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OECD TAXONOMY OF ECONOMIC ACTIVITIES BASED ON R&D INTENSITY

Fernando Galindo-Rueda, Fabien Verger

ABSTRACT

This paper provides a new taxonomy of industries according to their level of R&D intensity - the ratio of R&D to value added within an industry. Manufacturing and non-manufacturing activities are clustered into 5 groups (high, medium-high, medium, medium-low, and low R&D intensity industries), drawing on new and expanded evidence from most OECD countries and some partner economies. This paper also reports on differences in R&D intensity within industries across countries.

This document represents an update and reframing of previous OECD taxonomies that were based on earlier versions of the International Standard Industrial Classification (ISIC). One special feature of this new taxonomy in ISIC Rev.4 is the inclusion of non-manufacturing industries, especially services, whose coverage has improved in the R&D tables collected under the latest ISIC nomenclature and published in the OECD ANBERD database (www.oecd.org/sti/anberd). While most services display a low R&D intensity, *information and communication services* and the *professional, scientific and technical activities* emerge as R&D intensive industries. Alternative measures have been used to test the robustness of the proposed taxonomy. The groupings appear relatively stable while heterogeneity across countries is shown to be significant, indicating the potential for countries to raise their R&D intensity within industries.

This taxonomy is intended to support the pooled presentation of various statistics for groups of industries when R&D is deemed to be a relevant discriminant factor across a number of countries. Within a particular country, a given industry can be more or less R&D intensive that for the aggregate reported here. Users should also bear in mind that R&D intensity may be a rather imperfect indicator of other concepts such as reliance on/use of highly educated personnel, advanced technology or wider forms of knowledge based capital.

This taxonomy may be expanded on in the future as evidence collected under the guidelines of the revised Frascati Manual 2015 enables a more accurate assessment of R&D performance and use within and across industries.

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OECD TAXONOMY OF ECONOMIC ACTIVITIES BASED ON R&D INTENSITY

1. Background and objectives

This study provides a new taxonomy of economic activities according to their average level of R&D intensity. This proposed new classification builds on previous OECD work and incorporates three main novelties:

- It explicitly focuses on a measure of R&D performance intensity as the defining criterion that is an indicative but insufficient measure of high technology, a concept that is no longer explicitly associated to this OECD classification.

- It extends the analysis of R&D intensity to economic activities in services.

- It is based on the latest revision of the International Standard Industrial Classification, ISIC Revision 4.

The OECD has drawn in the past a series of technology-themed classifications of economic activities. Such classifications, based on ISIC Rev.2 and ISIC Rev.3, respectively, defined four broad groups of manufacturing industries: high, medium-high, medium-low and low technology. In the seminal study by Hatzichronoglou (1997), the technology classification was created by clustering industries based on a measure of internal R&D intensity combined with estimates of R&D indirectly acquired through purchases of both domestic and imported intermediate inputs and capital goods. OECD (2003) provided an update based solely on R&D intensity, but the classification continued to be referred to as a technology classification. The application of this classification is quite widespread across OECD countries, as it provides a convenient way to summarise the presentation of a number of industrial statistics.

As noted in the OECD Innovation Strategy (OECD, 2010) and its recent update (OECD, 2015a), and echoing a wide body of literature, innovation is a much broader concept than R&D and not all firms that are successful at developing or implementing innovation are necessarily R&D performers. Many of these firms are successful adopters of technology which they have not developed. Measuring R&D intensity or embedded R&D in their purchases may not effectively characterise the innovative performance of firms or industries. Subsequent OECD work on measuring skill intensity, patenting activities and innovation by industries has provided a series of complementary indicators that facilitate a more refined description of the overall knowledge intensity in different economic activities, although these measures are not always widely available across a majority of OECD countries and partner economies. Recent work on a methodological framework for statistics on the development, application and impact of technologies cautions about the inappropriate use of the term “technology” and its confinement to R&D performance.

For this reason, the focus of the proposed taxonomy is solely and explicitly on a measure of R&D intensity. While our aim is not to develop a broader taxonomy, this provides a first step towards that objective, which could be attained once relevant measures of skilled labour force, patents, innovation expenditures, knowledge-based capital are developed at the industry level for a sufficiently wide number of countries. Consequently, the proposed clustering should not be interpreted or referred to as a knowledge-

or technology-intensity taxonomy, especially in service industries where R&D expenditure is a less appropriate predictor of technology use, knowledge generation or innovation in general.

