support		1%	1%		2%	30%	1%	2%		16%		41%	7%
ITA	Intramural R&D	1%	1%	3%	5%	3%	13%	4%	12%	23%	5%	1%	6%	21%
	Direct support	0%	0%	1%	1%	2%	17%	1%	3%	39%	7%	0%	22%	8%
JPN	Intramural R&D	0%	2%	15%	2%	4%	19%	9%	8%	18%	0%	0%	3%	18%
	Direct support	0%	0%	5%	1%	5%	14%	10%	3%	6%	0%	0%	4%	53%
NLD	Intramural R&D	1%	5%	6%	4%	2%	8%	7%	14%	3%	8%	2%	21%	18%
	Direct support	0%	1%	0%	0%	0%	7%	1%	0%	1%	3%	0%	61%	26%
	Tax support	0%	8%	6%	7%	4%	12%	12%	22%	7%	8%	0%	11%	2%
NOR	Intramural R&D	9%	2%	4%	2%	8%	7%	2%	4%	4%	12%	0%	4%	41%
	Direct support	2%	2%	5%	1%	13%	5%	3%	6%	4%	1%	1%	9%	46%
	Tax support	1%	6%	3%	1%	6%	6%	2%	7%	4%	6%	0%	4%	54%
NZL	Intramural R&D		8%	1%	1%	2%	5%	10%	6%	1%	21%	1%	12%	32%
	Direct support		0%	0%	0%	2%	5%	9%	5%	0%	14%	0%	27%	38%
PRT	Intramural R&D	0%	5%	2%	8%	3%	2%	4%	1%	4%	8%	15%	3%	45%
	Direct support	0%	2%	1%	33%	5%	3%	3%	1%	1%	18%	1%	7%	26%
	Tax support	0%	5%	4%	21%	5%	3%	5%	2%	8%	11%	1%	2%	33%
SWE	Intramural R&D		0%	2%		3%			7%	21%	3%	1%	11%	50%
	Direct support		0%	0%		2%			0%	79%	0%	0%	14%	4%
	Tax support		0%	5%					10%	0%	10%	0%	19%	56%

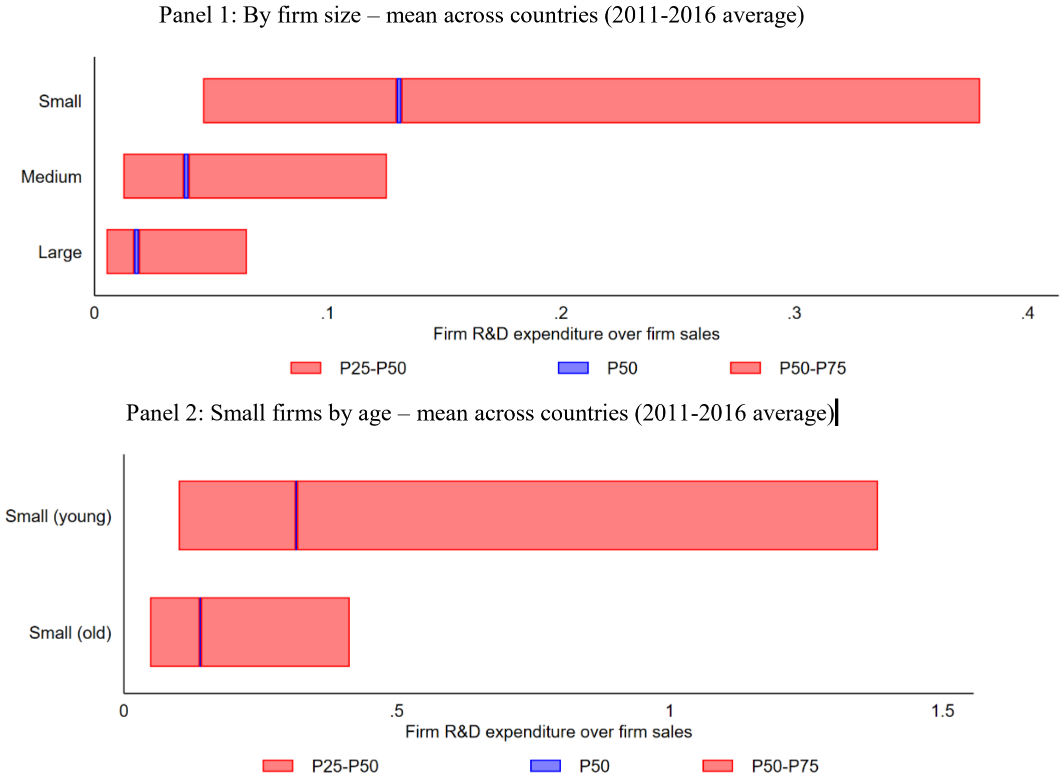
Note: For each country, the figure shows the distribution of intramural R&D expenditure, direct funding of business R&D and government R&D tax relief across A38 industries, and reflects for a given country-industry an average value across all years where relevant data are available in the period 2011-2016. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries. With the exception of Ireland, the distribution R&D tax relief is calculated based on the matched BERD and tax relief sample and may deviate from official R&D tax relief statistics that are based on the whole population of R&D tax relief recipients. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

4.4. The role of small and young R&D performers

Evidence on how R&D performance patterns vary across different business characteristics, especially those not usually captured by available statistics (e.g. firm age), is essential for understanding the structure and dynamics of R&D performance across countries. In addition to industry classification, firm size and firm age are key dimensions in which R&D performing firms – and their R&D activities – differ. This section presents novel microdata based statistics that provide new evidence on the distribution of R&D across firms of different size and age , the role of small and young firms as R&D performers across industries and the variation in R&D intensity by firm size and age.

Figure 17 plots the distribution of R&D intensity (R&D expenditure-sales ratio) among R&D performers by firm size and firm age. Small R&D-performing firms tend to have a higher R&D intensity than medium-sized and large firms, looking at the median R&D intensity (50th percentile) within each size class. However, this is conditional on firms having strictly positive R&D and it does not imply that small firms are in general more R&D intensive than larger ones. Small firms younger than 5 years show particularly high R&D intensity, which is at least partially linked to the limited sales that such firms generate in the early years of operation.[18]

Figure 17. Distribution of R&D intensity among R&D performers by firm size and age

