Capturing international R&D trade and financing flows: What do available sources reveal about the structure of knowledge-based global production?[1]

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1. Introduction

1. Globalisation is usually described as a multi-faceted process of structural, economic, and social change characterised by the opening of national economies to trade, foreign capital, and workers, as well as the integration (and dis-integration) of activities across national borders. Measuring the magnitude and intensity of this process across its many different dimensions is a key activity of statistical agencies in response to growing demand from policy makers. The fragmentation of production processes across different global sites is one of the most distinctive features of the recent wave of globalisation and has profound implications for countries' economic and financial interdependence. In turn, Research and Development (R&D) activities have also become fragmented, with a combination of demand factors, incentivising the dispersal of production into global value chains (GVCs), as well as being driven from the supply side as knowledge creation requires inputs from dispersed technological inputs across and within companies. Thus, a better understanding of the processes driving the creation, funding, diffusion and exploitation of knowledge-based assets, can contribute to furthering our understanding of global production.

2. This paper emphasizes the importance of compiling and contrasting various statistics about knowledge-based assets, incorporating sources which are specifically designed to map the creation and funding of R&D. R&D, as defined by the OECD Frascati Manual (OECD, 2015), comprises *creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge*. R&D covers three

[1] The opinions expressed and arguments employed herein are solely those of the authors and do not necessarily reflect the official views of the US National Science Foundation, the OECD or its member countries.

types of activity: basic research, applied research, and experimental development.[2] For over 50 years, Frascati R&D statistics have kept track of investment in this very important type of knowledge both within and across countries. It is only with the 2008 revision of the System of National Accounts (SNA 2008) (EC et.al. (SNA 2008, 2009) that expenditures on R&D were formally recognised as investment, thus as assets that can be used by their owner(s) for their own internal use or for a range of possible commercialisation activities, including with affiliates, that may span beyond a country's national boundaries.

3. The main focus of this paper is on R&D globalisation in the business sector[3]examining new and existing international statistical evidence in this area. R&D activities are important factors in variations in productivity and innovation performance among multinational enterprises (MNEs) and other companies engaged in cross-border trade and/or Foreign Direct Investment (FDI) ((Berry, 2014); (Castellani, Montresor, Schubert, & Vezzani , 2016); (Kylaheiko, Jantunen, Puumalainen, Saarenketo, & Tuppura, 2011)). In terms of the structure of global production, increased production fragmentation by MNEs in the form of vertical FDI and global value chains (GVCs) (Baldwin, 2006); (Sturgeon , 2013); (UNECE, OECD, 2015) have resulted in dispersed R&D activities that require exchanges of R&D inputs and outputs (Cantwell, 2017); (Moris, Intangibles Trade and MNEs: Supply-Chain Trade in R&D Services and Innovative Subsidiaries, 2017) (Dachs, Stehrer, & Zahradnik, 2014). These trends are apparent in official data such as trade in R&D services statistics, which represent transactions in knowledge-based intermediaries, as well as Business R&D statistics which capture the complex international R&D funding flows associated with outsourcing, contracting with external partners, and with cost sharing agreements within MNEs.

4. The 2015 Frascati Manual incorporated recommendations for tracking R&D globalisation that are still in the process of being implemented by countries. This paper aims to promote further work in this area by demonstrating the relevance of the additional evidence to a wide range of current statistical and policy discussions that span areas such as output, income and productivity measurement, international trade, investment, intellectual property, taxation, and the migration of highly qualified individuals, as well as the importance of collaboration across National Statistical Organisations (NSOs) in delivering new data and insights. This paper presents, to our knowledge, the first attempt to bring together a comprehensive range of R&D statistics relevant to the analysis of

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

[3] It is nonetheless important to note the importance of other actors in the globalisation of R&D, including the role of international organisations as performers of R&D - especially of large collaborative undertakings requiring shared infrastructure, cross border bilateral and multilateral government R&D funding. Private non-profit organisations also fund and undertake R&D across different locations globally. In many economies, these non-business related flows can be significant. It is therefore important that these are correctly identified in line with current SNA rules on R&D capitalisation.

globalisation following the revision to the various statistical manuals that underpin their conceptualisation and collection. In this respect, this document provides an updated view to previous OECD work (OECD, 2008).

5. This paper is organized as follows: **Section 2** discusses the rationale and approach to measurement of R&D globalisation, and the implications of treating R&D as a produced asset in the SNA, going on to introduce the main three types of inter-related sources that support measurement, namely those relating to international trade, R&D performance, and the activities of MNEs. **Section 3** examines evidence from trade statistics. This is followed by **Section 4** an assessment of the evidence provided by Frascati-based R&D performance and funding statistics, and compares this with the findings from trade statistics. **Section 5** investigates the R&D funding and performance of multinational enterprises (MNEs), adopting both inward and outward perspectives when data are available. **Section 6** concludes with the main findings and proposals for further analysis, including links to other complementary data sources.

2. Measuring R&D globalisation

2.1. Why measure R&D globalisation?

6. Economic globalisation presents opportunities to decouple where, and under whose responsibility, innovation activities take place. This runs from who funds R&D to where and how it gets used, along various dimensions. This decoupling can be in itself a major driver of economic globalisation. Innovation practices that generate knowledge flows crossing organisational boundaries trade-off control for benefits from specialisation. Furthermore, organisations can distribute their internal innovation activities across different locations, with knowledge and related financial flows within them resulting from a range of possible considerations, such as the availability of human resources and infrastructures to draw upon to generate new knowledge, synergies with other activities, and other objectives including the ability to control knowledge outputs and minimise global tax obligations. The combination of these elements lies behind the interconnectedness of cross-boundary material flows for both intermediate and final goods that is associated with GVCs and the networks underpinning knowledge flows across organisations and countries in pursuit of innovation - often referred to as Global Innovation Networks (GINs) (OECD, 2017a).

7. In the business context, innovation refers to the introduction to the market of new or significantly improved products and processes (OECD, Eurostat, 2005). It is closely related to, but distinct from, R&D. R&D is a key component of the innovation activities and strategies of a large number of firms, including those in more traditional industries (OECD, 2009a). The Frascati Manual defines R&D globalisation as the subset of global activities involving the funding, performance, transfer, and use of R&D (OECD, 2015).

8. Having a global perspective on business R&D and innovation more broadly is of particular importance across several research and policy domains. For economic policy management purposes and productivity analysis, it is important to base decisions on well-aligned R&D asset stocks and services to measures of economic output. Cross-country R&D knowledge flows also matter when assessing the sustainability of a country's trade and financial position with respect to the rest of the world. Understanding the link

between GINs and GVCs can add to a more nuanced assessment of the impact of barriers to trade and investment. This can also inform the allocation of government support for R&D as well as help in mapping global processes of value creation, key factors for international tax policy standards.

2.2. R&D capitalisation as a test case for measuring and understanding R&D globalisation

9. The capitalisation of R&D in the 2008 SNA - i.e. the treatment of R&D as a production activity that generates assets (capital formation) - had a series of implications for the compilation of National Accounts. A key factor in the capitalisation decision was the availability of R&D data gathered under the OECD Frascati Manual guidelines for collecting and reporting data on R&D (OECD, 2015). These record, among other things, spending on inputs used for R&D within national economies and are thus used to estimate domestic production of R&D by summing R&D production costs and import data in accordance with the method laid out in the 2008 SNA and related international manuals drafted or revised thereafter.

10. Building upon this, both conceptual and practical data considerations were considered in preparing the OECD Handbook on Deriving Capital Measures of Intellectual Property Products (OECD, 2010a), an explanatory manual on how to measure R&D, software and databases, and other Intellectual Property Products (IPPs) as capital formation for national accounting purposes, including IPP trade. In the course of this work, various globalisation-related issues were highlighted, including:

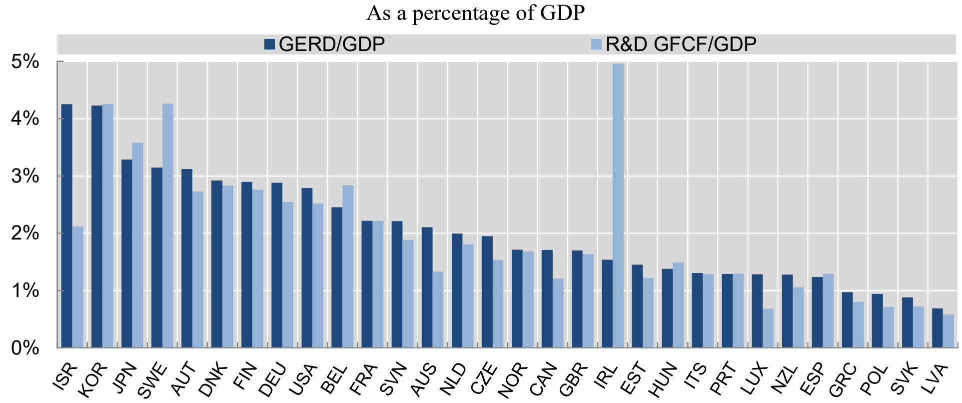
- *Imports of R&D services* add to total supply (domestic production plus imports) of R&D and represent capital formation of the purchasing country (OECD, 2010a). Unlike the no-capitalisation scenario, under the 2008 SNA imports of R&D assets have no impact on the measure of GDP as they increase capital formation by the same amount as they reduce net exports.
- *Patented entities* and related assets are no longer treated as non-produced assets in the 2008 SNA. Transactions in the outright ownership of these legal rights, which are now presumed to come into existence through production, cease to be represented as acquisitions less disposals of non-produced assets and are therefore included in exports and imports.[4] To the extent that these transactions can be large and infrequent, this can in turn generate lumpy shocks to IPP trade and capital formation, and GDP statistics in small economies.
- *Unconditional transfers of R&D.* The provision across boundaries of R&D knowledge (or R&D financing) without receiving in return from the recipient any good, service, or asset represents a capital transfer. Such transactions would previously have been recorded as current transfers and would not necessarily have been identified as R&D-related.

[4] The 1993 SNA, by convention, included patent licensing related services in output and, therefore, royalty and similar payments in respect of patent licences were considered payment for services and not property income as in the 1968 SNA (1993 SNA, page 660). https://unstats.un.org/unsd/nationalaccount/docs/1993sna.pdf In spite of this, some licensing flows related to R&D knowledge continued to be reported or recorded as property income.

11. Notwithstanding practical differences across R&D performance measures and SNA IPP investment statistics (notably, the recognition of R&D relating to software development as *software* investment[5]), the globalisation of R&D appears to be, as expected, a first order factor underpinning observed differences between Frascati-based statistics on R&D performance and the SNA view of how much countries invest in R&D (**Figures 1** and **2**). In most countries, the value of R&D assets capitalised annually has been fairly similar to the value of domestic R&D performance, with the ratio of R&D investment to performance sitting in a band between roughly 80% and 110% in many cases and being relatively stable over time. However, divergence has been more marked in countries characterised by large international R&D related flows. In Ireland, R&D investment has grown much more quickly than GERD (Gross Domestic Expenditure on R&D)[6] since around 1997. This difference is driven by large imports of R&D assets as noted in OECD (2016) and has led Ireland's R&D stock to increase more than nine-fold, from 9.6bn USD PPP in 2000 to 88bn USD PPP in 2014 (latest available). By contrast, R&D investment in Israel[7] is estimated to be less than half of R&D performance in 2014, having declined from nearer 100% in the 1990s.

Figure 1. Comparison between R&D performance within countries and national accounts measures of R&D capital formation, 2015

As a percentage of GDP



Notes: 2014 for DNK, EST, DEU, IRL, LVA, NOR, POL, PRT, SVK, ESP, SWE. 2013 for AUS, ITA.
Source: OECD National Accounts Database (oe.cd/1Fb), OECD R&D Statistics (RDS) database (oe.cd/rds), US Bureau of Economic Analysis, fixed assets accounts (http://www.bea.gov/iTable/iTable.cfm?ReqID=10&step=1#reqid=10&step=1&isuri=1). October 2017.

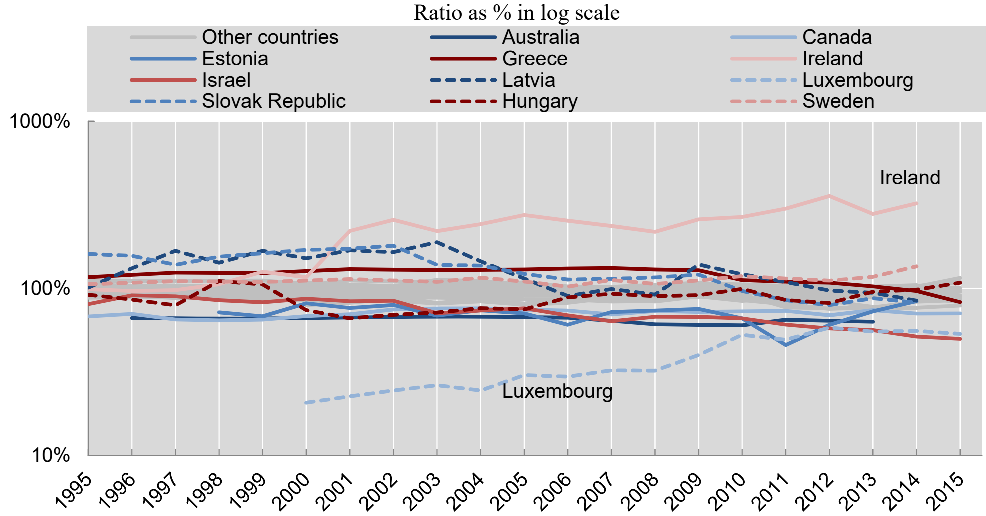
[5] According to OECD (2010a) guidance, R&D relating to software development is to be included under software investment, not R&D investment. Cross-country R&D GFCF data used in this paper were compiled in late 2017 and reflects this guidance. For the USA, starting with the 2018 Comprehensive Update of the NIPAs (released by the Bureau of Economic Analysis 27 July 2018), software R&D investment appears under R&D GFCF. See (Chute, McCulla, & Smith, 2018).

[6] GERD is total intramural expenditure on R&D performed in the national territory

[7] The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Figure 2. Evolution of R&D capital formation as ratio to R&D performance, 1995-2015

Ratio as % in log scale



Notes: "Other countries": AUT, BEL, CZE, DNK, FIN, FRA, DEU, ITA, JPN, KOR, NLD, NZL, NOR, POL, SVN, POL, PRT, SVN, ESP, GBR, USA.
Source: OECD National Accounts Database (oe.cd/1Fb), OECD R&D Statistics database (oe.cd/rds), US BEA, www.bea.gov/iTable/iTable.cfm?ReqID=10&step=1#reqid=10&step=1&isuri=1). October 2017.