This new classification extends previous work by covering not only manufacturing but also non-manufacturing industries, namely agriculture, mining, utilities, construction and a broad range of services. R&D in these industries can also have a particular significance, even if, in many cases, it may appear to play a less important role than in manufacturing. The measurement of R&D in services does indeed pose a number of methodological challenges, which have been the subject of a dedicated OECD project[1] and have been considered throughout the latest revision of the OECD Frascati Manual (OECD, 2015b) following the improvements introduced in its previous edition (OECD, 2002). In the past, OECD classifications omitted non-manufacturing sectors due to data limitations that have now been greatly diminished as a result of the adoption of the ISIC Rev. 4, which facilitated the in-depth analysis of service industries. Our latest analysis is also enabled by the additional effort of statistical authorities in recent years to ensure an exhaustive coverage of R&D performance across all business sectors in the economy.

The proposed taxonomy includes five groups differentiated according to their level of R&D intensity: high, medium-high, medium, medium-low, and low. For manufacturing industries, the results are very similar to previous classifications based on ISIC Rev.3 and a transitional adaptation implemented by Eurostat in NACE Rev.2.[2] This document reports on the robustness of this classification to different measurement approaches and notes the extent to which R&D intensity varies within industries across countries. This is a major feature that users should take into account when considering the application and the interpretation of statistics based on this proposed taxonomy.

The remainder of this report is structured as follows. Section 2 presents the basic concepts and measurement challenges related to R&D intensity. Section 3 describes the data sources and the level of industry detail. Section 4 presents the proposed classification and a number of robustness checks. Section 5 provides some concluding remarks.

2. The concept and measurement of R&D intensity

R&D intensity

R&D intensity is usually defined as the ratio of R&D expenditure to an output measure, usually gross value added (GVA) or gross output (GO) (OECD, 2015). This indicator is commonly used at the level of an economy to measure its relative R&D effort (GERD over GDP) or its business sector (BERD over GDP or a more closely aligned measure of GVA for the business sector). In this study, R&D intensity serves as the criterion for ranking and classifying economic activities.

Industries and economic activities

A representative indicator of R&D intensity has been calculated for each industry. The concept of industry or economic activity is used here indistinctively, referring to the set of statistical units in the business sector that are allocated to the same ISIC code. The generally recommended statistical unit for compiling production account data by industry is the establishment, i.e. an enterprise or part of an enterprise that is situated in a single location and in which only a single (or a dominant) productive activity is carried out (EC et al, 2009). For R&D data aggregated by industry, the recommended statistical unit is the enterprise. These differences concerning the statistical units used for reporting R&D and GVA may cause biases in R&D intensity measures.

Furthermore, the R&D performed by an enterprise is, in principle, allocated to its main activity. However, there are different national practices concerning the treatment of large and complex multi-activity enterprises (broken down by sub-activity or not) and those firms specialised in providing R&D

services (broken down by industry served or not). As a result, the criterion (employment, GVA or also R&D) or line of questioning used to define what represents the main activity of the R&D-performing enterprise may differ from that used in the context of economic statistics, especially when data sources are not integrated. This divergence may be further accentuated by efforts to collect policy-relevant data on the basis of the intended application of the R&D, which may differ from the dominant lines of activity within the enterprise. When such data are collected, the R&D is allocated to the industry to which the R&D is oriented, according to the nature or the final use of the R&D outcome. The OECD Frascati Manual of 2015 includes recommendations on separately collecting both types of information and avoiding, whenever possible, hybrid approaches that mix the two.[3]

Output and R&D data used in this study are respectively compiled according to the System of National Accounts (SNA) (EC et al., 2009) and the OECD Frascati manual. An important change between the SNA 2008 and the previous version (SNA 1993) concerns the capitalisation of R&D expenditure, which boosts the measure of value added among industries that invest in R&D. As a result, value-added data from the latest SNA version are systematically higher, especially in the more R&D intensive industries. All the ratios standardised by value added (especially R&D intensity) are impacted. In this study, in order to maintain the previous interpretation of the indicator among users, the output data are based on data compiled and reported under the SNA 1993, except for Australia which was an early adopter of SNA2008. Nevertheless, robustness checks have been conducted, using data compiled according to the SNA 2008 instead of 1993.