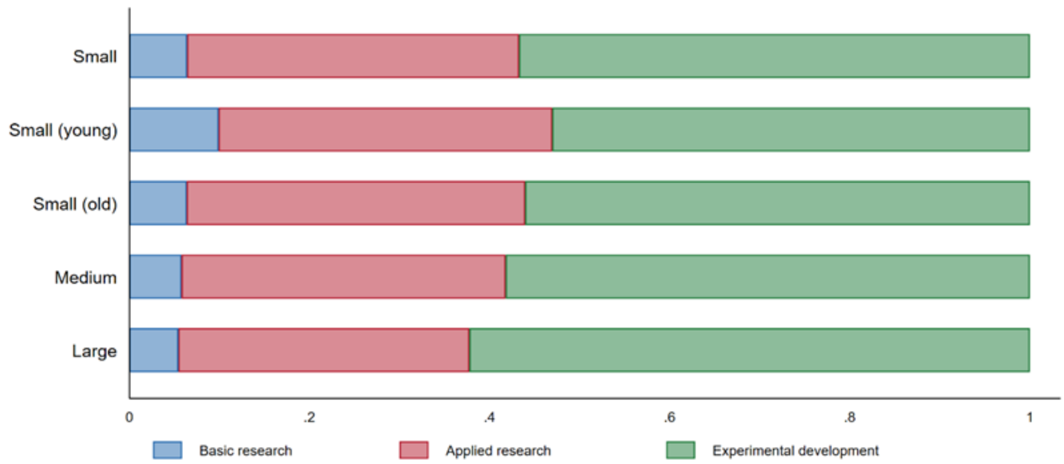


Note: The figure shows the distribution (25th, 50th and 75th percentile across firms) of R&D intensity (R&D expenditure divided by sales) by firm size and age. It displays averages across countries. It is based on average values across all years available for a given country in the period 2011-2016. Countries: AUS, AUT, BEL, CHL, CZE, DEU, ESP, FRA, IRL, ISR, JPN, NZL, PRT, SWE. "Young" firms are defined as those with less than 5 years of age and old" firms as those that are five years and older. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

Small firms, and particularly young small firms, also invest the largest share of their business R&D expenditure into basic and applied research, but the differences are not large (Figure 18). These differences may be more pronounced for one country than another possibly also reflecting differences in the typical size of companies within each size class. Official R&D statistics by the US National Science Foundation on business R&D expenditure by firm size and type of R&D for 2018,[19] for instance, point to more marked differences in the share of basic and applied research for small companies (31%) and medium-sized (27%) vis-à-vis large firms (21%).

Figure 18. Orientation of intramural R&D expenditure by firm size and age

Mean across countries adjusted for country compositional effects (2011-2016 average)



Note: The figure shows the composition of R&D expenditure in terms of the type of R&D by firm size and age. The figure displays averages across countries. Country-specific effects have been removed by subtracting country-specific means and replacing them with the overall population mean. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. Countries: AUS, AUT, BEL, CHE, CHL, CZE, DEU, ESP, FRA, ISR, ITA, JPN, NLD, NOR, PRT, SWE.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

Larger R&D performers in turn exhibit a somewhat higher rate of full time dedication to R&D by R&D staff (ratio of R&D employment in full-time equivalents to R&D employment in headcounts), and they also pay substantially higher wages (Figure 19), as measured by R&D unit labour costs (ratio of total labour R&D expenditure to total number of R&D employees). R&D unit labour costs are actually about 50% higher for large firms than for small firms, with medium-sized firms placed in between.

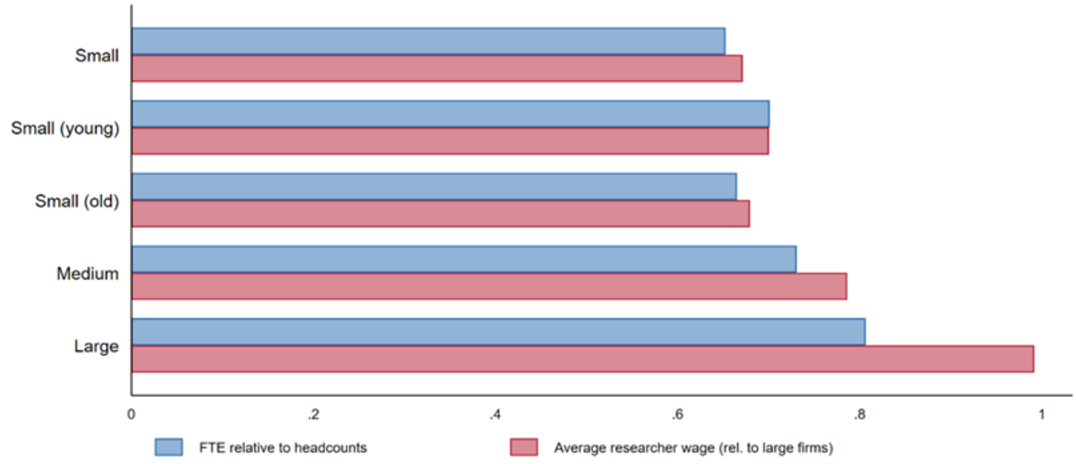
Looking at differences in the composition of the R&D work force (Figure 20), young firms have on average the highest share of R&D employees with a doctorate degree, but they also have the lowest share of female R&D employees. Large firms have the highest share of female R&D employees.

Large firms also outsource R&D twice as much as small and medium-sized firms, as measured by the ratio of extramural to total (intramural and extramural) R&D expenditure (Figure 21).

In terms of the importance of public support for R&D for firms of different size (Figure 23), smaller firms rely to a larger extent on public support for R&D in financing their R&D investments, both in terms of direct and tax support.

Figure 19. R&D employment and unit labour costs by firm size and age

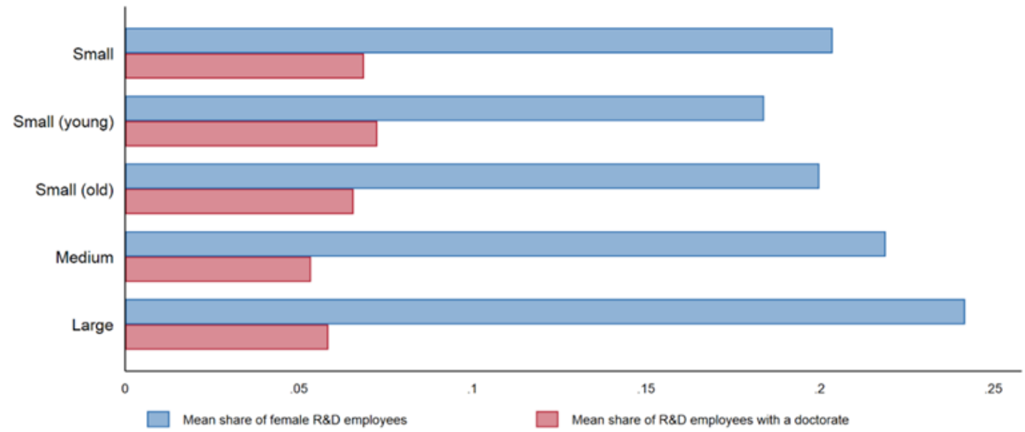
Mean across countries adjusted for country compositional effects (2011-2016 average