2.2.1. The concept of R&D ownership and the market for intellectual property

12. A fundamental foundation of the National Accounts approach to measuring assets (including R&D assets) is that they should be recorded in the national balance sheets of the country where the *"institutional unit entitled to claim the benefits associated with the use of the [assets] in question in the course of an economic activity by virtue of accepting the associated risks"* is considered to be resident (2008 SNA). However, identifying the economic owners of knowledge products such as the results of R&D is challenging (United Nations Economic Commission for Europe, 2015). This is in large part because of the intangible nature of those products, characteristics of which are relative ease to codify and transfer the information and a lack of rivalry in use of knowledge (Lipsey, 2010) (Rassier, 2017).

13. One "knowledge item" can combine with several others and give rise to multiple entities and associated flows including those applying to the effective and legal right to use and exclude others from the knowledge for a wide range of possible uses. Economic ownership over R&D assets and related asset bundles can be exerted at different operational levels which need not neatly fit within jurisdictional boundaries. Furthermore, control over R&D and derived assets can also be used to exert ownership over broader operations in cases where most of the value added can be accounted for by the capital services generated by intellectual assets.

14. Evidence from R&D and innovation surveys and administrative data suggests that a wide range of intellectual property rights (IPRs), especially patents, are of importance for R&D performers and funders but indicate that maintaining secrecy is especially key (OECD, 2013). This is relevant when examining trade in R&D and derived assets within and across international boundaries. IPRs other than patents are also used to protect outcomes of R&D. Explicit IPRs facilitate the existence of markets for protected knowledge assets that incorporate outcomes of R&D, facilitating their transferability (as

well as their use as collateral for financing purposes), but these markets are underdeveloped for a number of reasons, including the idiosyncratic features of knowledge (OECD, 2013). Knowledge that is protected in principle by trade secrets can be exchanged by means of confidentiality agreements.

15. Use of R&D outcomes is not systematically associated to separately identifiable transactions. Companies may acquire financial interests in other companies in order to gain access to or ownership of IP assets. In the case of IP assets, true economic ownership may not stop at the entity that makes effective use of knowledge in production (e.g. of goods or services for the market) but on the ultimate controlling financial owner of that entity. Therefore, similar levels of control over R&D outcomes can be exerted by using a range of very different administrative arrangements. These create various records that statistics can draw upon. In some cases, international mergers and acquisitions (M&A) may be considered as implying automatic transfers of R&D to the buying company, but this can be difficult to establish if the acquired entity maintains its activities.

16. The M&A example also helps highlight that R&D capitalisation has implications not only for production and accumulation accounts but also for income distribution. A case in point is the treatment of R&D ownership within MNEs. While the R&D costs incurred by a foreign-controlled firm developing knowledge for its own internal use ("own-account R&D") generate assets that add to the domestic stock of knowledge and to Gross Operating Surplus, the resulting notional earnings, ultimately, represent property (investment) income of the foreign owner of the affiliate, which it may "reinvest" or transfer; raising questions about who in fact is the ultimate owner of the R&D asset and indeed where (in which country) the value-added generated by the asset should be recorded. Property income accrues when the owners of financial assets and natural resources put them at the disposal of other institutional units. The income payable for the use of financial assets is called investment income. Operating surplus associated to own account R&D capital formation represents a source of investment income for the unit with equity on the economic owner of the R&D asset (Yorgason, 2007).

17. National income includes all income earned by a country's resident persons and businesses including property income from intellectual property abroad - while excluding domestically-generated property income flowing to residents of other countries. This implies a need for detailed and coordinated understanding of where in the world decisions over intellectual property assets are being taken, what production processes rely on them, the incomes they generate, and where and who those revenues accrue to.

18. The distinction between economic ownership and financial (or legal) ownership has implications for measurement. Practical challenges for global measurement of flows arise when complex ownership structures are put in place and involve entities located in jurisdictions in which statistical coverage is limited. The existence, economic meaningfulness, and measurability of R&D-related flows are shaped by a wide range of economic factors and government and business policies. In particular, businesses may choose between keeping R&D performance and intellectual property activities "in house" – at their head office or in their home country – or distribute them across the globe for reasons including access to labour with the required skills, proximity to local markets abroad, and incentives relating to government policies such as tax and contract law relating to intellectual property. Some firms find incentives to establish holding companies in jurisdictions abroad to hold and manage their intellectual property or even to act as the ultimate owning company of the business as a whole. Economic ownership

is, therefore, especially challenging to identify in the case of MNEs (United Nations Economic Commission for Europe, 2015)

19. It can become unclear which economic entity ultimately makes decisions about the use of the knowledge and the financial results so that identifying ownership and/or control over the asset – that is, identifying the economic owner (or perhaps even the legal owner) – can be challenging, as can be establishing whether a cross-border financial flow (e.g. licence payment) relates to R&D assets owned and recorded in the capital stock of the recipient country or elsewhere. Since functionally equivalent production activities can yield different arrays of recorded transactions reflected in statistics, this poses crucial challenges for presentations and analyses focussed on "economic" (rather than legal) reality, including National Accounts.

2.3. Sources of empirical evidence on R&D globalisation

20. Data limitations have been a longstanding obstacle to developing an accurate picture of R&D globalisation (OECD, 1998). The protection of confidentiality can be at odds with mapping out in sufficient detail different flows, by partner and for detailed industry groups. The complexity and commercial sensitivity of the information requested is therefore seen to present challenges to eliciting responses from businesses if surveyed. Furthermore, targeted respondents may have restricted awareness about decisions that span multiple jurisdictions. As a result, it may be the case that information about certain aspects of R&D globalisation can be more accurately reported at a local level while others require a higher-level view of the organisation, especially in the case of MNEs.

21. The remainder of this document reviews evidence from three main families of statistical sources which have been used to track R&D globalisation from different perspectives and are consistent with the new 'Measurement of R&D Globalisation' chapter 11 in the OECD Frascati Manual:

- Trade statistics contain information on the flow of services as implied by related payments across different economies. This allows tracking not only the provision of custom R&D services but also payments for the right to use or control the outcomes of past R&D efforts.
- R&D performance and funding statistics enumerate financial and human resources dedicated to R&D by resident units within an economy, including funding from external and/or foreign sources. These statistics often also provide information on funding given to third parties.
- Statistics on the activities of multinational enterprises (AMNE), which includes their affiliates abroad, measure MNE operations related to inward and outward investments, including R&D. Information about ultimate cross-border ownership over a company's assets (and liabilities) is another important source of information about R&D globalisation.

22. These three main frameworks are very closely related. These frameworks use similar concepts and definitions for R&D, effectively consistent with the Frascati Manual concepts. On the other hand, R&D services trade and MNE R&D performance statistics emerged as part of broader international economic statistics on trade and MNE activities. For the purposes of analysing R&D globalisation, they offer significant complementarities that help offset the limitations of each individual framework. These complementarities may be exploited by linking R&D and MNE or services trade statistics (Moris & Zeile, Innovation-Related Services Trade by Multinational Enterprises, 2016).

The following sections examine the evidence available from these different sources and potential connections across them.

3. R&D in services trade statistics

3.1. What is captured in R&D trade statistics?

23. Transactions in R&D services, as defined in the Manual on Statistics of International Trade in Services ("MSITS", UN et. al (Manual on Statistics of International Trade in Services 2010, 2010)) refer to cross-border transactions in R&D services (part of "Other business services"), where R&D itself is defined by reference to the Frascati Manual. These services trade data are typically collected in international trade surveys and valued at market prices (MSITS 3.32). They may include details for affiliated (intra-MNE) and unaffiliated transactions.

24. Statistics on R&D services transactions collected on the basis of MSITS are currently used by countries to account for R&D 'exports and imports' in national economic accounts.

25. The hierarchy for these data is set out in the Extended Balance of Payments Services (EBOPS) classification reproduced in **Table** 1. Data are most often available for the overarching "R&D services" heading (SJ1) which comprises both two sub-categories: "*Work undertaken on a systematic basis to increase the stock of knowledge" (SJ11) and "Other research and development services*" (*SJ12)*. The wording of the former is closely aligned with the R&D definition in the Frascati Manual, however further subdivision into "*Provision of customized and non - customized research and development services" (SJ111)* and "*Sale of proprietary rights arising from R&D*" *(SJ112)* reveals that there is not full alignment. While the former is compatible with the Frascati Manual definition of R&D; the latter covers payments related to the transfer of intellectual property, namely rights applying to the outright sale of R&D-based IP. This may include outright sales of property rights relating not only to the outcomes of R&D conducted in the period (current output) but also property rights over R&D conducted in previous periods. [8] This differs from the strict "current period" recording of Frascati Manual R&D data and National Accounts R&D output. Additionally, the *"Other research and development services*" (SJ12) category is defined on a residual basis, as activities related to patents, and its scope is somewhat less clear.

[8] Licenses for the use of such IP are recorded under a separate category (SH2) under *"charges for the use of intellectual property"*.

Table 1. EBOPs trade categories directly related to R&D

EBOPs descriptor	EBOPS Item Code	Commentary
Other business services	SJ	
Research and development services	SJ1	
Work undertaken on a systematic basis to increase the stock of knowledge	SJ11	Aligned to FM definition, but combines provision of R&D produced in the period and produced in the past.
Provision of customized and non - customized research and development services	*SJ111*	Closest alignment to Frascati R&D performance. R&D is produced within period, contemporary to trade.
Sale of proprietary rights arising from research and development	*SJ112*	Covers change of economic ownership of the whole of the IPR- seller no longer has rights or obligations with IP. Includes second hand outright sales of IPRs. Computed in SNA93 as capital account transaction.
Other research and development services	SJ12	Not exactly R&D (the R&D definition used in MSITS 2010 includes the rather speculative concept of "other testing and other product development that may give rise to patents").
Charges for the use of intellectual property n.i.e.	SH	Includes charges for "non- produced" assets, not treated as property income since SNA93
Licences for the use of outcomes of research and development	SH2	Relates to R&D produced in previous periods. May or may not represent capital formation on the part of the buyer. Rarely reported in full - combined into SH.

Note: Government services in the CPC classification include the category of Government services to R&D (9114), which might be reported under MSITS category 12.3 "Other government goods and services".
Source: Extended Balance of Payments Services classification, 2010.

26. An examination of cross-institutional transactions reveals the challenges in aligning business practice with SNA and BOP recording conventions, which add to those already captured in UNECE (UNECE 2011, 2011):

- R&D transactions from services trade statistics can relate to R&D produced either in the current period (and hence also covered by statistics from Frascati-based surveys for the same year) or in prior years.
- Licence agreements for IP may include R&D assets in combination with other related intangible assets, such as - in the technical domain - a range of technology sharing agreements, unpatented proprietary technology, technology development rights, engineering drawings and designs, schematics and technical documentation, regulatory approvals and licenses, as well as computer software (object code and source code), databases, brands, advertising programs, brochures and marketing materials, name-related goodwill. Agreements may apply to individual assets or entire IP portfolios.
- In the case of multi-year licensing contracts, accounting practices indicate that if the provider of the IP is engaged in upgrading its "functionality" over time, then the expenses/income have to be recognised over time rather than as one-off.
- The provision of R&D services or licences to use outcomes of R&D is often embedded in the price of other goods and services. In such instances, these fees are missed by both services trade and R&D surveys.
- Exchanges corresponding to multi-year exclusive licenses to use outcomes of R&D represent in principle a requirement to compute negative capital formation on the part of the seller and positive capital formation on the part of the buyer). This includes exclusive rights in a given territory or market.

- Payments of damages for IPR infringement may be granted by courts or agreed by affected parties. While these may function as ex-post licensing of outcomes of R&D, the recording convention in National Accounts appears to be to record them as *current* transfers.
- It is possible for firms originating IP to retain sole exclusive licenses while giving away ownership. The distinctive feature of IP ownership is the ability to bring action against alleged IPR infringement (OECD, 2013). The geographic location of this form of residual ownership can be influenced by market size and value as well knowledge of which courts tend to be more favourable towards plaintiffs.
- Cross-licensing is a common, barter-like practice across firms. This means that the gross value of transactions cannot be recorded - only the net money balance that is transferred across organisations (OECD, 2013).

3.2. A global picture of trade in R&D services

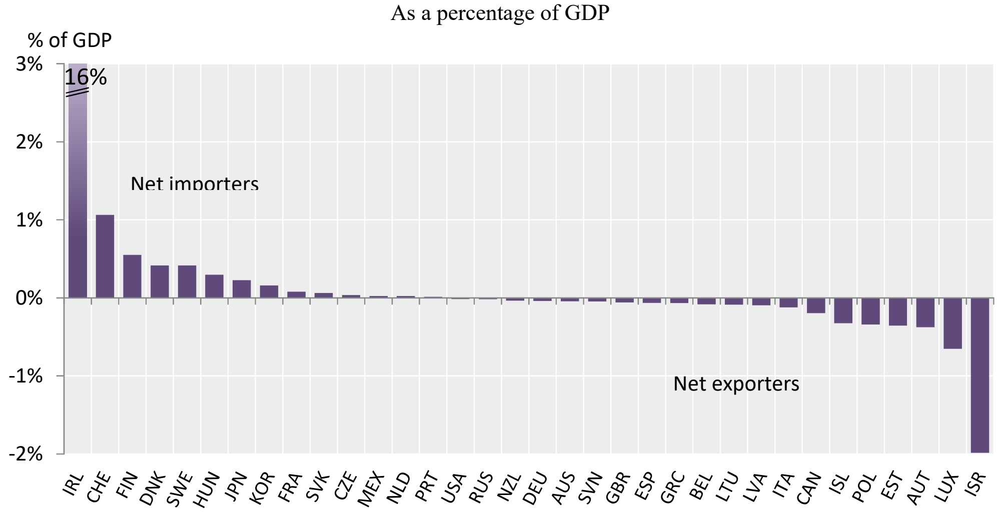
27. **Figure 3** presents net imports (imports *minus* exports) of total R&D services for countries in the OECD EBOPS databases. This margin represents the main adjustment to R&D output required to arrive at a measure of R&D capital formation for any economy (OECD, 2010a). As would be expected from the foregoing analysis, this shows a high volume of R&D - equivalent to 16% of GDP - being *imported* to Ireland, while Israel sees R&D exports equivalent to 2% of GDP. Switzerland is also a significant net R&D importer at 1.1% of GDP while Luxembourg is a net exporter of R&D (0.7% of GDP). The United States achieved a near perfect R&D trade balance in 2016, with a net position very close to zero.

28. The United States, Germany, and France account for over half (52%) of the 138bn USD value of R&D exports from these countries. The US exports the most R&D services, with sales of over 37bn USD in 2016 – equivalent to 0.2% of GDP. In contrast, R&D services are worth 3.3% of GDP in Luxembourg, 2.2% in Israel, 1.5% in Ireland (though if sales of proprietary rights related to R&D are discounted the ratio in Ireland falls to 0.7%), and 1.1% in Belgium. In all other countries the proportion is less than 1% (**Figure 4**).

29. Decomposing R&D services exports wherever possible (not the case for the US using OECD EBOPS data), **Figure 4** shows that sales of rights arising from R&D are generally a relatively small share of total R&D services exports though in Ireland they comprise over half the total and around a quarter in the Czech Republic and Sweden.