Calculation of R&D intensity

R&D intensity is calculated as the industry's business R&D expenditure divided by gross value added (GVA). Gross output is employed as an alternative denominator for comparison purposes. In this study, GVA is preferred for a number of reasons. Firstly, the coverage for GVA data is better than for gross output. Secondly, GVA is less sensitive to sector specific reliance on material inputs like raw goods. The proportion of intermediate inputs needed in the production process varies across industries and largely depends on intrinsic industry characteristics. For example, in the *coke and refined petroleum industry* (ISIC 19), intermediate consumption offsets 87%[4] of the gross output because of the crude oil inputs bought from the mining and quarrying industry. Intermediates over gross output ratios are heterogeneous across industries, from 35% for the *real estate sector (excluding ownership of dwellings)* to 87% for the *coke and refined petroleum industry*. The variation is also significant between manufacturing and non-manufacturing industries (73% and 42% respectively). Unlike GVA, gross output measures lead to double counting the production of goods that are reintegrated within the same industry as intermediates and, in addition, are impacted more by changes in firm structures (e.g. mergers and break-ups). However, there are some potential caveats. Gross output has the advantage of being less responsive to outsourcing, contrary to the GVA which varies depending on whether jobs or, for example, the performance of R&D for the firm are externalised or not. But considering all the previous reasons, GVA is primarily used to normalise measures of R&D performance.

R&D is directly performed by industries but is also indirectly incorporated in both their purchased intermediates and capital goods. Indirect R&D measures intend to capture the diffusion of outputs' R&D content. The common way of estimating R&D flows between industries is to build indicators based on global input-output tables. Nevertheless, the limited availability of input-output tables in ISIC Rev.4 (and the absence of industry-by-industry investment flow matrices) did not allow for calculating such indirect R&D measures.

Industry-based R&D intensities are calculated as a weighted average of countries' R&D intensities, using value added in purchasing power parities (PPP) terms as weights in order to combine national figures into a representative total. The median across economies is also used in addition to the weighted average to

test the consistency of the results. We prefer the use of the weighted mean as it eliminates the global value chains bias, i.e. the fact that the R&D and the production can be undertaken in different countries.

3. Data

Data sources

For OECD countries, output data mainly come from the OECD's STructural ANalysis (STAN) Database.[5] STAN provides annual series on gross output components, capital, employment and trade flows by economic activity. It is primarily based on National Accounts by industry while complementary sources such as Business Statistics are used for estimating detailed activities. The internal OECD version of STAN, covering more countries than the online dataset, is the main source for gross output and GVA data. Complementary sources were used when necessary: for European countries, missing data in STAN were estimated using Eurostat's structural business statistics when possible. For non-European economies, additional sources were also used to fill gaps: the ABS's "Australian Industry 2012-13" for Australia, the METI's Census of Manufactures for Japan, the OECD's Structural Business Statistics for Korea and Mexico, and the US Census Bureau's Annual Survey of Manufactures as well as the BEA's GDP-by-industry detailed accounts for the United States. Data for Chinese Taipei are derived from the National Accounts and census data from the Statistical Bureau. For Singapore, Input-Output tables from the national Department of Statistics were used.

For the business R&D data (BERD) by industry, the Analytical Business Enterprise Research and Development (ANBERD) database[6] is employed. ANBERD belongs to the OECD's STAN family databases and presents estimated annual BERD data by industry in ISIC Rev.4. It is mainly based on official data submissions to the OECD[7]. It also includes estimates complementing or substituting official numbers in order to improve the international comparability and the coverage of BERD time series. For Greece, R&D data come from the OECD's Research and Development (RDS) database.

Personnel data are also used for the purpose of comparison with results based on R&D expenditure. Data on R&D personnel and employment by industry come from the RDS and STAN databases respectively. Structural Business Statistics serve as a complementary source for estimating detailed industries not covered in STAN.

Industry level of disaggregation

The industry list used in this study is based on the International Standard Industrial Classification (ISIC) Revision 4. The industry level of disaggregation depends on the availability of both value added and R&D data. In some cases, 2-digit industries were grouped together and only the higher category was considered. This occurred when the coverage was unsatisfactory at the 2-digit level or when *ad-hoc* calculations on restricted data samples suggested that industries could be aggregated given their homogeneity in terms of R&D intensity. For instance, ISIC 10, 11 and 12 (food, beverages and tobacco respectively) were not individually selected. Instead, only the higher category ISIC 10 to 12 was used, for which data are well covered. When intra-industry variance was presupposed within 2-digit activities or was established in earlier works, sub-industries at the 3-digit level were included in the final list.