Note: The figure documents the characteristics of R&D employment by firm size and age. The first measure is calculated as the ratio of R&D employment defined in full-time equivalents and R&D employment defined in headcounts. The second measure is calculated as the ratio of total labour R&D expenditure to total number of R&D employees, normalised to be 1 in pharmaceuticals. The figure displays averages across countries. Country-specific effects have been removed by subtracting country-specific means and replacing them with the overall population mean. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. Countries: AUT, BEL, CHE, CHL, CZE, DEU, ESP, FRA, HUN, ITA, NLD, NOR, PRT.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

Figure 20. Share of female R&D employees and R&D staff with a doctorate degree

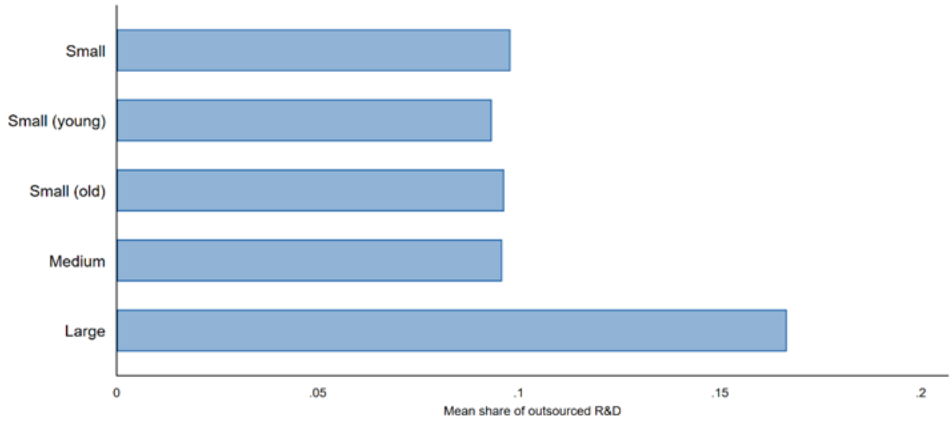
Mean across countries adjusted for country compositional effects (2011-2016 average



Note: The figure shows the share of women and of doctorate-holders among R&D employees by firm size and age. The figure displays averages across countries. Country-specific effects have been removed by subtracting country-specific means and replacing them with the population mean. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. Countries: AUT, BEL, CHL, CZE, ESP, ISR, ITA, JPN, PRT.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

Figure 21. Outsourced R&D as share of total intramural and extramural R&D expenditure

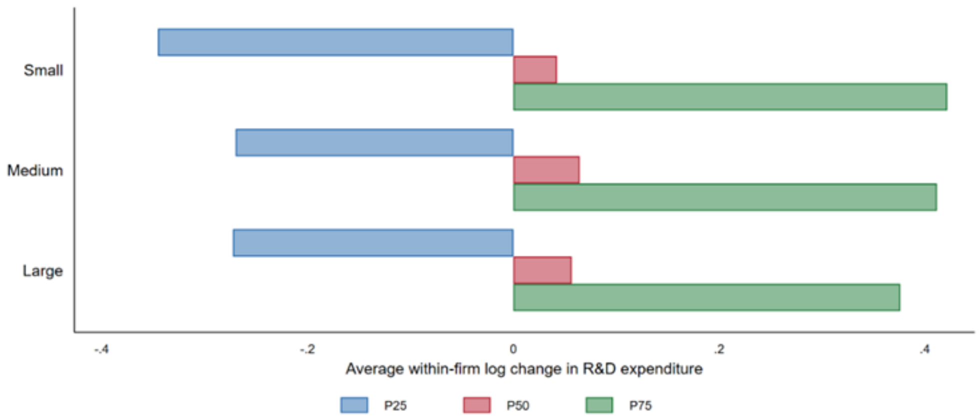
Mean across countries adjusted for country compositional effects (2011-2016 average)



Note: The figure shows the share of extramural R&D expenditure in the combined intramural and extramural R&D expenditure by firm size and age. The figure displays averages across countries. Country-specific effects have been removed by subtracting country-specific means and replacing them with the overall population mean. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. Countries: AUT, BEL, CAN, CHE, CHL, CZE, DEU, ESP, FRA, HUN, IRL, ISR, ITA, JPN, NLD, NOR, NZL, PRT, SWE. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

Figure 22. Within-firm growth in R&D expenditure by firm size and age

Mean of growth quantiles across countries (2011-2016 average)

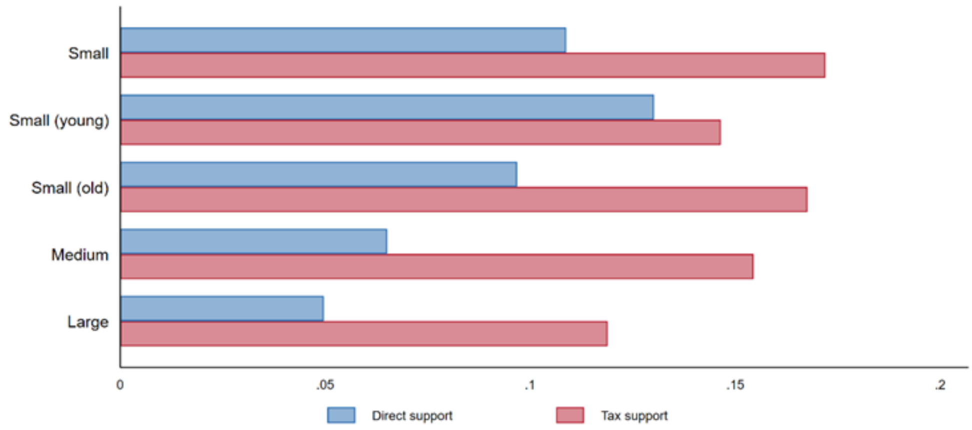


Note: The figure shows the 25th, 50th and 75th percentile of the distribution in firm R&D expenditure annual growth (log change) across firms by firm size. The figure displays averages across countries. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. Countries: AUS, AUT, BEL, CAN, CHL, CZE, DEU, FRA, HUN, IRL, ISR, ITA, JPN, NLD, NOR, NZL, PRT, SWE. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

The distribution of within-firm growth in R&D expenditure is also quite similar across firms of different size, although small firms have a greater dispersion, as shown by the larger interquartile range (ration of p75 to p25) of the rate of growth (Figure 22).