Figure 3. Net imports (imports *minus* exports) of all R&D services (SJ1), 2016

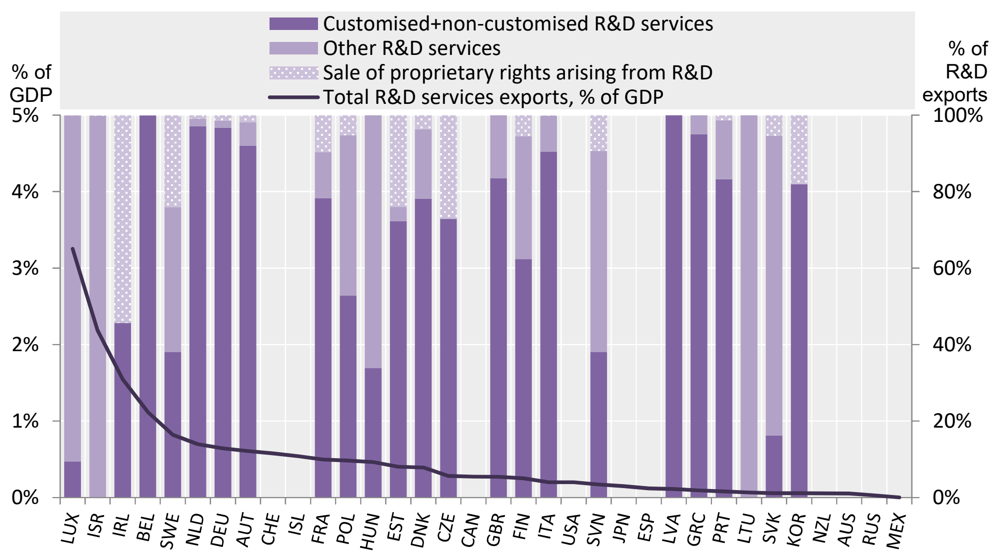
As a percentage of GDP



Note: This chart presents EBOPS 2010 class SJ1 "Research and Development Services".
Source: OECD Trade in Services by Partner Country database (http://oe.cd/2dm), OECD National Accounts database (http://oe.cd/1Fb), Office for National Statistics; February 2018.

Figure 4. Exports of R&D Services, 2016 or latest

Total R&D services exports as a share of GDP (left scale), breakdown of total R&D exports (right scale)



Note: Absence of columns indicates that only total exports is available. Netherlands, Lithuania: 2015 data.
Source: OECD Trade in Services by Partner Country database (http://oe.cd/2dm), OECD National Accounts database (http://oe.cd/1Fb), UK Office for National Statistics; February 2018.

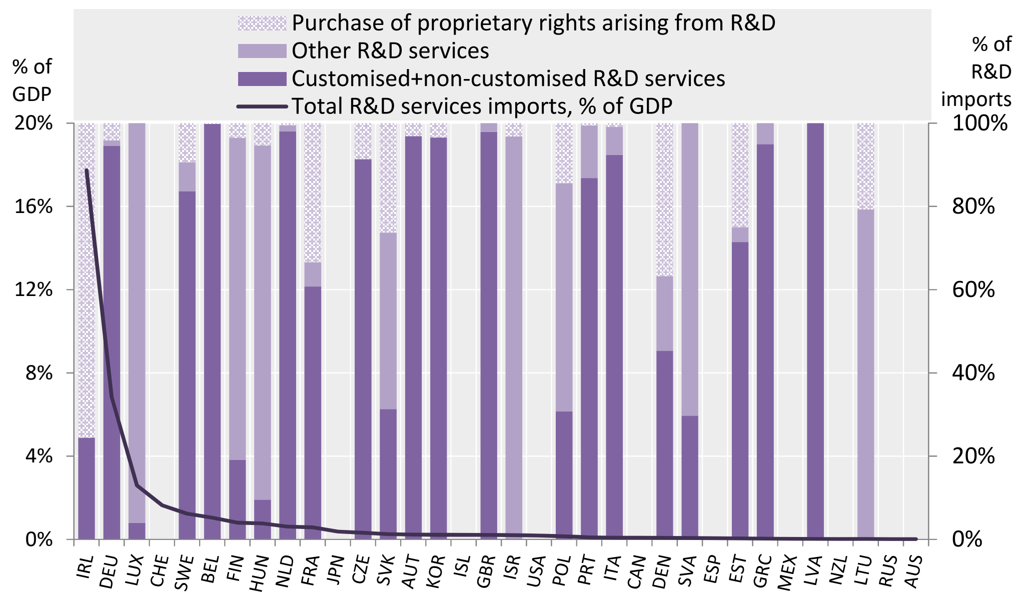
30. R&D imports are more concentrated, with Ireland, the United States, and Germany receiving 56% of the 190bn USD R&D services imported by the countries for which data are available (which, it should be noted, do not include China).

31. As seen in **Figure 5**, in 2016 R&D services imports were equivalent to almost 18% of Ireland's GDP - the greatest share in the available data. Changes in tax provisions applying to intangible assets have been linked to this trend (OECD, 2016).

Imports of R&D services have the second-greatest ratio to GDP, 6.8%, in Germany while Luxembourg has the third greatest ratio at 2.6% - though the data show none of these imports being purchases of intellectual property, suggesting that such purchases, if in reality there are any, may be being recorded in the other categories or have been excluded altogether.

Figure 5. Imports of R&D Services, 2016 or latest

Total R&D services imports as a share of GDP (left scale), breakdown of total R&D imports (right scale)



Note: Netherlands: 2015 data. Absence of bars indicates that only total exports is available.
Source: OECD Trade in Services by Partner Country database (http://oe.cd/2dm), OECD National Accounts database (http://oe.cd/1Fb), UK Office for National Statistics; February 2018.

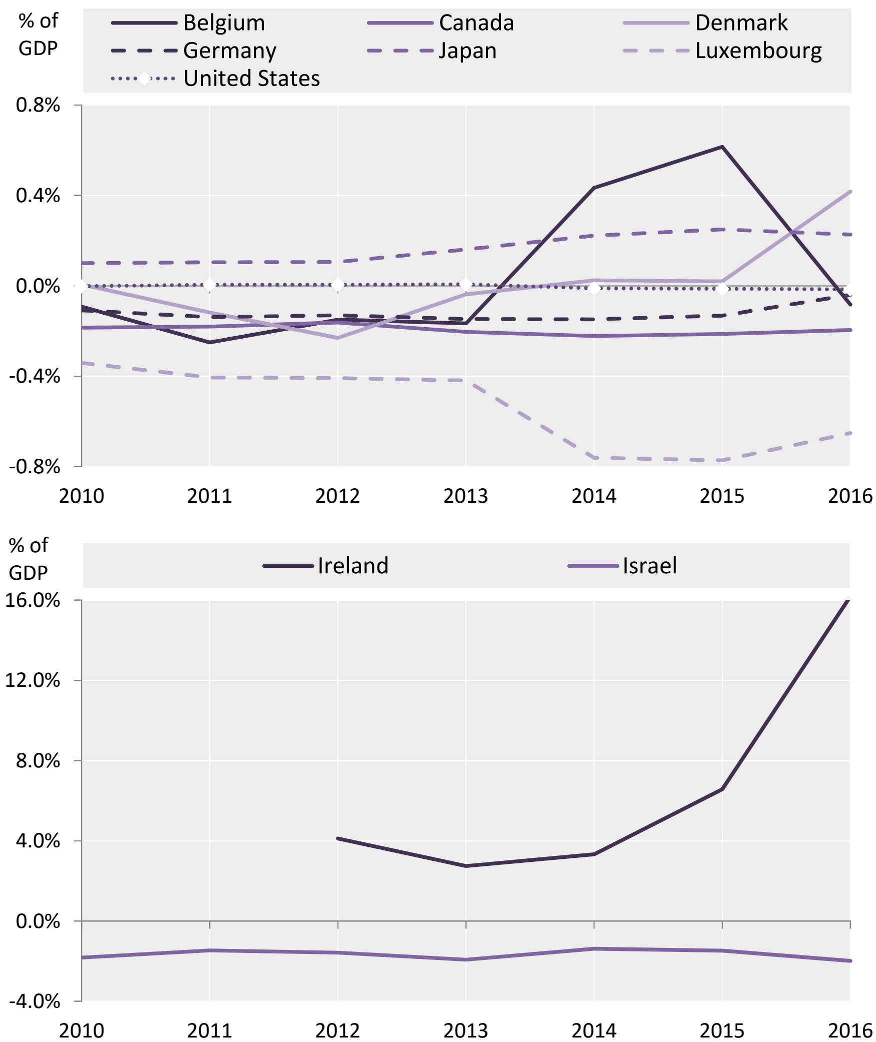
3.2.1. R&D trade trends

32. Time series for these detailed data are very limited, only going back to when methodological changes to the SNA and Balance of Payments guidelines were introduced in 2010. It is nevertheless possible to observe in **Figure 6** that the United States has maintained a near zero R&D trade balance over the period, Canada and Germany have been stable net R&D exporters, and Japan a stable R&D services importer. Denmark has moved from being a net exporter to a net importer, while Belgium's position oscillated sharply to become a net R&D services importer in 2014 but back to a near balance in 2016. Luxembourg's net R&D exporter position has become more accentuated over the period.

33. Ireland and Israel are shown separately as they are far outside the range of R&D net import intensities observed in the other presented countries. Israel has been relatively stable as a strong net exporter, averaging 1.7% of GDP from 2010 to 2016. Meanwhile, net imports of R&D services to Ireland increased from around 3-4% of GDP over 2012-2014 to 6.6% in 2015 and 16% in 2016. Examining the underlying data, this appears to be driven mainly by imports of proprietary rights relating to the outcomes of R&D.

Figure 6. Net imports (imports *minus* exports) of total R&D services, 2010-2016

Selected countries, as a percentage of GDP



Note: Chart presents EBOPS 2010 class SJ1 "Research and Development Services". In those countries for which further detail is available, this parent class primarily comprises classes SJ111 "provision of customised and non-customised research and development" and SJ12 "other research and development services" but also includes SJ112 "sale of proprietary rights arising from Research and Development".
Source: OECD Trade in Services by Partner Country database (http://oe.cd/2dm), OECD National Accounts database (http://oe.cd/1Fb); February 2018.

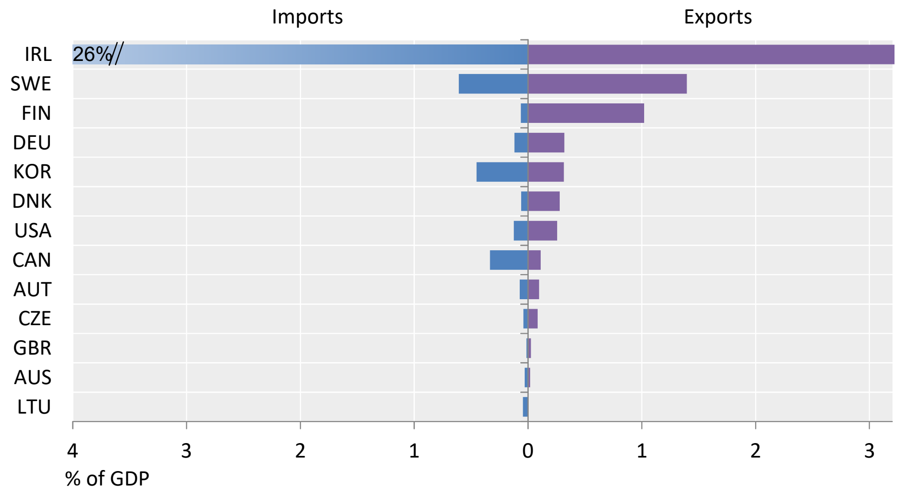
3.2.2. R&D licensing trade flows

34. A further R&D globalisation-related component is captured in trade statistics: cross-border payments for the use of intellectual property. As noted earlier, these differ from the "sale of proprietary rights arising from Research and Development". **Figure 7** presents the value of imports and exports of licences for the use of outcomes of R&D as a share of GDP. These data are available for a very small set of countries. Exports range

from 0.2 million USD, worth a minute fraction of GDP in Lithuania to 9.5bn USD, equivalent to just over 3% of GDP in Ireland. This would be generally consistent with there being a relatively large volume of R&D assets owned by resident units in Ireland and these being licensed out for use abroad. The United States and Germany have the greatest nominal R&D licencing exports – 47bn USD and 11bn USD respectively, though this equates to just 0.3% of GDP in both cases.

Figure 7. International trade in licenses for the use of outcomes of R&D, 2016

As a share of GDP



Source: OECD Trade in Services by Partner Country database. http://oe.cd/2dm, OECD National Accounts database http://oe.cd/1Fb, UK Office for National Statistics; February 2018.

35. Ireland also has by far the greatest imports of licences for the use of outcomes of R&D, at 80bn USD in 2016 – equivalent to over a quarter of GDP and more than three times the 23bn USD of licences flowing to the United States. This suggests that companies in Ireland also engage in holding licences for the use of intellectual property owned by other parties.

3.3. Bilateral trade in R&D

36. **Table 2** details R&D services and licencing exports and imports on a bilateral basis, breaking down total trade figures for selected countries according to the shares going to their five most important trading partners as reported by the published OECD EBOPS data. This shows that the United States is a key hub in global R&D-related trade and the main recipient of R&D services exports from all other countries presented (DEU, FRA, ISR, IRL, CAN), accounting for as much as 62% of R&D services exports from Canada and 76% from Israel.

37. Switzerland, Ireland, Singapore, and Bermuda (BMU) also rank highly based on the volume of R&D services they receive from the United States. Meanwhile the United Kingdom and Germany are key partners for almost all of the countries presented. For Israel, the British Virgin Islands (VGB) is one of the top 5 destinations for R&D services exports. The VGB figure is unavailable for the other countries (e.g. due to confidentiality) and therefore is included in the right-hand "other*" column.