A total of 27 OECD countries[8] and 2 partner economies (Singapore and Chinese Taipei) covered in the OECD R&D database are included in the sample. Information on economy and industry coverage is available in **Annex 1**. The taxonomy is based on data for 2011, the latest year for which both output data compiled according to the SNA 1993 and BERD data by industry are sufficiently well covered. For Singapore, data correspond to 2010. Furthermore, ISIC 84 to 88 (*public administration and defence; compulsory social security; education; human health; residential care and social work activities*) are

excluded because most of the R&D in these industries is carried out by sectors other than the business enterprises (namely government and higher education). Finally, the *imputed rent of owner-occupied dwellings* was removed for measuring the output level of the *real estate activities* (ISIC 68), as this National Accounts' specific imputation has no counterpart in terms of R&D.

The choice of 2011 as the reference year is largely determined by the narrow window of opportunity provided by the combination of ISIC Rev.4 data for R&D and value added, combined with value added data on the basis of SNA 1993. More timely information cannot be used without incurring a substantial loss of country coverage, given the above requirements. We have undertaken some analysis to ensure that results are not driven by specific economic circumstances for that particular year. By 2011, business R&D appeared to have recovered in most economies relative to low levels experienced during the worst of the global financial crisis.

4. Results

Proposed classification

Industries have been classified in **Table 1** into five groups (high, medium-high, medium, medium-low, and low). All manufacturing industries can be found in the high and medium categories, while non-manufacturing industries are more widely scattered, from high to low R&D intensity. Within the group of the most R&D intensive industries, we find *air and spacecraft* (ISIC 303), *scientific research and development* (ISIC 72), *software publishing* (ISIC 582), *pharmaceuticals* (ISIC 21) and *computer, electronic and optical products* (ISIC 26). Two service industries thus occupy the highest position, alongside three manufacturing industries which were previously characterised as highly R&D intensive.

This new classification provides, for the first time, a more detailed appreciation of the R&D intensity in a number of non-manufacturing industries. While most are classified as low R&D intensity, industries within the *information and communication services*, the *professional, scientific and technical activities*, *publishing* as well as *mining and quarrying* feature in the higher four categories.

Identifying the cut-off points for distinguishing between groupings does not pose particular challenges. One potential exception is the delimitation between the medium and the medium-low R&D intensity industries, where there is a fairly small distance between the extremes. The frontier remains blurred when considering other criteria (see **Table 2**). ISIC 13, 14, 15, 23, 24, 33 and 69-75X could be alternatively classified in either class depending on the selected criterion. Within the medium-high group, there are two industries that are particularly distinct from and above the rest, namely *weapons manufacturing* and *motor vehicles*.

A more aggregated version of the taxonomy is provided in **Annex 2** in order to facilitate its application in the context of reporting on more aggregated industry-based databases. Thus, as for the 3-digit activities of the taxonomy, higher-level industries of the ISIC hierarchy are also categorised to one of the five classes according to their R&D intensity: *fabricated metal products, except machinery and equipment* (ISIC 25) is attributed to the medium-low group, *other transport equipment* (ISIC 30) to the medium-high group, *other manufacturing* (ISIC 32) to the medium group – or, if ISIC 31 and 32 are not separately available as in the SNA A*64 list, *furniture and other manufacturing* (ISIC 31 to 32) to the medium group - and *publishing activities* (ISIC 58) to the medium-high group.

Table 1. Proposed classification of economic activity into five major groups

	Manufacturing	R&D as % of GVA[2]	Non-manufacturing	R&D as % of GVA[2]
High R&D intensity industries	303[1]: Air and spacecraft and related machinery	31.69	72: Scientific research and development	30.39
	21: Pharmaceuticals	27.98	582[1]: Software publishing	28.94
	26: Computer, electronic and optical products	24.05		
Medium-high R&D intensity industries	252[1]: Weapons and ammunition	18.87	62-63: IT and other information services	5.92
	29: Motor vehicles, trailers and semi-trailers	15.36		
	325[1]: Medical and dental instruments	9.29		
	28: Machinery and equipment n.e.c.	7.89		
	20: Chemicals and chemical products	6.52		
	27: Electrical equipment	6.22		
	30X[1]: Railroad, military vehicles and transport n.e.c. (ISIC 302, 304 and 309)	5.72		
Medium R&D intensity industries	22: Rubber and plastic products	3.58		
	301[1]: Building of ships and boats	2.99		
	32X[1]: Other manufacturing except medical and dental instruments (ISIC 32 less 325)	2.85		
	23: Other non-metallic mineral products	2.24		
	24: Basic metals	2.07		
	33: Repair and installation of machinery and equipment	1.93		
Medium-low R&D intensity industries	13: Textiles	1.73	69-75X: Professional, scientific and technical activities except scientific R&D (ISIC 69 to 75 less 72)	1.76
	15: Leather and related products	1.65	61: Telecommunications	1.45
	17: Paper and paper products	1.58	05-09: Mining and quarrying	0.80
	10-12: Food products, beverages and tobacco	1.44	581[1]: Publishing of books and periodicals	0.57
	14: Wearing apparel	1.40		
	25X[1]: Fabricated metal products except weapons and ammunition (ISIC 25 less 252)	1.19		
	19: Coke and refined petroleum products	1.17		
	31: Furniture	1.17		
	16: Wood and products of wood and cork	0.70		
	18: Printing and reproduction of recorded media	0.67		
Low R&D intensity industries			64-66: Financial and insurance activities	0.38
			35-39: Electricity, gas and water supply, waste management and remediation	0.35
			59-60: Audiovisual and broadcasting activities	0.32
			45-47: Wholesale and retail trade	0.28
			01-03: Agriculture, forestry and fishing	0.27
			41-43: Construction	0.21
			77-82: Administrative and support service activities	0.18
			90-99: Arts, entertainment, repair of household goods and other services	0.11
			49-53: Transportation and storage	0.08
			55-56: Accommodation and food service activities	0.02
			68: Real estate activities	0.01