Figure 23. Government direct funding and tax support for business R&D by size and age

As a share of total bus. R&D expenditure, mean across countries adjusted for country compositional effects (2011-16 avg)



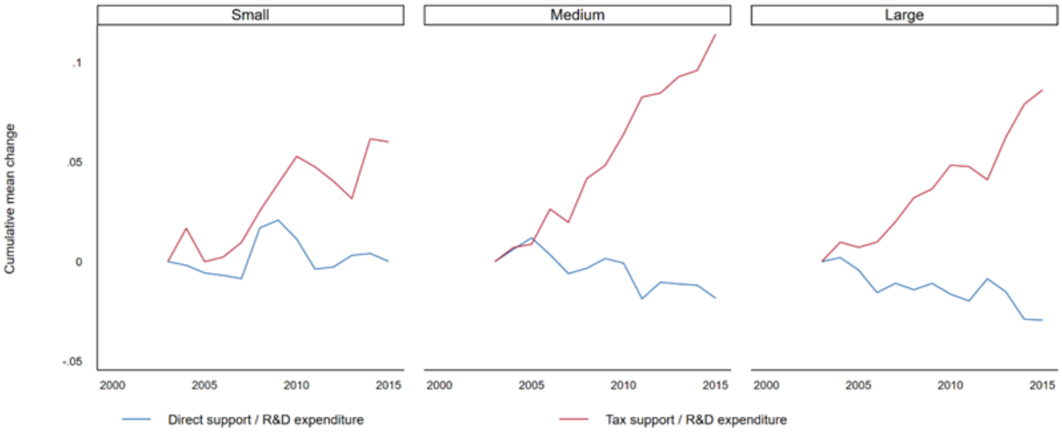
Note: The figure shows the ratio of direct and tax support to R&D expenditure by firm size and age. The figure displays averages across countries. Country-specific effects have been removed by subtracting country-specific means and replacing them with the overall population mean. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. Tax support figures are calculated based on the matched BERD and tax relief sample and may deviate from official R&D tax relief statistics that are based on the whole population of R&D tax relief recipients. Countries (direct support): AUS, AUT, BEL, CHE, CHL, CZE, DEU, ESP, FRA, HUN, ISR, ITA, JPN, NLD, NOR, NZL, PRT, SWE. Countries (tax support): AUS, BEL, CAN, CZE, FRA, HUN, IRL, NLD, NOR, PRT, SWE. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

An interesting difference also exists between young and old small firms in terms of the relative importance of the two types of support: while young small firms rely on direct support almost as much as on tax support, and this more than any other set of firms, for older small firms tax incentives are noticeably more important than direct support, on average. Medium-sized and particularly larger firms receive substantially less direct support compared to their R&D expenditure than small firms. The same is true also for R&D tax relief, albeit to a lesser extent. Around 11% (13%) of R&D expenditure is financed through direct (tax) support in the case of small firms, compared to 7% (11%) for medium-sized and 5% (8%) for large enterprises. The stronger reliance of young firms on direct support might be related to the earlier timing with which firms typically receive direct vis-à-vis tax support or demonstration effects connected to the receipt of direct funding.The importance of the two types of public funding for firms of different size are also shown separately for each country in Figure A B.3 of Annex B.

Figure 24 shows how the importance of direct funding and tax support has evolved over time for firms of different sizes. For small firms, the importance of direct funding has remained stable from 2000 to 2016, with exception of a short-term peak during the global financial crisis. For both medium-sized and large firms, the importance of direct funding as a source of R&D funding declined over the 2000-2016 period. In sharp contrast, the importance of tax incentive as source of R&D funding has increased sharply for all size classes over the time period considered.

Figure 24. Trends in government direct and tax support for business R&D by size

As a share of total business R&D expenditure, mean across countries (2011-2016 average)



Note: The figure shows the ratio of direct and tax D support to R&D expenditure by firm size over time. It displays the cumulative average change in each ratio across countries. In each year, a weighted average annual change in each ratio is calculated across all countries based on the changes observed in a given year. Average annual changes are then added up over time. Changes in the ratio of tax support to R&D expenditure are calculated based on the matched BERD and tax relief sample and may deviate from official R&D tax relief statistics that are based on the whole population of R&D tax relief recipients. Countries (direct support): AUS, AUT, BEL, CHE, CHL, CZE, DEU, ESP, FRA, HUN, ISR, ITA, JPN, NLD, NOR, NZL, PRT, SWE. Countries (tax support): AUS, BEL, CAN, CZE, FRA, HUN, IRL, NLD, NOR, PRT, SWE. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

5. Conclusion and next steps

Drawing on the micro-aggregated statistics collected as part of the first phase of the microBeRD project (2016-19), this report highlights novel and stylised facts about business R&D performance and funding that aggregate R&D and tax relief statistics have not previously documented on a cross-country basis. Following an analysis of the coverage and representativeness of micro-aggregated R&D and tax relief data vis-à-vis aggregate R&D and tax relief statistics, it describes recent and long-term trends in business R&D performance and funding across countries and industries, exploring differences across firms of different size, age and foreign ownership. This includes trends in the concentration of R&D activity, intensity and structure of R&D performance (e.g. orientation of R&D), R&D employment and the way different types of firms fund their R&D activities.

The micro-data based findings highlight the strong concentration of business R&D at country, and in particular industry level, but also point to a variation in the rate of R&D concentration across different industries, whether measured by the share of 10 largest R&D performers in an industry or by the Herfindahl index. Available results further suggest that the within industry concentration of R&D has remained stable or, more often, declined over time and that this decline is, at country level, positively correlated with the increasing adoption and generosity of R&D tax incentives, that reduce the cost of R&D and encourage R&D investment among existing and new R&D performers, especially the smaller ones (OECD, 2020a).

The micro-aggregated statistics also provide new insights into the role of foreign-controlled affiliates and young and small firms as R&D performers, looking at R&D expenditure and employment, as well as their reliance on public support for business R&D through direct funding and R&D tax incentives. While foreign-controlled firms account for a significant share of business R&D expenditure in many OECD economies, they tend to receive proportionally less R&D support through direct funding compared to their share in total R&D expenditure. By contrast, SMEs tend to account for a disproportionally higher share in direct funding compared to their contribution to business R&D performance in most industries, but the difference is particularly large in Mining and Pharmaceuticals. As expected for market-based and less discretionary support measures, the SME share in R&D tax relief tends to match more closely the SME share in R&D expenditure across different industries. An interesting difference also exists between young and old small firms in terms of the relative importance of the two types of support: while young small firms rely on direct support almost as much as on tax support, and this more than any other set of firms, for older small firms tax incentives are noticeably more important than direct support, on average.

The micro-aggregated statistics presented in this report also show how the orientation of R&D differs across industries. Overall, cross-industry differences in the share of basic and applied research versus experimental development can be found, although they do not tend to be particularly large. Research (basic and applied) accounts for close to 40% to 60% of all R&D expenditure in all main R&D industries except for Transport equipment, where it accounts less than 30% of total R&D. Basic research represents a minor share of total R&D in all industries. It is most important in Scientific R&D and Pharmaceuticals with a share in intramural R&D expenditure of close to 10%.

Large differences are found in the share of female R&D employees and share of R&D staff with a doctorate degree in R&D employment across industries. Women represent over one third of R&D employees in Chemicals, Scientific R&D and Food & beverages and more than 50% of R&D employees in Pharmaceuticals. 10% or less R&D employees in Transport equipment, Metal products and Machinery and equipment are women. Likewise, a high share of doctorate holders among R&D staff can be found in science-based industries such as Pharmaceuticals, Scientific R&D and Chemicals.