Table 2. Bilateral R&D imports and exports, selected countries, 2016

Shares of total R&D services (SJ1) imports to / exports from country; shading (purple) indicates partner in top 5 for one or more reporting country

Legend: Top 5 partners: (purple) | Data unavailable (e.g. due to confidentiality): (grey) | Not applicable: (black)

Exports — Exports of R&D Services, % of total (Recipient partner)

Exporting country	Total USD PPP	USA	CHE	IRL	SGP	BMU	JPN	DEU	GBR	BEL	ESP	FRA	CHN	ITA	VGB	Other*
USA	37,176		17.0	21.1	13.3	6.1	8.3	3.2	2.5		0.2	1.4	0.4	0.2		26.3
DEU	22,290	35.8	11.4	1.1	1.1		3.4		4.8	3.7	1.3	5.3	5.2	2.5		24.6
FRA	12,267	15.9	10.9	0.8	0.3		3.5	12.8	13.1	3.0	13.3		1.0	1.3		24.2
ISR	6,960	76.2	0.3	-	0.2		-	4.1	8.7	-	-	0.2	-	1.5	0.7	8.1
IRL	4,542	18.4	0.6		-		-	7.1	0.1	-	-	0.2	-	-		73.6
CAN	4,541	62.3	5.9	1.3	1.3		1.4	6.8	1.8	2.6	0.0	1.9	0.0	0.1		14.5
Average		*41.7*	*7.7*	*4.9*	*2.7*	*6.1*	*2.8*	*6.8*	*5.2*	*1.9*	*2.5*	*1.8*	*1.1*	*0.9*	*0.7*	*28.5*
Weighted average		*37.3*	*12.0*	*10.8*	*6.4*	*6.1*	*5.7*	*5.6*	*4.9*	*3.3*	*2.6*	*2.4*	*1.9*	*1.1*	*0.7*	*26.0*

Exports of Licences for the use of outcomes of R&D, % of total (Recipient partner)

Exporting country	Total USD PPP	USA	IRL	GBR	CHE	DEU	CHN	FRA	NLD	SGP	KOR	BEL	AUS	Other*
USA	47,512		18.4	3.6	17.8	5.8	8.8	2.2	5.6	4.4	7.0	1.0	0.9	24.5
DEU	11,078	29.1	0.2	2.9	5.4	-	19.9	7.0	3.7	0.6	1.8	0.7	0.5	28.1
IRL	9,540			9.9	1.6		0.2		1.1	2.2	0.3	2.5	2.0	80.2
Average		*29.1*	*9.3*	*5.5*	*8.3*	*5.8*	*9.6*	*4.6*	*3.5*	*2.4*	*3.0*	*1.4*	*1.1*	*44.3*
Weighted average		*29.1*	*12.3*	*7.2*	*6.7*	*5.8*	*5.4*	*3.8*	*2.8*	*2.6*	*2.4*	*1.8*	*1.5*	*57.2*

Imports — Imports of R&D Services, % of total (Supplier partner)

Importing country	Total USD PPP	USA	DEU	IND	ISR	CHN	GBR	FRA	BEL	ITA	AUT	ESP	Other*
IRL	52,150	34.8	0.1				0.4	0.2				0.2	64.3
USA	34,243		10.7	10.2	6.5	7.6	7.0	2.7	3.5	1.6	0.2		53.3
DEU	20,923	27.7		4.5	-	6.2	9.1	10.0	1.0	2.7	6.9	1.9	24.0
FRA	14,216	17.6	26.7	2.4	-	2.4	15.0	-	2.6	3.9	0.2	5.5	26.1
CAN	1,184	67.2											32.8
ISR	635	41.5	5.6	1.1	-	0.1	6.4	5.6	4.7	0.3	-	2.7	36.7
Average		*37.8*	*10.8*	*4.5*	*6.5*	*4.1*	*7.6*	*4.6*	*3.0*	*2.1*	*1.8*	*2.6*	*39.5*
Weighted average		*30.9*	*7.5*	*6.8*	*6.5*	*6.1*	*5.5*	*2.9*	*2.6*	*2.4*	*2.2*	*1.5*	*49.5*

Imports of Licences for the use of outcomes of R&D, % of total (Supplier partner)

Importing country	Total USD PPP	USA	JPN	CHE	DEU	FRA	GBR	BEL	MLT	ESP	Other*
IRL	79,820		0.7			0.1	0.8	0.5	0.5	0.2	97.2
USA	23,200		44.9	14.4	9.0	7.4	4.8	1.1	-	0.1	18.2
DEU	4,126	20.4	5.2	9.9		5.8	4.0	1.2		0.6	52.9
Average		*20.4*	*16.9*	*12.1*	*9.0*	*4.4*	*3.2*	*0.9*	*0.3*	*0.3*	*56.1*
Weighted average		*20.4*	*20.0*	*12.0*	*9.0*	*5.5*	*3.8*	*1.0*	*0.5*	*0.3*	*46.6*

Note: Other* category includes shares relating to partners if unavailable (grey cells). Canada: 2015 data.
Source: OECD Trade in Services by Partner Country database (http://oe.cd/2dm)

38. Germany and the United Kingdom are also key suppliers of R&D services imports for these selected counties; nevertheless the United States is the source for a greater overall share of R&D services imports than Germany and the United Kingdom combined. India and China rank highly on the basis of their shares in R&D imports to the

United States (10.2% and 7.6% respectively). France is not a top-5 partner for the United States on either R&D imports or exports; its key relationships are with Germany, Ireland, and Canada.

39. Information on bilateral imports and exports of licences for the use of outcomes of R&D is only reported by 3 of these countries: the United States, Germany, and Ireland. Over 18% of US licence exports flow to Ireland; with a measured export value of around 8.7bn USD (second panel in **Table 2**). Switzerland, China, and Korea are other key recipients of licence exports. Germany appears particularly closely linked with China, which receives 30% of R&D-related licences exported by Germany. Judging from importers' reports, Japan is a key supplier of R&D licences, accounting for 44% of licences imported by the United States; Switzerland again features as a key source of licences.

3.3.1. Consistency of bilateral R&D trade statistics

40. **Table 3** compares the bilateral trade in R&D services reported by different economies in relation to the United States. This involves comparing what the United States reports exporting to any given economy with what that economy reports having imported from the United States - and vice versa for US R&D imports.

41. Looking at the left-hand "exports from the US" panel, reported R&D exports from the United States appear to be relatively understated compared to the counterpart R&D imports reported by partner countries.

42. The right-hand "exports to the US" panel presents a more mixed picture. With regard to large R&D performers such as France, Germany and Canada, declared imports from the US-side are relatively lower than the amounts that these countries declare exporting as R&D services to the United States. This appears to suggest that smaller amounts are systematically reported by the United States than by its counterparts. In the cases of Canada and Germany, the bilateral trade balance is not significantly impacted by the reporting perspective but for Israel, Sweden, and France respectively there is a USD 3bn, 1bn, and1bn gap.

43. In the case of US R&D imports from Ireland, the largest in value from a US-perspective, it is US-reported imports that are relatively higher than exports reported by Ireland. Thus, from an US viewpoint, the trade balance is close to USD 2bn while from an Irish perspective, it is close to USD 18bn. This gap may be affected by the comparison being based on older 2013 trade data from Ireland however.

44. There are several potential reasons for the lack of balancing in R&D trade data: they may stem from differences in data collection and use of standards, differences in valuation, as well as potentially from re-exporting, which is a factor known to distort bilateral trade comparisons for all goods and services. In the case of R&D services, this may be related to subcontracting or R&D services being embedded into other goods and services. While it is recognised that these are important issues, it is beyond the scope of this paper to attempt to provide an explanation. The OECD working party on trade in goods and services has an ongoing initiative that brings together trading partners to

discuss the large discrepancies and try to determine what is causing them and if they can be resolved[9].

Table 3. Comparison of R&D services bilateral trade figures involving the United States, 2016 (Millions of US dollars, annual average exchange rates)

	Exports from the United States				Exports to the United States			
	US R&D services *exports*	R&D services imports *from* USA	Ratio (%)	Year (if not 2016)	US R&D services *imports*	R&D services exports *to* USA	Ratio (%)	Year (if not 2016)
	A	B	B/A		A	B	B/A	
Total	37 176				34 243			
Australia	291				297			
Austria	10	60	600		67	76	113	
Belgium	1 094	1 264	116	2015	1 198			
Canada	391	796	204		2 025	2 601	128	
Chile	6				68			
Czech Republic	13	9	67		140	97	69	
Denmark	395	335	85	2015	185			
Estonia	2	1	60		44			
Finland	337	384	114	2015	279	115	41	
France	517	2 498	483		919	1 949	212	
Germany	1 206	5 805	481		3 674	7 979	217	
Greece	0	3			22	9	41	
Hungary	6			2013	63			
Ireland	7 842	18 172	232		5 387	420	8	2013
Israel	153	264	172		2 242	5 306	237	
Italy	91	161	177		537	834	155	
Japan	3 100				1 253			
Korea	304				268			
Latvia	0	0			5	3	60	
Luxembourg	288				19			
Mexico	89				695			
Netherlands	2 009	1 258	63		1 371	1 466	107	
New Zealand	5				33			
Norway	64				184			
Poland	30	22	74		194	474	244	
Portugal	7				19			
Slovak Republic	5	5	102		16	7	44	
Slovenia	0	2			3	6	200	
Spain	60				183			2015
Sweden	1 194	2 407	202		287	292	102	
Switzerland	6 326				1 072			
Turkey	2			2015	29			
United Kingdom	919				2 406			
Reporting Source	USA	Partner			USA	Partner		

Source: OECD Trade in Services by Partner Country database (http://oe.cd/2dm); February 2018

[9] The OECD and WTO have developed a balanced bilateral trade in services database based on EBOPS 2002 data. For more info see: http://www.oecd.org/sdd/its/balanced-trade-in-services.htm

3.4. R&D trade between affiliates

45. Multinationals play a first order role in the global trade of R&D. However, the prices reported for such transactions may be distorted for various reasons including as a means to transfer profits from one country to another for tax reasons or because the country where the ultimate owner enterprise is domiciled imposes restrictions on the repatriation of income. Transfer prices are the prices at which an enterprise provides physical goods, services, or intangible property to affiliated enterprises.

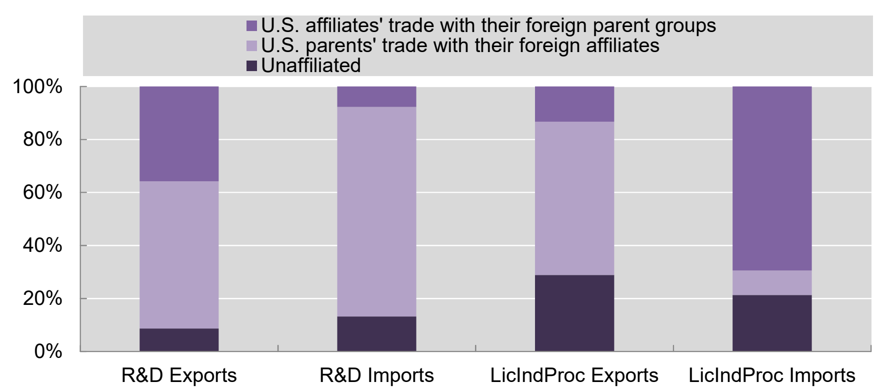
46. The OECD Transfer Pricing Guidelines (OECD, 2017b) stipulate the application - for MNE and tax administration purposes - of the arm's length principle, whereby individual group members must be attributed profits and taxed on the basis that they act at arm's length in their transactions with each other, i.e. applying comparable prices to those that would transpire in transactions with non-affiliated parties. Intangibles may have special characteristics that complicate the search for such comparators, and in some cases make pricing difficult to determine at the time of the transaction. Key factors to take into consideration are the exclusivity, extent, and duration of legal protection, the geographic scope, expected useful life, stage of development, rights to enhancements, revisions, or updates, as well as expectations of future benefit associated to the assets subject to transaction.

47. There are not many published data sources that break down R&D trade between affiliates from the total. The valuation of intra-MNE transactions of any type is challenging given concerns over transfer prices (MSITS 3.36 and Balance of Payments and International Investment Position Manual, 6th Ed, (International Monetary Fund, 2009) chapters 3 and 11). Further, some desirable information such as industry detail and the type of R&D being transmitted are not available, while guidance to distinguish sales vs. licensing of IP resulting from R&D has yet to be implemented across countries (see Moris and Zeile, (Innovation-Related Services Trade by Multinational Enterprises, 2016).

48. **Figure 8** presents evidence for the United States that the affiliate share of R&D trade is very significant, accounting for more than 90% of R&D exports from the United States. Nearly two thirds corresponds to trade between US parents with their foreign affiliates, while the remainder corresponds to services provided by US-based affiliates with their parents abroad. For comparison, the affiliate share for all services is 30%.

Figure 8. Affiliate and non-affiliate R&D-based trade, United States, 2016

Shares of total trade



Notes:LicIndProc: "Licensing of Industrial Processes"; considered a proxy for licenses to use R&D outcomes.
Source: Bureau of Economic Analysis. US Trade in Services, by Type of Service and by Country or Affiliation, 2017.

49. Affiliated trade is nearly as important for US R&D imports, though with a less significant role for groups owned abroad. Thus, behind the US net export position for R&D, the figures indicate that arms' length trade exhibits a USD 1bn deficit, US parents show a deficit in excess of USD 6bn, while the overall net exporting position is accounted for by affiliated trade within foreign groups, which has a net export position in 2016 in excess of USD 10bn.

50. In the case of licenses for the use of R&D outcomes, these are approximated in the affiliate trade statistics by figures on licences on industrial processes. Non-affiliated trade is slightly more important but still a minority at 30% for exports and is 20% for imports. US parents account for most of licence exports but only a fraction of imports, suggesting that licensing financial flows go towards the parent which is in principle holding the asset. What is not possible to establish from the data is the extent to which there is trade with other affiliates of the same parent company.

51. Given the difficulties in tracing and pricing R&D flows, developing a clear view of R&D globalisation requires building up evidence on where substantive R&D production activities are taking place in order to follow on and assess related flows. The next section discusses the relevant evidence.

4. Statistics on R&D performance and sources of funding

4.1. R&D performance and flows of funds

52. Frascati Manual-based business surveys focus on current-year domestic R&D activity, which is conceptually close to the SNA concept of R&D output when measured as the sum of production costs. The business sector is the main R&D performer in most countries, undertaking around 70% of R&D on average across the OECD area.

53. Frascati surveys can help inform a better understanding of R&D globalisation along different dimensions:

- They help identify the location of substantive R&D activity on a performance basis, including the location of human resources dedicated to R&D.
- Information on sources of funding for such R&D helps identify the engagement of other parties based abroad.
- They also gather data on payments made to other units outside the country for R&D performance, referred to as "funding for extramurally performed R&D".
- Data on R&D performance and funding can be further complemented with enterprise ownership data to provide a view of the role of MNEs in R&D performance and funding (Moris, R&D Performance of U.S.-Located Multinational Companies: Results from Multiagency Survey Linking Project, 2016).

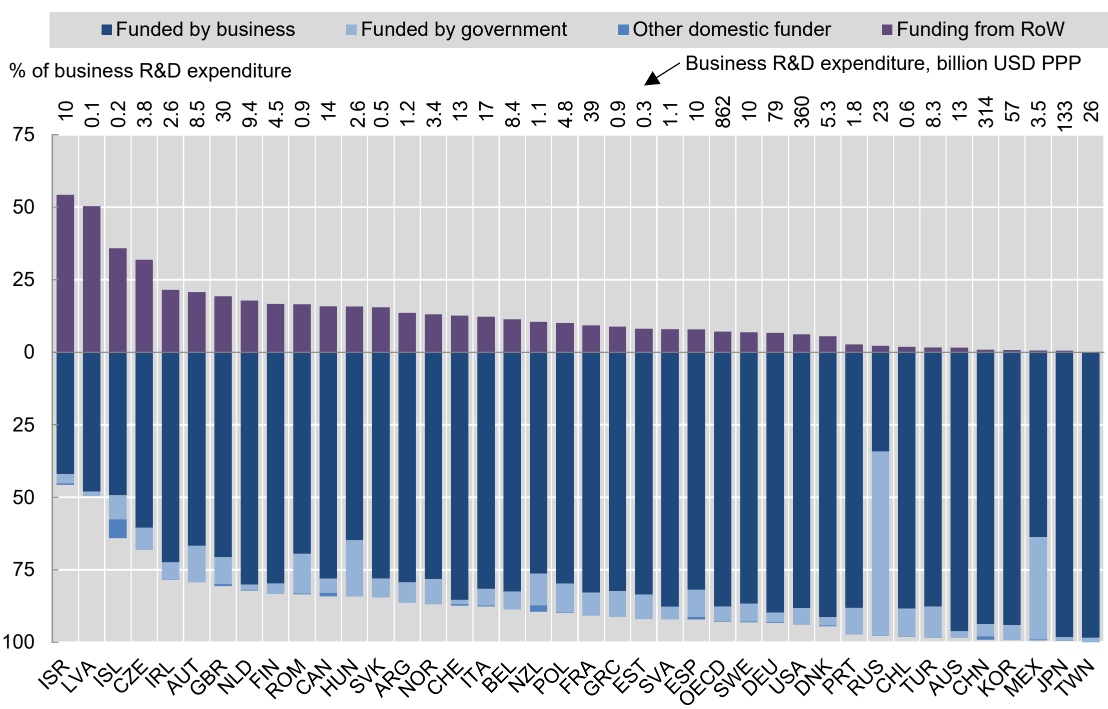
54. A fundamental principle behind R&D performers' reporting of the sources of funding for their R&D activities is that amounts received are only reported as external R&D funds if they were specifically earmarked or intended for R&D. Internal R&D funds are defined as "the amount of money spent on R&D that originates within the control of and are used for R&D at the discretion of a reporting statistical unit. Internal

R&D funds do not include R&D funds received from other statistical units explicitly for intramural R&D." (OECD, 2015). If external funding is received without explicitly being for R&D but the receiving unit internally makes the decision to use them for R&D, these are recorded as an *internal* source of R&D funds. Loans received from other units that the recipient may use for R&D but that has to repay under normal market terms are also treated as internal R&D funds for the same reason. A reporting convention for international comparisons is that funds from other units in the same business group should be treated as external funds, but separately itemised whenever possible, especially in the case of international funding flows.

4.2. Business R&D funded by the Rest of the World

55. **Figure 9** presents Business enterprise Expenditure on R&D (BERD) and the shares thereof funded by different sectors including the Rest of the World (RoW) sector[10]. Businesses in OECD countries spent 0.86 trillion USD PPP on R&D in 2015, with United States businesses accounting for almost 42% of that amount. Funding from abroad is greatest in Israel, which appears to be consistent with Israel having the lowest net R&D imports (i.e. greatest net exports) as shown in Figure 3. Likewise, a relatively large share of R&D performed in Iceland is also funded from abroad. Ireland ranks fifth for the share of business R&D funded by the RoW but first in terms of R&D exports.

Figure 9. Business R&D expenditure by sector providing funding for R&D, 2015



Notes: IRL, ISR, ITS, FRA, PRT: data relate to 2014; AUS, AUT, BEL, SWE: 2013.

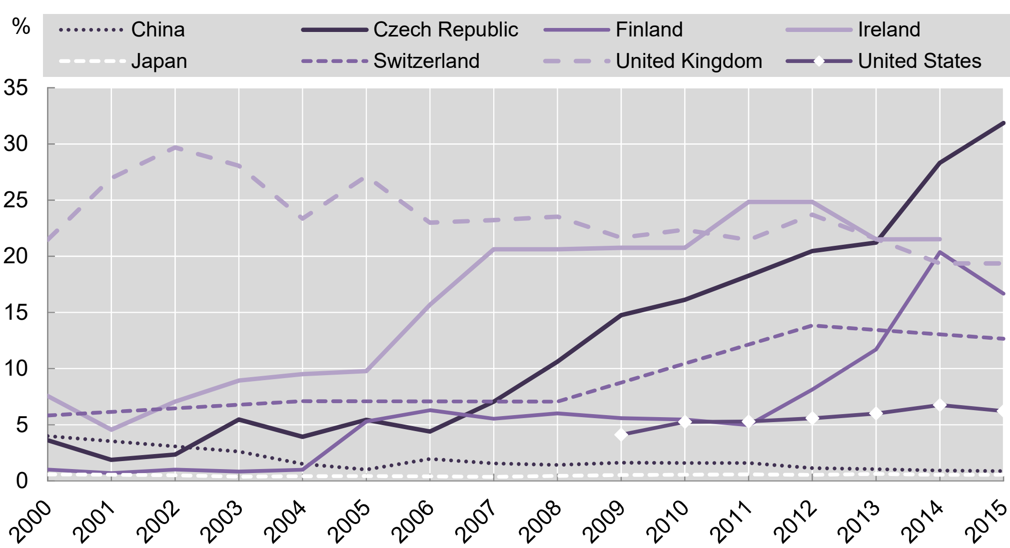
[10] In what follows, the terms Rest of the World (RoW), abroad, overseas, and outside the country are used as equivalents.

Source: OECD Main Science and Technology Indicators database (http://oe.cs/msti); January 2018.

56. **Figure 10** presents changes in the share of BERD funded by the Rest of the World in selected countries over the period 2000-2015. The general trend has been upward – consistent with R&D becoming a more globalised activity. The United Kingdom and China are exceptions to this trend (as are Australia, Austria, and Canada; not presented). Even so, the share of BERD funded from overseas remains relatively high in the United Kingdom at almost 30%. In China it has declined from 4% in 2000 to less than 1% in 2015 despite the value of R&D funding from abroad more than doubling in real terms as domestic funding has grown rapidly.

57. The Czech Republic is representative of the strong upward trend seen in various Eastern European countries including Poland and the Slovak Republic (not shown). Overseas funding of business R&D has been persistently low in Japan and also in Korea (not shown), indicative of a relatively low level of integration by businesses in these countries in the international R&D environment. The share of business R&D performed in Ireland that is funded from abroad increased markedly from less than 9% in 2003, the year a business R&D tax credit was introduced (OECD, 2017c), to reach 25% in 2012.

Figure 10. Share of BERD funded by the Rest of the World, selected countries, 2000-2015



Source: OECD Main Science and Technology Indicators database (http://oe.cs/msti); January 2018.

4.3. Comparing R&D funding from the Rest of the World and trade statistics

58. Services trade and Frascati Manual-based business R&D sources have complementary strengths relative to other sources for capturing international flows of R&D funding and outputs (Moris, R&D exports and imports: new data and methodological issues, 2009). Trade surveys collect transactions on R&D services based on either current or prior R&D, and also collect data on R&D services imports even if the respondent company is not an R&D performer or funder of current-year R&D (or historically). These transactions are valued at market prices (MSITS 3.32) while Frascati data are on a factor cost basis and capture current R&D production only.

59. **Figures 11a** and **11b** compare R&D services exports recorded by trade statistics with BERD funded by the Rest of the World. In about three quarters of countries, R&D services exports exceed R&D reported as being funded from abroad. Large differences are found in many countries; for example, Japan's R&D services export revenues are seven times greater than the funding businesses receive from overseas for R&D. As noted earlier, differences should be expected for many reasons, notably:

- BERD funding is constrained to equal business' total expenditure on R&D (i.e. input costs) while exports include any **profit** made on the transaction. On this basis, exports will tend to be larger than funding from abroad because of margins missing from the latter.
- R&D services exports use a broader definition of R&D, including "other product development that may give rise to patents"
- BERD funding relates specifically to **R&D performed in the period** while the category of R&D services exports (SJ1) includes "sales of proprietary rights arising from R&D", which may sometimes relate to R&D conducted in earlier periods. A comparison should focus in principle on trade category SJ111 "*Provision of customized and non - customized research and development services*" though data availability limits this. This also contributes to R&D exports being larger, and potentially more volatile, than funds from abroad.
- R&D export statistics apply to the **entire economy**. There are no readily available statistics that break down exports by institutional sector to allow a like for like comparison with R&D funds received by businesses only. This effect is expected to be small for a majority of countries due to limited R&D export activity of units in other sectors.
- Funding of R&D from the rest of the world includes not only payments for purchases of R&D services but also **unrequited payments made to support R&D performance**. Under current SNA and Balance of Payments Manual (International Monetary Fund, 2009) rules these would, in theory, be recorded as capital transfers - reflecting the recommendation in the 2008 SNA that expenditures on R&D are recorded as investment when they occur, as long as the expenditures satisfy investment criteria (formerly current transfers under the 1993 SNA).[11] Therefore, these payments do not imply a stake in or economic ownership over any results.

60. This last point is crucial; R&D funding from the RoW is not a measure of international trade in R&D but of a construct that combines trade and transfer elements. Cash and in-kind transfers are contemplated in the Balance of Payment Manuals but not as part of trade statistics. On that basis, R&D funding from RoW may provide an upper bound of the share of current-year business R&D performance which might result in outputs that are *de facto* owned by the RoW. The gap is likely to be larger in the case of countries whose businesses rely more on R&D grants and related contributions from supranational agencies and international donors. This is fairly consistent with the results in **Figure 11**.

[11] In practice, this may still be the case, especially in cases where it is not clear that the funding is for the creation of an asset – in cases of uncertainty the 2008 SNA advocates recording transactions as current and not capital transfers.

Figure 11a. R&D services exports and BERD funded by Rest of the World, 2015 or latest

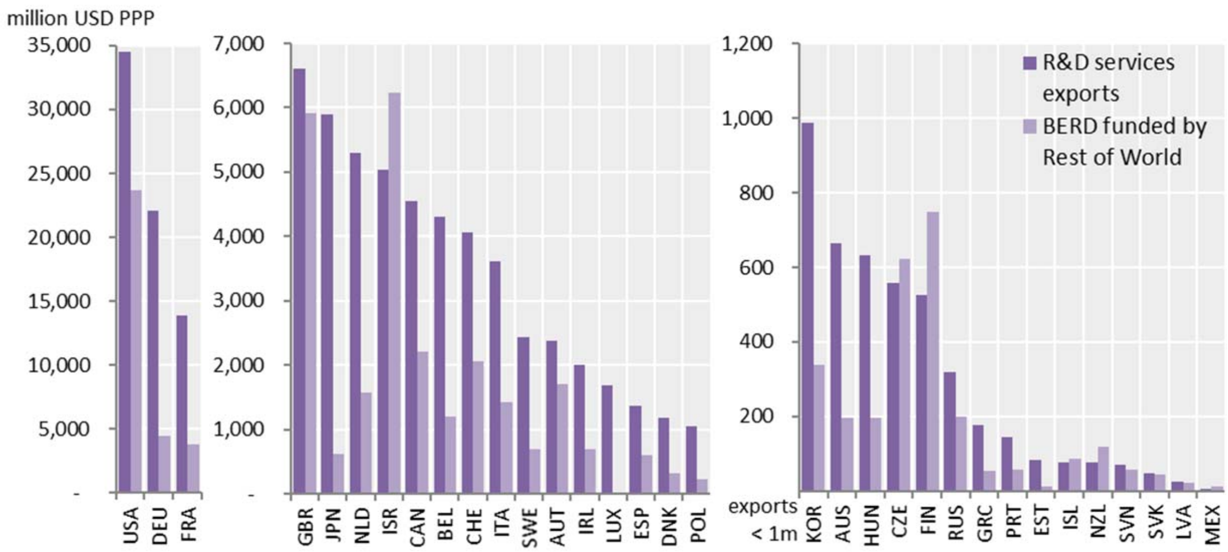
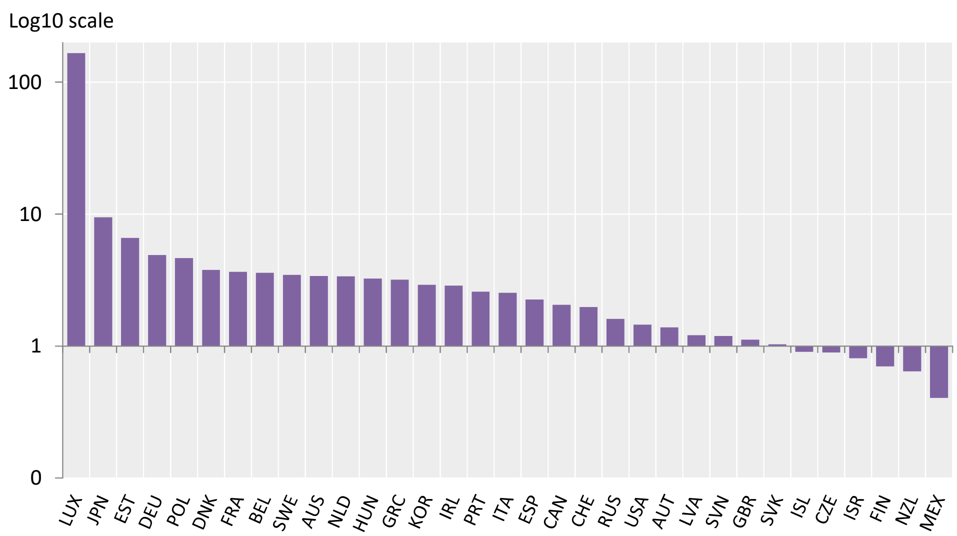


Figure 11b. R&D services exports relative to BERD funded by the Rest of the World, 2015

R&D services exports / BERD funded by the Rest of the World, Log10 scale



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Source: Add the source here. If you do not need a source, please delete this line.
Note: When multiple is 1, R&D services exports = BERD funded by the Rest of the World. Latest year for which both export and R&D expenditure data are available: data for France 2014, Sweden 2013.
Source: OECD Trade Statistics database, OECD R&D statistics database (http://oe.cs/rds); February 2018.

61. The Frascati Manual 2015 explicitly acknowledges the need to distinguish funding transactions by introducing a recommendation to undertake a new disaggregation of R&D funding into:

- "**exchange** funds" – funds paid in exchange for the provision of R&D services – which imply a sale of R&D, and
- "**transfer** funds" – which are paid towards the business' R&D performance but with no expectation that the funder will directly own or access the results; as such economic ownership remains (at least initially) with the R&D performer. In the international arena, an example would be R&D grants provided by the European Union Framework Programme or Structural Funds.

62. This breakdown promises further insight into the economic *nature* of the transaction taking place – a commercial sale or an unrequited transfer – and this can provide an indication of whether the resulting R&D assets will be owned in the producing country or elsewhere.[12]

63. National statistical authorities are still in the process of implementing the 2015 Frascati Manual, including data on R&D globalisation. As a result, the data currently available are very limited, especially when it comes to funds from the RoW. However, new, not yet published data provided to the OECD by Statistics Finland and the Federal Statistical Office of Switzerland suggest that over 80% of R&D funds received by businesses from the Rest of the World are exchange funds, and that the precise share is likely to vary between countries - being 97% in Finland, 82% in Switzerland.