These new micro-aggregated statistics provide an important input for policy analysis, pointing to important variations in business R&D performance and funding across industries and different types of firms that are hard to uncover based on aggregate R&D statistics. These can reveal new evidence that either confirms or challenges existing assumptions about how policies work, helping refine policy research questions for analysis. The microBeRD approach enables the exploration of different data beyond established tabulations that countries regularly submit to the OECD. The latter, as the implementation of the Frascati Manual 2015 has shown, are difficult to change in a sufficiently responsive fashion due to a combination of factors. microBeRD helps demonstrate how it is possible to enhance the range of policy relevant indicators while protecting business respondent confidentiality.

As the microBeRD+ project progresses, by incorporating new countries in the analysis, expanding data linking activities, the work of micro-aggregated R&D statistics will further advance to shed new light on key trends in the innovation and economic performance of R&D performing firms across different countries and industries.

Endnotes

[1] To ensure cross-country comparability, the analysis focuses on small, medium-sized and large firms. Many countries do not cover micro firms with less than 10 employees in business R&D surveys.

[2] See http://www.oecd.org/sti/inno/oecdinnovationmicrodataproject.htm, http://www.oecd.org/sti/ind/multiprod.htm and http://www.oecd.org/sti/dynemp.htm.

[3] Most of the data available for this study are based on guidance within the 2002 edition of the OECD Frascati Manual. Data fully consistent with the most recent 2015 update are now becoming available.

[4] Different enterprise concepts – variably defined enterprise units, plants and establishments or enterprise groups – exist and may be adopted by countries in business R&D surveys and the computation of R&D tax benefits at firm level. This has implications for the comparability of indicators collected in regular data collections as well as those compiled by microBeRD (e.g. concentration statistics). While warnings flags are provided in this report, whenever country-specific enterprise definitions were reported, further OECD work aims to investigate this issue in more detail. This includes the collection of additional metadata and review of the existing firm size definitions.

[5] The excluded industries are "Wholesale and retail trade and repair of motor vehicles and motorcycles" (45), "Retail trade, except of motor vehicles and motorcycles" (47), "Accommodation" (55)," Food and beverage service activities" (56)," Real estate activities" (68) and "Legal and accounting activities" (69).

[6] Observations are considered as outliers and dropped (a) if the logarithm of R&D intensity is more than 5 standard deviations above the mean (within a given country and year), or (b) if the ratio of labour R&D expenditure and R&D employment is more than 5 standard deviations above or below the mean.

[7] Throughout the report, industries are defined in the STAN A38 industry classification, which consists of ISIC rev. 4 2-digit industries, some of which have been aggregated together.

[8] See https://oe.cd/anberd and https://oe.cd/rds

[9] The microBeRD code drops imputed observations and reweights the remaining observations, assuming that the imputed observations perform the same amount of R&D as the non-imputed observations in the same industry and size class. In the case of Belgium, the imputed firms perform on average less R&D than non-imputed firms in the same industry and size class, which leads to an overestimation of total R&D by microBeRD. This issue does not arise for other countries as they either do not use imputation or seem to satisfy the above-mentioned assumption.

[10] Both the official R&D statistics and microBeRD totals for business for R&D expenditure and direct support of business R&D presented for the Netherlands in this report are based on an earlier time-series of business R&D survey data. They are thus not directly comparable with the newly revised official R&D statistics for the Netherlands, reported by the OECD since March 2021. In 2019, the Netherlands revised their R&D statistics for BERD to capture from 2013 onwards R&D activities undertaken by hired personnel as part of a company's own R&D and those of public entities that acquire a large share of income on the market. For additional details (in Dutch), see https://www.cbs.nl/nl-nl/achtergrond/2020/02/research-en-development-revisie-2019.

[11] Average mean value of a statistic or decomposition (e.g. industry, firm size, age etc.) across countries.

[12] In an average year during the period 2011-2016.

[13] The Herfindahl index for R&D is the sum, across R&D performing firms, of their squared shares in in total intramural R&D expenditure. The Herfindahl Index ranges from 1/N to one, where N is the number of firms

[14] An **enterprise** is the view of any institutional unit – not necessarily within what the Frascati Manual defines as the Business enterprise sector – as a producer of goods and services (See SNA). The term enterprise may refer to a corporation, a quasi-corporation, a non-profit institution or an unincorporated enterprise. An enterprise is an economic transactor with autonomy in respect of financial and investment decision-making, as well as authority and responsibility for allocating resources for the production of goods and services. It may be engaged in one or more economic activities at one or more locations. An enterprise may be a sole legal unit. An **enterprise group** is a set of enterprises controlled by the group head. The group head is a parent legal unit that is not controlled either directly or indirectly by any other legal unit. It can have more than one decision-making centre, especially for the policy on production, sales and profits, or it may centralise certain aspects of financial management and taxation. It constitutes an economic entity that is empowered to make choices, particularly concerning the units that it comprises. An establishment is an enterprise, or part of an enterprise, that is situated in a single location and in which only a single productive activity is carried out or in which the principal productive activity accounts for most of the value added. Establishments are sometimes referred to as local kind-of activity units. See https://www.oecd.org/sti/inno/Frascati-2015-Glossary.pdf

[15] Foreign-controlled affiliates (FCA) are the fully consolidated enterprise group within the compiling country that are majority-owned members of foreign MNEs (thus majority-owned by their foreign parent companies (OECD, 2015).

[16] The trends in Austria, Israel and Sweden are less informative due to relatively short time series.

[17] See https://ncses.nsf.gov/pubs/nsf21312/table/12#data-tables

[18] R&D intensity based on overall company costs may be another relevant indicator for very young firms.

[19] See https://ncses.nsf.gov/pubs/nsf21312/table/12#data-tables

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Annex A. Data

Table A A.1. Country-years included in the descriptive analysis based on micro-aggregated data

Year	AUS	AUT	BEL	CAN	CHE	CHL	CZE	DEU	ESP	FRA	GBR	HUN	IRL	ISR	ITA	JPN	NLD	NOR	NZL	PRT	SWE
2000				✓			✓				✓					✓					
2001			✓	✓			✓	✓		✓	✓					✓		✓		✓	
2002		✓		✓			✓			✓	✓			✓		✓		✓			
2003			✓	✓			✓	✓		✓	✓			✓		✓		✓		✓	
2004		✓		✓			✓			✓	✓			✓		✓	✓	✓	✓		
2005	✓			✓			✓	✓		✓	✓			✓		✓	✓	✓		✓	
2006	✓	✓		✓			✓			✓	✓			✓		✓	✓	✓	✓		
2007	✓	✓	✓	✓			✓	✓	✓	✓	✓			✓	✓	✓	✓	✓		✓	
2008	✓			✓	✓		✓		✓	✓	✓		✓		✓	✓	✓	✓		✓	
2009	✓	✓	✓	✓		✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓		✓	
2010	✓			✓		✓	✓			✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	
2011	✓	✓	✓	✓		✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓		✓	✓
2012	✓			✓	✓	✓	✓			✓	✓		✓		✓	✓	✓	✓	✓	✓	
2013		✓	✓	✓		✓	✓	✓		✓	✓		✓		✓	✓	✓	✓			✓
2014	✓					✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
2015		✓			✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓			✓
2016	✓					✓	✓		✓		✓	✓	✓	✓		✓			✓		

Source: OECD microBeRD project, http://oe.cd/microberd, November 2021

Annex B. Additional results

Table A B.1. R&D expenditure in microBeRD relative to aggregate data by firm size

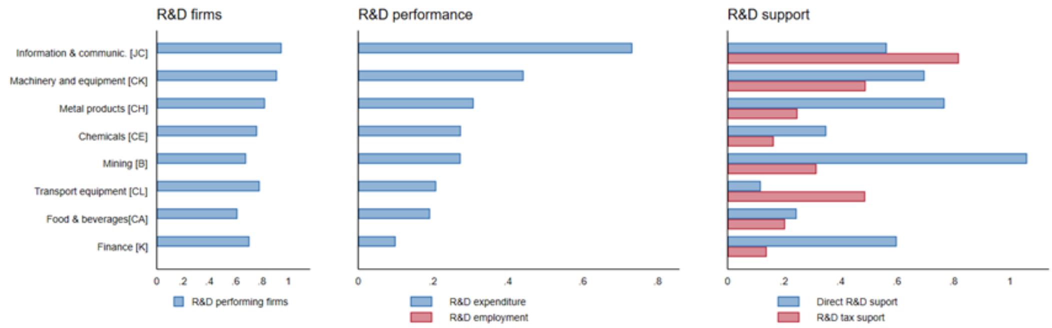
	AUS	AUT	BEL	CAN	CHE	CHL	CZE	DEU	ESP	GBR	IRL	ITA	JPN	NLD	NOR	PRT	SWE
Small firms																	
2000				100			86										
2001				101			89									100	
2002		103		100			101										
2003			57	100			101	90		154					88	100	
2004		101		100			105			312							
2005	79		56	100			101	87		241				91	89	100	
2006	92	99		100			106			340							
2007	78	100	100	101			118	94	100	428		76		86	89	100	
2008	99			100	96		110		100	245		100		123		101	
2009	101	98	95	100		100	99	96		272		98		92	87	98	
2010	90			100		99	127			212		91		132	91	99	
2011	82	97	114	100		100	121	98		181		90	46	119	92	100	87
2012				100	99	98	126			190		93	38	111	91	99	
2013		97	91	100		100	126	99		207		94	39	100	93		90
2014						99	112			188		93	36	109	91		
2015		96			99	100	98		100	215	38		23	104	91		83
2016						93	99		100	204			28				
Average	***89***	***99***	***85***	***100***	***98***	***99***	***107***	***94***	***100***	***242***		***92***	***35***	***107***	***90***	***100***	***87***
Medium firms																	
2000				102			99										
2001				102			98						31			90	
2002		99		100			96						34				
2003			93	101			101	86		136			34		76	100	
2004		97		100			101			171			33				
2005	71		88	100			95	84		165			31	87	68	100	
2006	85	100		102			95			215			32				
2007	86	99	145	105			94	93	100	248		101	33	98	72	100	
2008	89			102	102		100		100	202		106	34	117		100	
2009	90	98	128	103		100	105	96		279		101	39	94	69	99	
2010	89			100		100	101			239		102	38	118	72	99	
2011	111	95	114	100		100	108	100		201		103	68	103	69	101	111
2012				100	100	100	105			198		102	67	107	73	100	
2013		97	100	100		101	95	99		254		99	65	108	72		101
2014						100	110			244		101	55	105	69		
2015		100			100	99	101		100	249	47		58	107	71		83
2016						100	104		100	248			58				
Average	***89***	***98***	***111***	***101***	***101***	***100***	***101***	***93***	***100***	***218***		***102***	***44***	***105***	***71***	***99***	***98***
Large firms																	
2000				106			100										
2001				100			99									102	
2002		100		101			99										
2003			117	103			98	102		124					80	100	
2004		100		104			101			110							
2005	51		115	98			99	100		120				83	84	100	
2006	69	101		102			100			128							
2007	78	101	141	103			102	98	100	130		98		90	92	102	
2008	80			101	99		100		100	130		98		93		95	
2009	88	100	134	102		100	102	100		138		94		97	80	100	
2010	92			102		86	101			131		94		86	79	103	
2011	97	101	150	102		73	95	101		129		98	89	123	80	102	96
2012				104	100	101	98			132		94	74	127	79	103	
2013		101	121	100		101	81	101		125		97	73	128	82		97
2014						89	84			121		93	85	131	83		
2015		100			99	100	102		100	129	146		82	131	81		98
2016						101	99		100	125			74				
Average	***79***	***100***	***130***	***102***	***100***	***94***	***98***	***100***	***100***	***127***		***96***	***80***	***109***	***82***	***101***	***97***

Note: For each firm size class, country and year, the table shows the ratio of the total R&D expenditure derived by microBeRD based on weighted micro-aggregated data and the total R&D expenditure as reported in the OECD R&D Statistics. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

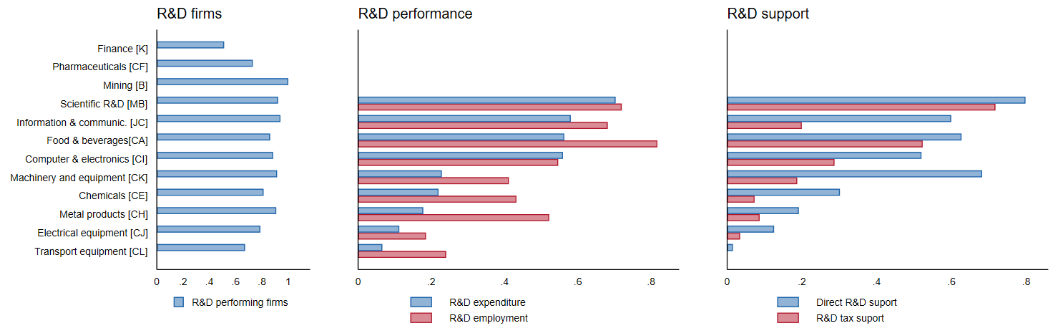
Figure A B.1. SME share in R&D firms, R&D performance and R&D support by country and industry