64. In the case of Switzerland, the amount of exchange-based funding from abroad (82%) is less than the total amount of R&D funding originating from business abroad (93%). This implies that some funding from businesses abroad is being reported as transfer funding. This gap may perhaps be explained by contributions or subscriptions to R&D performing non-profit institutions classified in the business sector, such as industry association bodies though the details needed to make this assessment are unavailable.

65. While these data *suggest* a strong correlation between the provision of R&D funding and ownership as indicated by exchange funding, there is at this point not enough exchange and transfer data available to draw firm conclusions. Nevertheless, this indicates that firms, including MNEs, can use a diverse range of arrangements to fund their R&D activities and how this may be translated into reporting, notwithstanding measurement guidelines. Key considerations are whether funds are internal or external to the unit, whether they are explicitly aimed for R&D or not, and what mechanism the funder has in place to get a return on the funding allocation. The ultimate equity on the outcomes of R&D is, in principle, an asset that can represent a counterpart to the funds provided but the uncertainty about the final outcome may plausibly entice respondents to record the funding on a transfer basis. This requires further investigation; **Box 1** briefly presents data on revenues from sales of R&D collected through Frascati Manual-based sources.

4.4. Sources of R&D funds from the Rest of the World

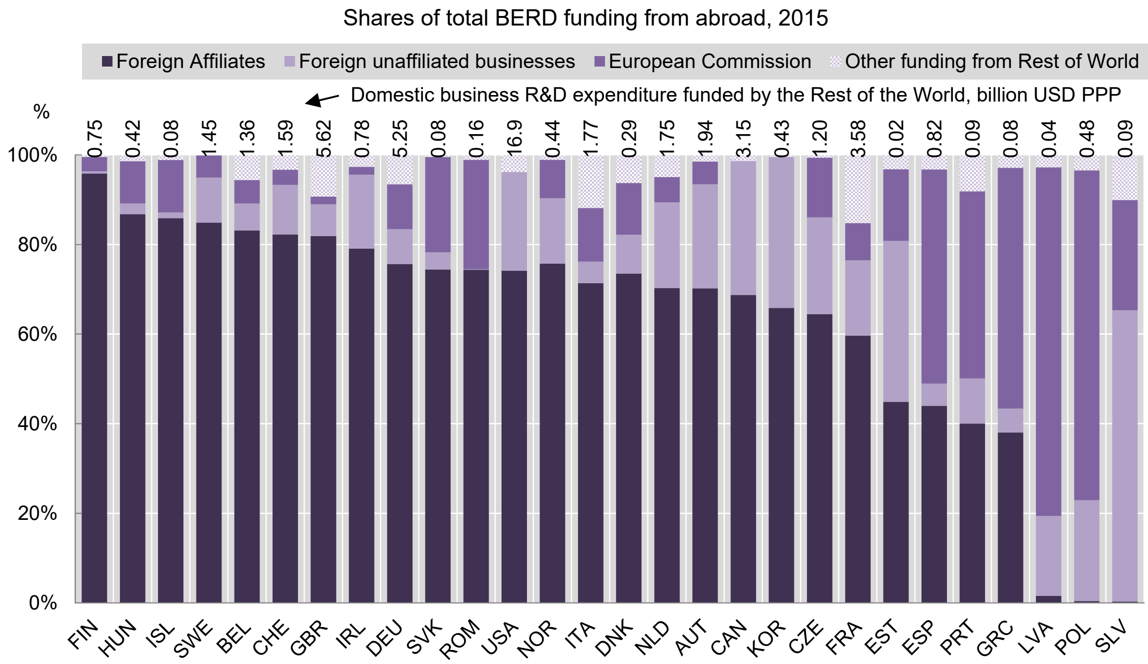
66. While relatively little information is currently available about the precise "exchange" or "transfer" nature of R&D funding from the RoW, for many countries there is information available on the foreign funders themselves. **Figure 12** presents the shares

[12] It is worth noting that exchange funds may still entail a transfer component if the buyer relinquishes its IP rights in part or in full, for example if the buyer only secures rights for its own use.

of BERD funding coming from businesses located outside the reporting country, the European Commission, and other funders abroad including foreign governments and higher education institutions abroad. It can immediately be seen that foreign affiliates of the R&D performing business are key funders, accounting for more than half of funds from the RoW in all but seven of the countries presented. In those countries, EU funding tends to make up a large share, though unaffiliated businesses account for almost 70% of foreign BERD funding in Slovenia, the greatest share of any country.

67. While transactions between unaffiliated enterprises might reasonably be assumed to be economically meaningful market transactions (i.e. with a price reflecting demand and supply), the economic substance of transactions between affiliates is harder to ascertain. Nevertheless, MNEs are clearly important actors in the international R&D ecosystem and are the focus of **Sections 5**.

Figure 12. Funding of Business R&D by non-resident sources, 2015



Notes: Estonia, France: 2014 data.
Source: OECD R&D statistics database (http://oe.cs/rds); pre-release data.

68. **Table 4** shows time series data on the distribution funding sources for R&D performed by businesses in the United States from its Business R&D and Innovation Survey. This longstanding survey takes as its reporting unit the domestic consolidated business group, which includes individual enterprises or groups that are ultimately owned by foreign companies. Over 90% of annual business R&D performed in the US was domestically funded, though foreign sources increased marginally over the period. Within foreign funding, the majority of the funding was intra-MNE.

69. Funds explicitly aimed to fund R&D from foreign parents of these units only account directly for 3% of US BERD, well below the 15% of US BERD that is accounted for by majority-owned affiliates of foreign MNEs (see next section). Part of this gap may be due to a combination of other external sources (e.g. government funds) but also to the

fact that domestic groups are in some cases given some degree of discretion on how to use their financial resources including how much to dedicate to R&D.

Table 4. Source of funds for R&D performed by business in the United States, 2010-2015

Millions of current dollars

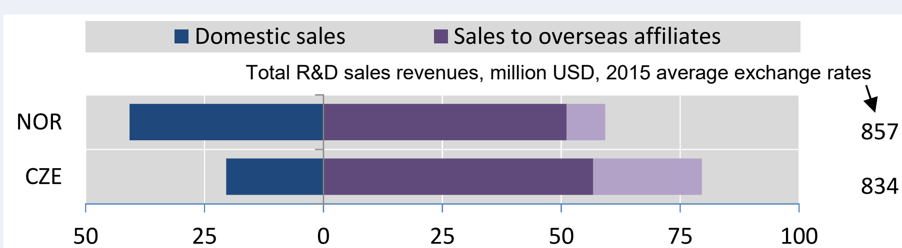
	2010	2011	2012	2013	2014	2015
R&D performed by business	278,977	294,093	302,250	322,528	340,728	355,821
Domestic funding	264,332	278,551	285,409	303,176	317,714	332,093
Funds from within the company's US-located units*	218,187	235,426	242,674	259,908	277,272	289,892
Other US-located companies	11,013	11,124	11,624	13,450	13,227	14,595
Federal government	34,199	31,309	30,621	29,362	26,554	26,990
All other domestic organisations***	933	692	490	456	661	616
Foreign funding	14,645	15,541	16,841	19,353	23,014	23,728
Funds from parent or subsidiary companies abroad	10,621	10,780	13,092	15,450	18,705	19,364
Foreign parent companies of US subsidiaries	7,102	7,438	8,486	10,445	13,407	12,579
Subsidiaries of US located companies*	3,519	3,342	4,606	5,005	5,298	6,785
Other companies abroad**	3,913	4,569	3,607	3,346	3,839	3,738
Other organisations abroad***	111	192	142	557	470	626

Notes: In the US R&D survey, the reporting unit is the US-based company, including all subsidiaries and divisions where there is more than 50% ownership. In the case of companies owned by a foreign parent, the reporting unit for the survey is the US-located company, including all majority-owned subsidiaries and divisions regardless of location. For reporting purposes, foreign parents and any foreign affiliates not owned by the US company are treated as any business partner, customer, or supplier that it does do not own.
* US located companies include companies owned by foreign enterprises.
** This category may include affiliated companies that are neither parents nor majority owned subsidiaries of the US located company
*** Other organisations abroad include foreign governments and all other non-business organisations outside the United States. All other domestic organisations include households and non-profit organisations.
Source: National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey (annual series). Science and Engineering Indicators 2018.

Box 1. Data on business sales of R&D

Several countries have implemented a Frascati Manual 2015 recommendation to gather data on R&D performers' revenues from sales of R&D in the period. The available data show that businesses in Norway and the Czech Republic made similar amounts of R&D sales in 2015. In the Czech Republic, 80% of business' R&D sales were to customers abroad, while for businesses in Norway a majority (59%) of sales were also to customers outside the country.

R&D sales revenues by customer location & relationship to R&D performing business, 2015



Source: Czech Statistical Office, Statistics Norway

The importance of foreign affiliates can immediately be seen. In both cases a similar share of R&D sales are to related businesses abroad (a little over 50%) with sales to unaffiliated businesses being greater for R&D-performers in the Czech Republic.

4.5. Business funding of R&D performed abroad

70. The Frascati Manual framework also recommends collecting information on *extramurally-performed R&D;* that is, information on the amounts paid out by R&D funders for the performance of R&D by others. This serves a practical role in helping R&D survey respondents delineate their own R&D from that which they have paid others to do but is also a source of information on the outsourcing of R&D. The Frascati Manual 2015 also proposes several breakdowns of funds for extramural R&D provided by businesses including distinguishing exchange and transfer funding provided and recipient type (e.g. business, government, higher education, non-profit and whether they are domestic or abroad).

71. Although the OECD maintains a facility to collect data on funds for extramural R&D very few countries provide these at present. The fact that, due to survey design, the data often represent only funds provided by businesses which themselves perform R&D (omitting firms which fund but do not perform R&D) and the resultant scope for user misinterpretation of the figures have been cited as concerns. This difference in scope implies that the reported amounts are less directly comparable to R&D import figures than funds from abroad can be compared with exports. Nevertheless, these data may provide some additional insight into international R&D linkages.

72. The US Business Research and Development and Innovation Survey (BRDIS) collects rich information on funds for extramural R&D including whether the recipient is in the United States or abroad, a majority owned subsidiary or a separate business (defined as including foreign parents and affiliates which aren't direct subsidiaries), and the country where those subsidiaries are domiciled. The R&D paid for with funds provided to the company by others is also reported.

73. **Table 5** presents these data, which show 83.5 billion USD paid to companies abroad of which 73.7 billion USD went to majority-owned subsidiaries of the US-located unit. It should be noted that while the responding units are US-located they may be ultimately owned elsewhere.

74. The greatest individual share of this R&D funding, 8.5billion USD, flows to subsidiaries in the United Kingdom while those in Germany receive nearly as much - 8.2bn. Businesses in China and India also receive considerable R&D funding from US-located parents - 6.3bn USD and 5.5bn USD respectively. The 18 selected countries presented account for 79% of all R&D funding flowing from US located to subsidiaries abroad.

75. Of these flows between US located parents and their subsidiaries, 92% are funded by the US parent itself and 8% by others - including other businesses in the US and abroad and the US government. This split varies by the country of the recipient however, from 15% of funds flowing to Switzerland-located subsidiaries and 14% of funds flowing to United Kingdom-located subsidiaries, to just 2% of flows to Israel-located subsidiaries and 1% of flows to Finland-located subsidiaries. This may suggest the extent to which US-based companies engage in joint R&D activities abroad.

Table 5. R&D performed abroad funded by businesses active in the United States, 2015

Selected countries with greatest US business-funded R&D performance, USD Million

Location	Total	Paid for by the company	Paid for by others	Share paid for by others
Total R&D performed abroad	83 501	76 985	6 515	8%
Performed by other companies abroad	9 810	9 163	647	7%
Performed by foreign subsidiaries of US-based companies*	73 691	67 822	5 868	8%
United Kingdom	8 565	7 368	1 197	14%
Germany	8 157	7 770	387	5%
China	6 265	6 000	266	4%
India	5 534	5 325	209	4%
Canada	4 381	4 172	209	5%
Israel	3 530	3 457	73	2%
Switzerland	2 926	2 489	437	15%
France	2 772	2 496	276	10%
Japan	2 684	2 307	378	14%
Ireland	2 317	2 268	49	2%
Belgium	2 058	1 911	148	7%
Singapore	1 707	1 520	186	11%
Brazil	1 413	1 323	90	6%
Australia	1 305	1 194	111	9%
Finland	1 255	1 241	14	1%
Netherlands	1 237	1 127	109	9%
Korea	1 148	1 087	61	5%
Italy	1 027	935	92	9%

Note: * Includes companies ultimately owned by foreign MNEs.
Source: 2015 Business Research and Development and Innovation Survey (BRDIS). National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey.

5. R&D performance by MNEs

76. The growth in the importance of foreign affiliates as sources of funding for R&D points to the major role, already alluded to, of MNEs as conduits for R&D globalisation. This should be expected as firms can, and increasingly do, engage in offshoring R&D out of the country where they are based/headquartered (UNCTAD, 2005); (Maftei, 2007).

77. Though data on business R&D funding from the Rest of the World *by country of origin* (i.e. where the unit providing the funds is located) are not available, some countries detail domestic R&D **performed** by foreign controlled affiliates. In some cases this R&D total is also available distributed by the *country of residence* of foreign parent companies (either immediate parent company or ultimate controlling business). This chapter examines statistical evidence on R&D performed by domestic units that are foreign-controlled, as well as R&D performed by foreign affiliates of domestic R&D performers. Data used in this section originate from either Frascati Manual-based business R&D surveys or have been obtained from R&D related questions included in

surveys specifically aimed at collecting information on the inward and outward activities of MNEs.[13]

5.1. R&D performance by Foreign-Controlled Affiliates

78. Foreign-controlled affiliates (FCAs) can account for a considerable share of business R&D performance. Around 60% of all business R&D in Ireland, Belgium, the Czech Republic, and the Slovak Republic takes place within businesses majority owned by firms abroad. In the United Kingdom and Austria the share is over 50%, and out of the countries for which data are available – presented in **Figure 13** – the FCA share of business R&D is only below 10% in Japan.

79. Despite this, in many cases the share of Business R&D funded from abroad is strikingly low. For example, in Belgium FCAs perform 62% of business R&D but only 10% is reported as being funded from abroad. In Ireland, FCAs account for 64% of R&D performed by businesses but 27% of BERD is funded by overseas businesses. Large differences are also seen in the Slovak Republic, Poland, Sweden, Spain, Slovenia, Estonia, and Germany. In the United States, FCAs account for an estimated 16% of BERD while 5% of BERD funding comes from abroad.