2011-2016 average

Australia

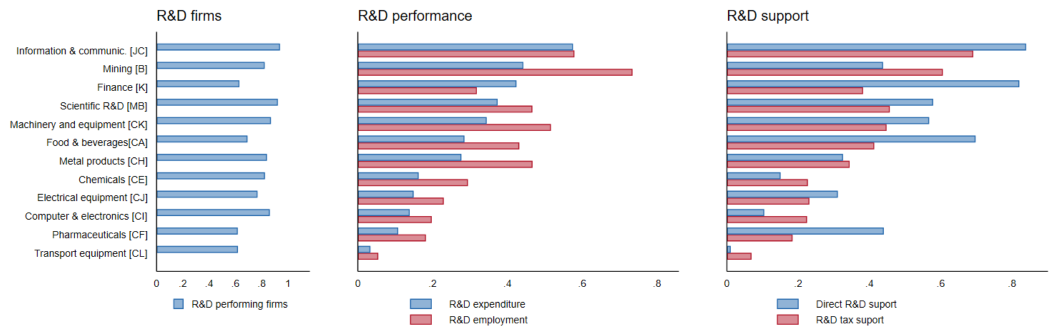


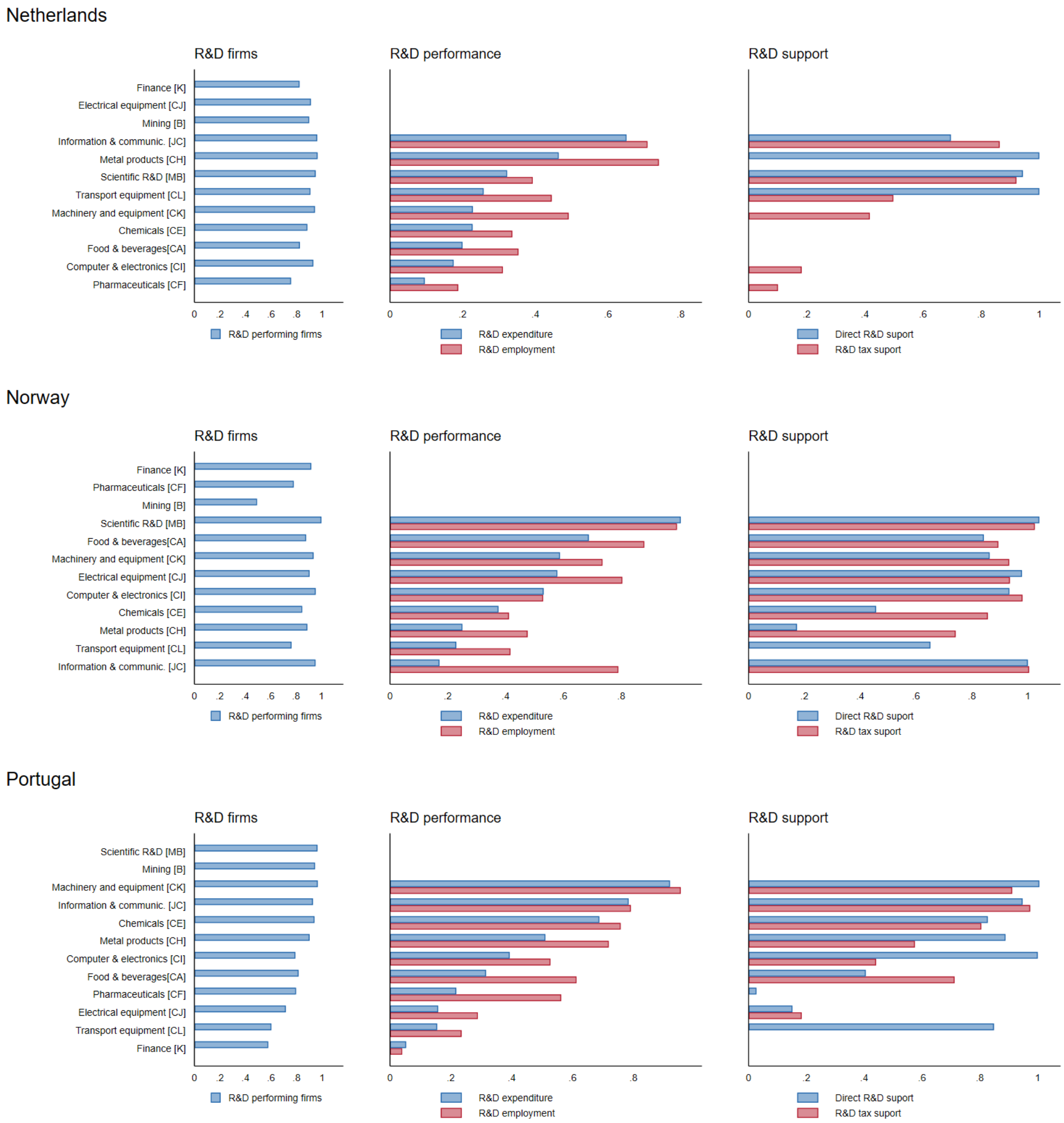
Belgium



Czech Republic

France

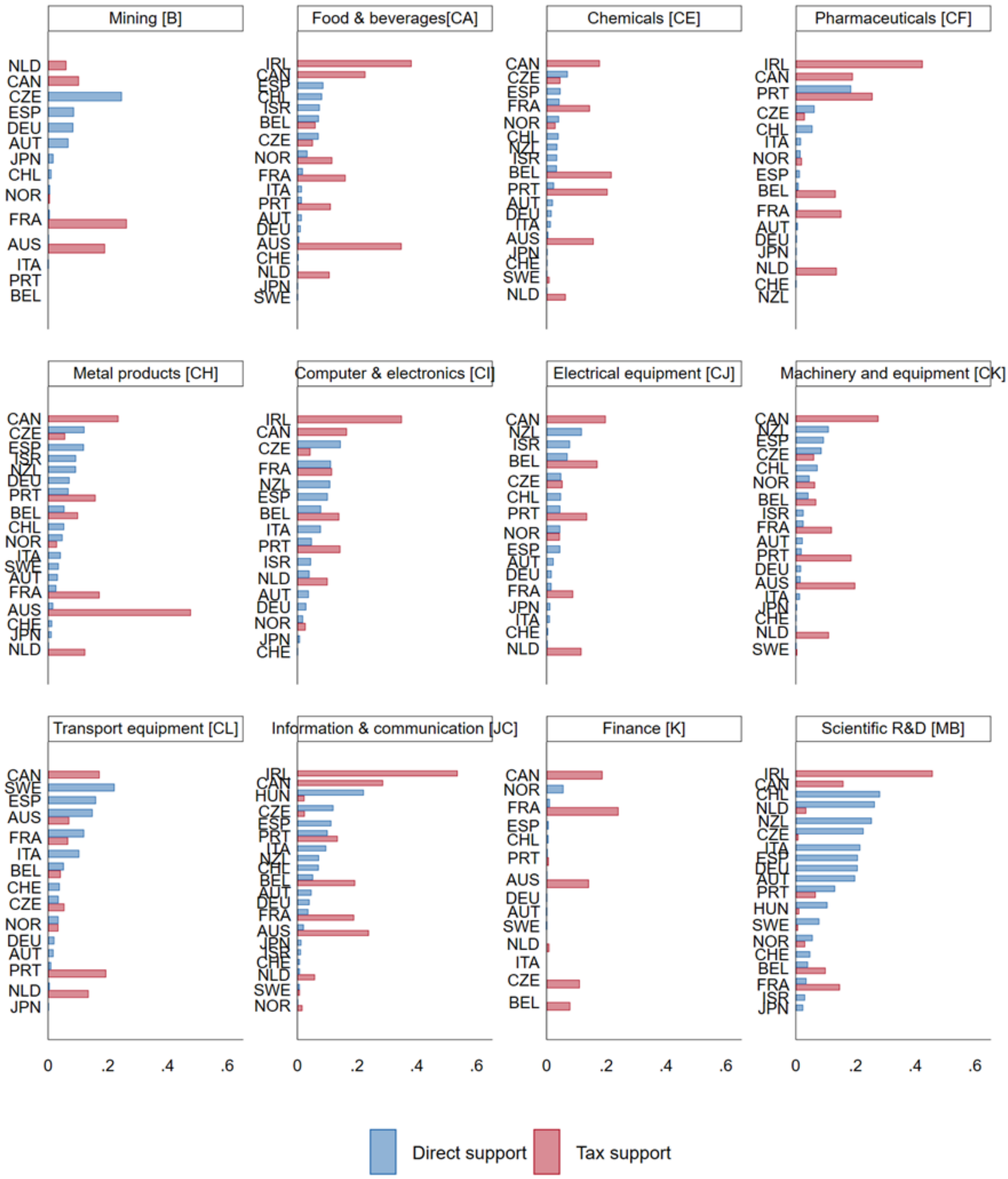




Note: For countries with both direct support and tax support data available in the period 2011-2016 and for selected A38 industries, the figure shows the share of SMEs (10-249 employees) in business R&D in terms of firm count, performance and funding. The figure is based on average values across all years available for a given country-industry in the period 2011-2016.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

Figure A B.2. Ratios of direct funding and R&D tax relief to R&D expenditure by industry and country

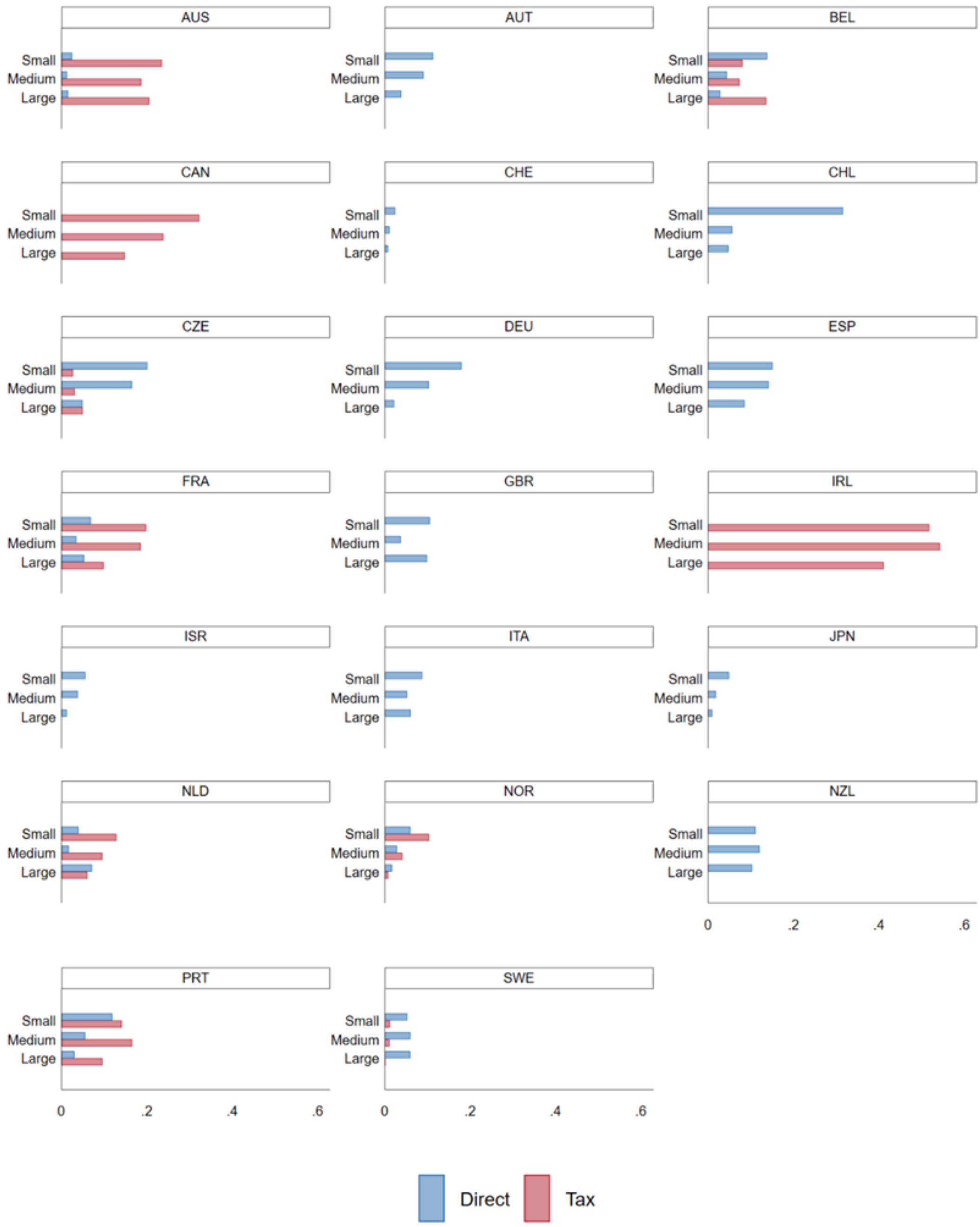
2011-2016 average



Note: For selected A38 industries, the figure shows the ratios of direct and tax support to business R&D expenditure. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. Countries (direct support): AUS, AUT, BEL, CHE, CHL, CZE, DEU, ESP, FRA, HUN, ISR, ITA, JPN, NLD, NOR, NZL, PRT, SWE. Countries (tax support): AUS, BEL, CAN, CZE, FRA, HUN, IRL, NLD, NOR, PRT, SWE. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.

Figure A B.3. Ratios of direct funding and R&D tax relief to R&D expenditure by country and firm size

2011-2016 average



Note: Separately for each country, the figure shows the ratio of direct and tax R&D support to R&D expenditure for different firm size classes. The figure is based on average values across all years available for a given country-industry in the period 2011-2016. The micro-aggregated statistics reported for Ireland are based on tax relief microdata and not directly comparable with the R&D survey-based results reported for other countries.
Source: OECD microBeRD project, https://oe.cd/microberd, November 2021.