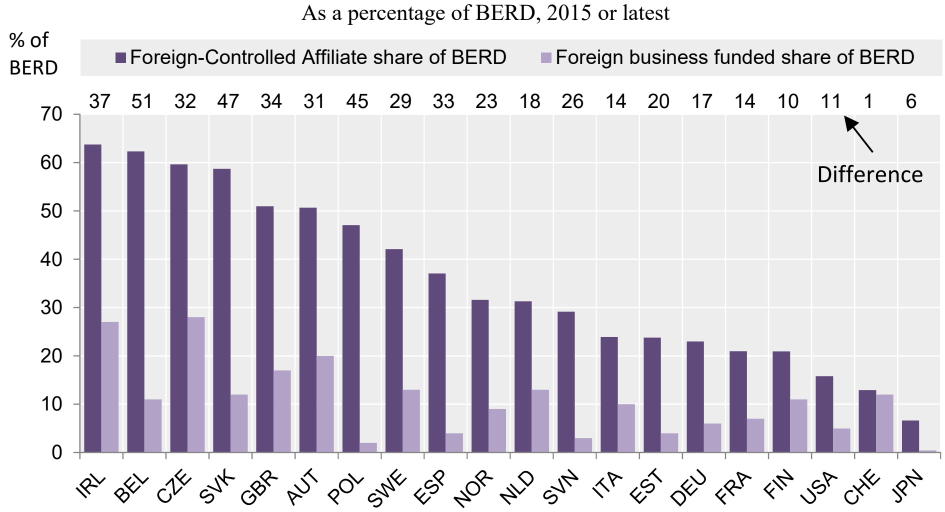
80. There is no definitive evidence on the precise causes of these disparities but some potential drivers can be considered and contrasted to well-documented business practices which are also acknowledged in the revised Frascati Manual (OECD, 2015). Some FCA R&D costs are likely covered with locally-generated funds, e.g. from domestic sales of the company's main products. However, domestic firms may receive funds -from group companies abroad- which are not specifically earmarked for R&D but nevertheless are eventually used to cover the costs of R&D performance. As explained in the previous section, these would be recorded as FCAs' "internal funds". This would understate the importance of funds from outside the unit but internal to the global group. As an example, an MNE parent outside Belgium may provide a lump-sum to a Belgium-based FCA to cover marketing, design, and R&D activities. The parent sets the key outputs and performance indicators for these activities but does not prescribe how the sum is to be allocated to deliver those activities, leaving this to the FCA to decide. The funds used for R&D would likely be recorded as internal in the FCA's R&D survey response even though it is explicit that a (non-prescribed) portion of the money received is for the conduct of R&D.

81. The portion of R&D conducted using internal funds is one indicator currently used by National Accountants to identify "own account" R&D which, by definition, is owned by the producing unit and hence recorded in the balance sheet of the company, industry, sector, and country which produced it. While the party identified as performing and directly funding the R&D *may* be the economic owner, it is possible that the MNE group could be paying or authorising the FCA to conduct R&D in the expectation that some or all of the other companies within the global group could have access to and benefit from the results.

[13] For example, US reported FCA data originates from the MNE surveys conducted by the Bureau of Economic Analysis, whereas US BERD totals, including that of FCAs in the US originate from R&D surveys conducted by NSF/NCSES and the U.S. Census Bureau. Consequently, R&D totals for a similar set of companies may differ in the two sets of surveys.

Figure 13. BERD performed by FCAs and BERD funded by foreign businesses

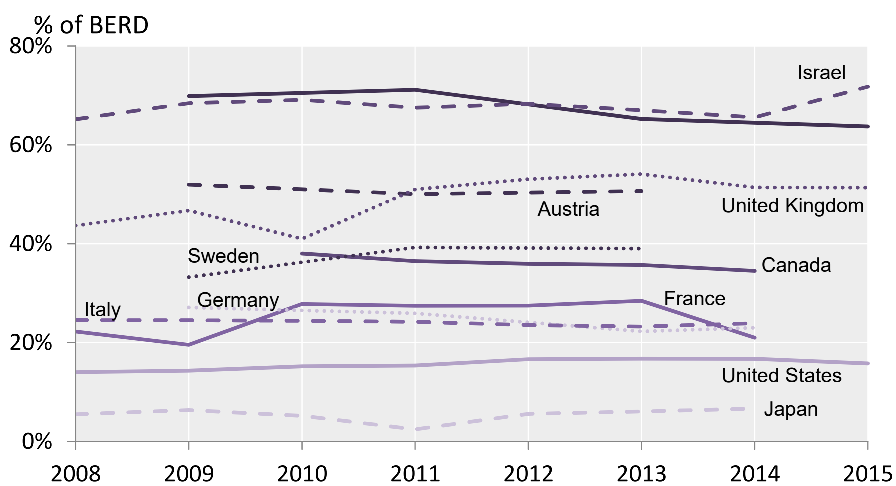
As a percentage of BERD, 2015 or latest



Notes: For NLD, POL, SVN, ESP only sections B to F of ISIC Revision 4 are covered. For EST and FIN only sections B to E are covered. SVN figures refer to 2011. NOR figures refer to 2012. AUS, AUT, BEL, EST, FIN, POL, ESP figures refer to 2013. FRA, ITA, JPN, NLD, USA figures refer to 2014.
Sources: OECD, Activity of Multinational Enterprises Database (http://oe.cd/amne); OECD Research and Development Statistics Database (http://oe.cd/rds); Eurostat, Inward FATS Database; national sources, July 2017, US Bureau of Economic Analysis, January 2018.

82. Available statistics indicate that the share of business R&D performed by FCAs has been relatively stable over the time period available - 2008-2015 (Figure 14). The share of BERD performed by FCAs in Israel and Ireland is consistently greater than the other countries for which data are available. In the United States, the FCA share of business R&D has increased slightly, from 14% in 2009 to 16% in 2015.

Figure 14. Recent trends in business R&D performed by FCAs, 2008-2015
Share of business R&D performed by FCAs



*Note: D*ata cover the “business sector” defined in the AMNE database as International Standard Industrial Classification sections B to S excluding O.
Source: OECD AMNE database (http://oe.cd/amne), UK Office for National Statistics, US Bureau of Economic Analysis, Statistics Canada, Stifterverband Germany, Central Bureau of Statistics Israel.

83. **Table 6** explores the ownership distribution over domestic R&D performing units. It presents total R&D expenditure by FCAs in the United States, Germany, United Kingdom, France, Canada, and Switzerland broken down by the place of residence of the ultimate owner of the FCA. For FCAs located in the United States, the countries with ownership over FCAs performing the greatest shares of BERD echo some of the key R&D services exporting partners identified in **Table 2** - with Switzerland and Japan being home to the parents of FCAs performing the greatest share of total FCA R&D. However, FCA ownership does not appear to align too closely with R&D services exports in other cases as Ireland ranks relatively low with 3.9bn USD of FCA R&D, behind the Netherlands (4.6bn USD), France (5.3bn USD), Germany (7.2bn USD) and the United Kingdom (7.9bn USD) as well as Japan (8bn USD) and Switzerland(9.6bn USD).

84. Germany-owned FCAs undertake around 8% of all FCA-performed R&D in the United Kingdom but almost double that - 14% - in France and match US FCAs' 25% share in Switzerland.

85. For Canada, the United Kingdom, and France, the greatest share of BERD performed by foreign-controlled affiliates is by businesses owned in the United States. The relationship is reciprocated somewhat in the case of the United Kingdom, which is one of the most likely headquarter countries for R&D-performing FCAs in the United States alongside Germany and Japan.

86. However, US owned FCAs spent 5.7billion USD PPP on R&D in the United Kingdom in 2017 while UK-owned companies in the US spent almost a third more - 8billion USD. This asymmetry is echoed for Germany, France, and especially Switzerland, where US owned FCAs performed 0.4billion USD PPP of R&D in 2015, while Switzerland-owned FCAs in the US spent 9.7bn USD PPP.

87. This indicates that in absolute levels, more European MNEs carry out R&D in the United States than US MNEs conduct research in Europe. A markedly different relationship exists between the US and Canada, with US-owned FCAs in Canada spending 3.2billion USD PPP on R&D in 2014, almost four times more than the 0.86billion USD than Canada-owned FCAs spent on R&D in the US in 2015.

88. These figures provide a partial indication of the extent of global ownership linkages concerning businesses which conduct R&D and suggest that this may, to some extent, translate into flows of R&D services and licencing exports.

Table 6. Domestic R&D expenditures by foreign-controlled affiliate firms, by location of ultimate majority ownership

Selected countries, latest available year, million USD PPP

	Country of business R&D performance (reporting country)					
Country of ultimate majority owner	USA 2015	DEU 2015	GBR 2016	FRA 2014	CAN 2014	CHE 2015
Total	56 344	16 934	15 983	8 112	5 164	1 624
USA	n/a	6 338	5 664	2 216	3 216	396
CAN	864			47	n/a	
Europe	40 707	9 136	5 596	5 476	1 571	
AUT	28			48	-	17
BEL	375			301	17	
CHE	9 670			1 514	183	n/a
CZE	-			-	7	
DEU	7 176	n/a	1 246	1 127	136	391
DNK	433			80		
ESP	114			123		
FIN	119			48		
FRA	5 317		960	n/a	334	108
GBR	7 943		n/a	440	423	32
IRL	3 943				8	
ISL	9					
ITA	179			188		28
LUX	22			281		107
NLD	4 645			790	67	
NOR	26			9		
PRT	3					
SWE	639			410	307	
Other Europe	69		3 390	118	90	
Caribbean	751				2	
BRA	27					
BHR	11					
CHN	545					
IND	114				50	
ISR	1 043				85	
JPN	8 019		959	235		57
KOR	1 034					
SGP	380					
THA	5					
TWN	106					
AUS	179					
Africa	14					
Residual	2 542	1 489	3 765	138	241	490

Source: US Bureau of Economic Analysis, UK Office for National Statistics, Stifterverband Germany, Statistics Canada, Ministère de l'Enseignement supérieur,de la Recherche et de l'Innovation France, Federal Statistical Office Switzerland.

89. One key finding is the relative importance of US MNEs for R&D performance within European economies. US owned FCAs account for around a third of FCA-performed R&D in Germany and the United Kingdom, and around a quarter of FCA-R&D in France and Switzerland but account for 62% of FCA-performed R&D in Canada.

Figure 15 visualises the ownership links in **Table 6** between R&D-performing FCAs in the United States, United Kingdom, and Canada and the countries where the FCAs' majority owners are domiciled. While these are not necessarily either transfers of R&D services or funds paid for R&D, they give an indication of the extent to which the knowledge gained might benefit MNE parents (and their other affiliates) abroad.

Figure 15. FCAs' R&D expenditure by country of FCA majority owner

Ribbon colour indicates FCA location (country of R&D performance)

Note: "RES" indicates "residual countries" i.e. the portion of FCA-performed R&D for which the country of ownership is not presented or not available. For example, in Germany only R&D performed by FCAs majority owned in the US is available separately; the ownership countries of all other FCAs are therefore not known and so the majority of R&D-performing FCAs in Germany are shown as being owned by "residual countries" even though some or all of these FCAs may in reality be owned by businesses in other countries presented such as France and Switzerland. Due to data availability, IRL, ISR, JPN, KOR, NLD, RES are presented only as FCA-ownership countries; the R&D performed by FCAs in those countries is not presented.
Source: US Bureau of Economic Analysis, UK Office for National Statistics, Germany's Stifterverband, Statistics Canada, Ministère de l'Enseignement supérieur,de la Recherche et de l'Innovation France, Federal Statistical Office Switzerland.

5.2. R&D performed by foreign affiliates of domestic MNEs - the outward perspective

90. The inward perspective of MNE R&D activities can be complemented with an outward perspective looking at R&D performed abroad by affiliates of domestically owned MNEs. The combination of inward and outward perspectives is necessary in order to properly identify the net balance of R&D performance ultimately controlled by resident units and so to underpin the measurement of national income.

91. Germany's business R&D statistics for 2015 indicate that German companies undertake 89bn USD PPP worth of R&D worldwide, of which 58bn is carried out domestically and 31bn abroad (Stifterverband, 2017), nearly double[14] the USD 16.9bn reported in **Table 6** as being performed in Germany by FCAs. This information, combined with the trade statistics in section 3, allow some simplistic calculations for the potential impact of R&D globalisation on the GDP and GNI aggregates for Germany:

- Germany has a net R&D export balance of USD 1.4bn. Since R&D capital formation is likely to be close to the level of R&D performance indicated by Frascati Manual R&D expenditure data *minus* this balance, more R&D can be used by units abroad than is secured by domestic units from units abroad and therefore, keeping everything else constant, R&D capital formation will be lower than R&D output.
- German MNEs appear to have an excess of financial claims on R&D carried out abroad over the claims of foreign MNEs on R&D carried out in Germany amounting to USD PPP 14.1bn (31bn outward minus 16.9bn inward). This would be expected to represent a positive net property income flow to Germany thus raising GNI relative to GDP. However, it should be noted that in order to carry out a more precise calculation, it would be necessary to identify the extent to foreign or domestic MNEs are involved in R&D trade.

92. The OECD database on the Activities of MNEs includes statistics on the outward activity of MNEs by location including R&D. However this database is sparsely populated and allows for few comparisons with R&D expenditure by affiliates of foreign owned companies (**Table 7**).

[14] The difference between what German companies report spending on R&D in the United States and what US-based affiliates of German companies report is smaller but still quite significant if current exchanges rates at the time are used instead of using USD PPPs (USD 26 bn vs USD 31 bn).

Table 7. Intramural R&D expenditure of affiliates located abroad vs R&D by affiliates of foreign owned companies, 2014 or most recent year available

Reporting country	Outward activity of reporting country	Year	Inward activity in reporting country	Year	Unit
Germany	17 274	2013	11 925	2013	Million EUR
Israel	3 717	2011	18 913	2011	Million NIS
Japan	834 001	2014	902 529	2014	Million YEN
Slovenia	15	2014	134	2011	Million EUR
Sweden	33 825	2013	Not available		Million SEK
United States	52 174	2014	56 904	2014	Million USD

Note: Data cover the "business sector" defined in the AMNE database as International Standard Industrial Classification sections B to S excluding O.
Source: OECD AMNE Database (http://oe.cd/amne). MNE inward & outward activity by country of location.

93. With the exception of Germany, inward R&D expenditures are greater than their outward counterparts; Japan, Israel, and the United States appear to attract more MNE R&D spending than they create abroad. Outward R&D activity can still be considerable and is equivalent to 39% of domestic business R&D expenditure in Sweden, 32% in Germany, 15% in the United States, 12% in Israel, 6% in Japan, and 2% in Slovenia.

94. In the case of the United States, figures show that USD 52bn of R&D is carried out by majority owned subsidiaries of US companies abroad versus USD 57bn of R&D by subsidiaries of foreign-owned MNEs in the United States.

95. Available US Bureau of Economic Analysis (BEA) statistics also make it possible to provide a geographic breakdown for the USD 52bn of R&D performed abroad by majority-owned subsidiaries of US companies. **Table 7** shows that Germany is a major location chosen by US companies to carry out R&D abroad, followed by the United Kingdom, Switzerland, Canada, and China. Comparing the US-reported data to BERD in the country of R&D performance, US-owned FCAs appear to be of particular importance in Israel (27%) and especially Ireland (94%).

Table 7. Business R&D performed by affiliates of US companies abroad, 2014

US and partner country data sources, Million USD (exchange rate)

Country of R&D performance	R&D performed by majority owned subsidiaries of US companies*	BERD performed by FCAs ultimately owned by US companies **
Total	52 174	
Germany	8 344	5 305#
United Kingdom	6 306	6 412
Switzerland	4 140	515#
Canada	3 418	3 593
China	3 036	
India	2 906	
Israel	2 695	
Japan	2 521	
Ireland	2 415	
France	2 395	2 363
Netherlands	1 226	
Brazil	1 221	
Australia	1 185	
Belgium	1 151	
Korea	946	
Italy	800	
Singapore	767	
Sweden	711	
Reporting source	United States	Partner country

Note: # Germany, Switzerland: 2015 data. The figures reporting on the right column are the exchange rate converted equivalent figures of those presented in Table 6 in USD PPPs.
Source: * US Bureau of Economic Analysis, Activities of US Multinational Enterprises: US Parent Companies and Their Foreign Affiliates: US MNE Activities: Preliminary 2014 Statistics (https://faq.bea.gov/international/xls/usdia2014p/Part%20II%20I1-I5.xls) **UK Office for National Statistics, Stifterverband Germany, Statistics Canada, Federal Statistical Office Switzerland.

96. The availability of R&D performance statistics from an outward perspective also opens up the opportunity for comparison with available counterpart inward reports as presented in the third column of **Table 7**. The gap between US-reported, outward estimates and inward estimates by the countries where R&D takes place is particularly pronounced in the case of US MNEs' R&D performance in Switzerland where the difference is an entire order of magnitude – Swiss-reported statistics record USD 515m of R&D performed by affiliates of US MNEs while more than USD 4bn is reported by US parents. This raises the question whether a material share of US-located parents are ultimately owned outside the United States. Differences are also pronounced for German owned firms.

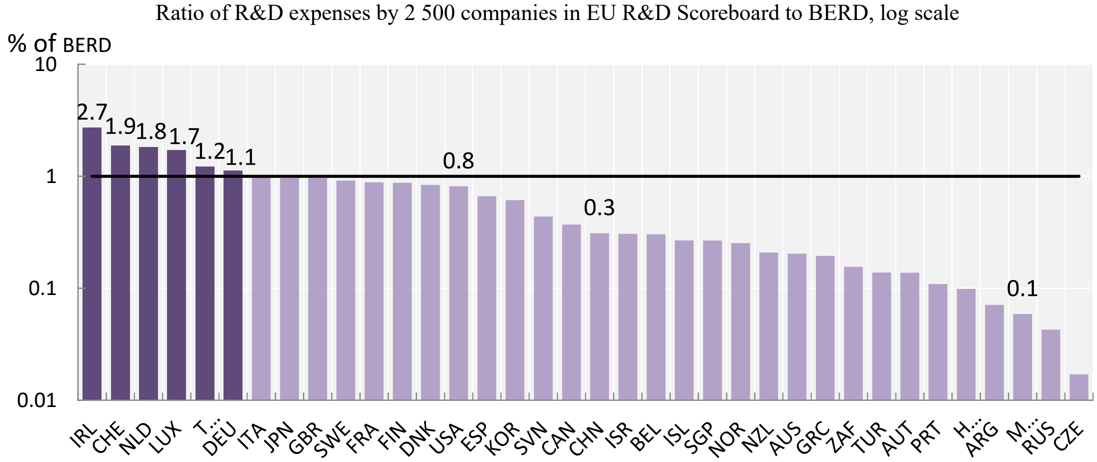
97. Statistics on "outward" R&D performance are rarely available - the authors are only aware of the US data being broken down by country - and as a result it is not possible to derive a more complete figure, limiting the scope for a full analysis of the net balance between outward and inward R&D performance within MNEs. Published company reports and accounts including details on R&D activities might in principle allow for a comparative exercise but these provide only limited and self-selected information which cannot be readily compared with official R&D statistics due to variations in R&D reporting requirements, consolidation practices, and the use of a different "net" approach from the intramural R&D concept in the Frascati Manual.

98. Nevertheless, with these limitations in mind, **Figure 16** compares the total R&D expenses reported by the 2 500 companies (consolidated to include all subsidiaries) with the greatest reported R&D expenses worldwide as presented in the EU R&D Scoreboard (EU Joint Research Centre, 2017) against national BERD. It shows that, in their business accounts, these business groups headquartered in Ireland, Switzerland, The Netherlands, and Luxembourg reported global R&D expenses significantly greater than the total Business R&D expenditure performed in those countries. Indeed, the total R&D reported by "Irish" companies was three times domestic BERD in Ireland. The opposite was true 10 years ago.

99. This finding is consistent with the foregoing analysis, which has found that Ireland and Switzerland are particularly integrated, alongside the US, in the international R&D production, trade, and ownership ecosystem. This is also true of the United Kingdom and Germany, in both of which the R&D reported by business groups ultimately owned in those countries is equal to domestic business expenditure on R&D.

Figure 16. R&D expenses reported by highest R&D reporting by headquarters country, 2015

Ratio of R&D expenses by 2 500 companies in EU R&D Scoreboard to BERD, log scale



Note: Data for IRL, RUS, SGP relate to 2014; AUS, ZAF to 2013.
Source: OECD Research and Development Statistics http://oe.cd/rds, February 2018, and 2017 EU Industrial R&D Investment Scoreboard. http://iri.jrc.ec.europa.eu/scoreboard17.html

5.3. Identifying substantive R&D activity

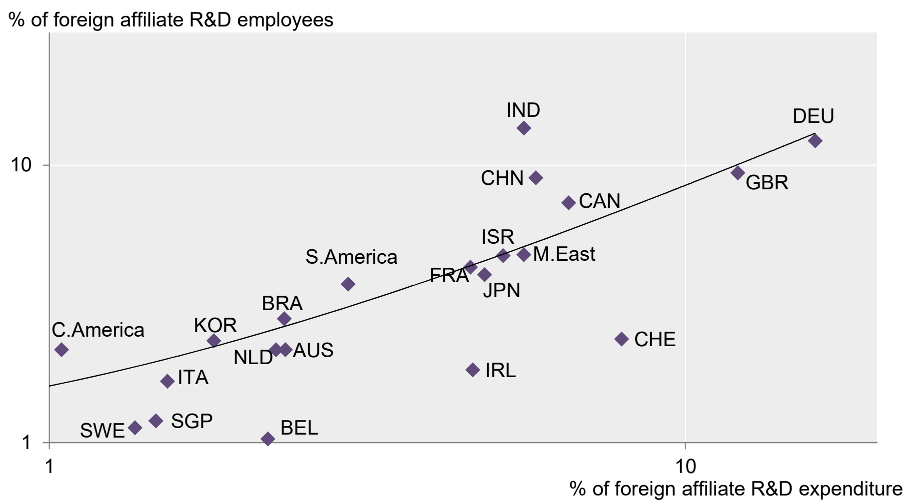
100. One conclusion from the previous sections is the difficulty in integrating expenditures reported under different frameworks. The concept of expenditure associated with R&D performance aims to identify the cost of substantive R&D activity within statistical units and economies, but this requires engaging companies in a process to separate out elements that incorporate R&D carried out elsewhere and vice versa in order to avoid double counting. Where this translation is not explicit, it is particularly difficult to assure that it is R&D *performance* and not another concept that is being captured because companies are more likely to refer to what is readily available in their accounts.

101. One mechanism for assessing the potential misalignment between reported R&D expenditures and substantive activity is to examine the link with other indicators of resources used for R&D activity. Human resources devoted to R&D are an ideal candidate because they account for a bulk of R&D expenditures across most industries and are more easily attributable to a particular location.

102. **Figure 17** compares different locations' shares in the total R&D personnel and expenditures of US majority-owned affiliates abroad using BEA data for MNEs. The results, presented on a log scale, indicate a close proportional relationship between the two measures of resources (financial and human) devoted to R&D. Some outliers may be explained by differences in wage rates (e.g. India and China's relatively high share of human resources to expenditures) and possibly also sector composition. A more in depth analysis should take these into consideration. It is also worth noting that Switzerland, Ireland, and to a lesser extent Belgium, have relatively low R&D employment levels in comparison to the amounts of R&D expenditures reported. This suggests that such R&D expenditures may include payments for R&D carried out elsewhere, including the US.

Figure 17. US majority-owned foreign affiliates R&D expenditure and personnel, 2014

Shares of economy over total affiliate values, log scale



Source: US Bureau of Economic Analysis, Activities of US Multinational Enterprises: US Parent Companies and Their Foreign Affiliates: US MNE Activities: Preliminary 2014 Statistics (https://faq.bea.gov/international/xls/usdia2014p/Part%20II%20I1-I5.xls).

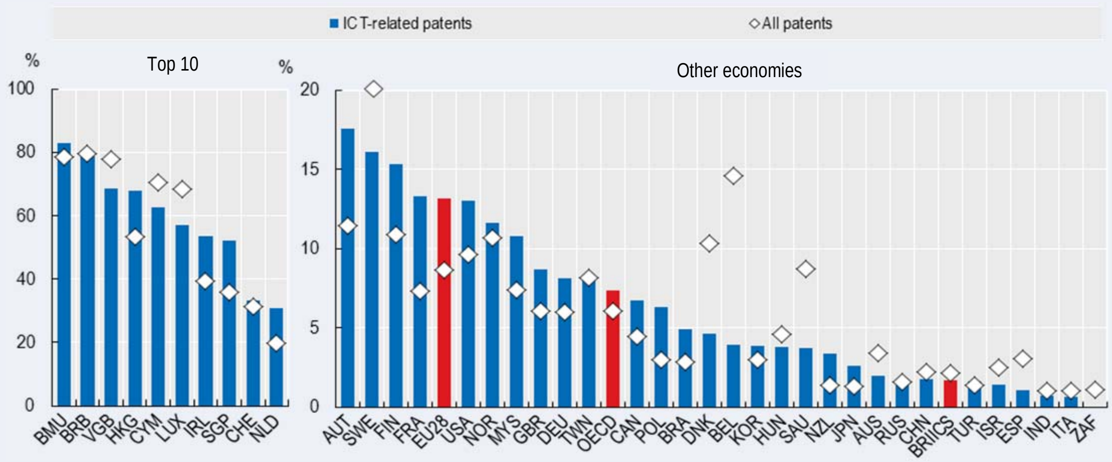
103. Another important message is that tracking transactions may not suffice to achieve the various intended uses of R&D globalisation data. Additional measurement sources and instruments may need to be deployed in order to assess where R&D assets are being used (see **Box 2**).

Box 2. Patent statistics and R&D globalisation

Patent statistics are based on administrative data and provide a rich source of evidence on R&D globalisation (OECD, 2009b); (OECD, 2010b). They contain information among other things on the registered ownership of patented inventions - i.e. to whom the patent is assigned. Patent data can be combined with company data to establish the characteristics of the registered "assignees", i.e. their "owners", which may be individuals or legal entities, as well as the entities that own the latter. Due to registration conventions, patent data also record information on the identity and characteristics of inventors, the individuals who are credited with developing the patented invention. The comparison between the location of inventors and ownership provides a useful source of evidence on the extent of R&D-related globalisation for R&D activities more likely to be subject to

this type of IP protection, as shown in the figure below.

Domestic-owned patents invented abroad
As a percentage of economies' owned total IP5 patent families



Note: Foreign inventions owned by an economy relate to the number of IP5 patent families owned by a resident of an economy for which none of the inventors reside in that economy, presented as a share of total IP5 patent families owned by that economy. Data refer to IP5 families, by filing date, according to applicant residence using fractional counts. *Source*: OECD, Science, Technology and Industry Scoreboard 2017, based on STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, June 2017. http://dx.doi.org/10.1787/888933619049

Patent administrative data can also leave a trace of ownership changes over time. Registering ownership with IP offices is generally not compulsory and can be costly, but owners have incentives to register such changes in order to assert their IPRs relative to third parties (OECD, 2013). Such data have been used for example to track patent relocation in response to policy incentives in the form of regimes that provide a favourable treatment of incomes arising from IPRs. For example, Ciaramella (Patent Boxes and the Relocation of Intellectual Property, 2017) shows that Ireland witnessed the highest ratio among EU countries of EPO (European Patent Office) patents gained to lost (5 times), followed by Luxembourg, Malta and Portugal. These data can be in principle compared with trade on *proprietary rights arising from R&D.*

6. Conclusions

104. This paper has investigated available statistical evidence for OECD countries on the extent and nature of R&D globalisation based on three inter-related domains: services trade, MNE activities, and R&D performance. It has made extensive use of US data owing to the greater availability and detail for this country but it has also used a wide range of OECD and national sources to provide a complementary picture for other countries and their mutual linkages whenever possible.

105. On this basis, this paper has presented what appears to be the first broad-ranging view on R&D globalisation measurement based on new or recently updated international statistics manuals across the three statistical domains. Once fully implemented across

countries, updated guidance may inform a better understanding of the role of R&D funding, performance, exchange, and use decisions in global production and innovation networks.

106. The concept of economic ownership of R&D assets across international boundaries plays a central role in making sense of the data. MNE activities represent the largest share of international R&D transactions, either trade-based or funding-related.

107. Official statistics at the level of MNE groups as a whole (business ownership-based frameworks) might often better reflect the true economic owner of R&D assets. For example, undertaking productivity analysis requires allocating inputs and outputs, including R&D, across the units to whom it delivers capital services in production.

108. Based on the evidence examined in this paper, it is possible to conclude with a number of recommendations for future statistical efforts:

- Various relevant data sources exist but variations in their conceptual frameworks and perspectives need understanding and bridging. Therefore triangulation across different sources can shed useful insights. It is also important to understand what records companies have access to and base their responses upon when completing statistical survey questionnaires.
- It appears increasingly important to consider and understand the role of exchanges between affiliated companies. Cases of direct parent/subsidiary relationships, as have been a main focus in this paper, are a first step though other forms of relationship such affiliated enterprises related between a mutual parent (i.e. sister companies) also need to be captured in data sources in order to achieve a comprehensive and consistent statistical representation of the world.
- Within countries, coordinating or benchmarking data collection on MNEs, as well as data linking across different statistical domains may facilitate policymaking and research on intangibles and knowledge as business assets.
- Analysis of microdata can help provide a more detailed understanding of the dynamics and compositional patterns associated to R&D globalisation. For example, it appears from ongoing OECD distributed R&D microdata work (http://oe.cd/microberd) that in spite of increasing concentration of economic activity on large players, R&D performance itself is becoming less concentrated within countries, pointing at a potential growing decoupling of R&D performance and use.
- Greater coordination across countries' statistical offices could help ensure a more robust and comprehensive view of R&D globalisation. New tools and standards may allow for this to take place without breaching confidentiality.
- Administrative data on intangibles have yet to be integrated in the analysis of R&D and innovation globalisation.
- The analysis of R&D globalisation needs to be better integrated in the broader analysis of global innovation networks. This is a major area for dedicated innovation surveys to attempt to develop further, including within the ongoing revision of the Oslo Manual innovation measurement framework (OECD, Eurostat, 2005).

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