1. *Higher-level industries of the ISIC hierarchy are also classified and the classification is performed at the 2-digit level. See* ***Annex 2****.*
2. *The classification is based on aggregated R&D intensities. Value added and R&D of the 29 economies of the sample are aggregated using purchasing power parities. As some data are missing, ratios are precisely calculated as the average of countries' intensities weighted by their GVA in PPP:* $\left(\frac{R\&D}{GVA}\right)_i = \frac{\sum_c R\&D_{ci}}{\sum_c GVA_{ci}} = \sum_c \frac{R\&D_{ci}}{GVA_{ci}} \frac{GVA_{ci}}{\sum_c GVA_{ci}}$*, where* $R\&D_{ci}$ *and* VA_{ci} *are respectively the R&D and the value added of industry i in country c measured in US PPP dollars.*

Robustness checks

Country coverage

The proposed taxonomy is sensitive to the choice of the group of economies for analysis. The results show the industrial R&D performance among all economies of the entire sample for which data are available. But there can be significant heterogeneity across economies in terms of the absolute and relative R&D intensity of specific industries, reflecting what role an economy's industry plays in the global context. For instance, the R&D intensity in the automobile industry is 16.4% when considering the motor vehicle producing economies (11 countries accounting for 90% of the sample total value added in this sector) and only 6.6% for the remaining economies. The taxonomy would slightly change if we were to remove some countries or economies from the sample. The demarcation of certain groups can, in a few cases, depend on the contribution of single country.[9]

Median vs mean

One mechanism for testing the impact of heterogeneity in R&D intensity is to look at the difference between the mean of R&D intensities and the median. **Table 2** shows a significant degree of consistency, with a rank correlation of 97.2% among the two measures. The results underline the difficult partitioning between the medium-low and medium R&D intensity industries, but the most significant difference concerns *software publishing* (ISIC 582). The median suggests that it should be allocated to the medium-high cluster and not to the highest. It is explained by the predominance of the United States in this industry: among the 12 countries having both value added and R&D data for *software publishing* (ISIC 582), the U.S. GVA in this industry represents 77% of the total sample and the U.S. R&D intensity reaches 35%, the second highest ratio.

Most differences appear to be driven by genuine heterogeneity in R&D intensity across countries within a given industry (see **Annex 3**). However, potential individual challenges may arise in the context of industries in which the mapping across different national classifications may not be straightforward, for example in the case of generic software design and programming where NAICS and ISIC may not entirely fully align. This may boost R&D intensity in software publishing in some countries relative to IT and information services.

Unfortunately, it is not possible to construct measures of R&D intensity at a detailed industry level for a number of major OECD partner economies. Ideally, these R&D intensity measures should be constructed on a global basis in order to ensure that entire industry value chains are captured. There is a risk that for some industries, their measured R&D intensity may be under- or over-stating the true global picture as a result of missing economies like Brazil, India or the People's Republic of China (hereafter "China"), whose share in the global industry's value added and R&D may differ according to specialisation or other factors. These shares have been rapidly shifting but it is unclear what the overall impact may be on the R&D intensity of industries outside the scope of our study.

In the case of China, partial data[10] were included in the sample and the impact on the taxonomy is presented in **Annex 6**, providing an additional robustness check. As many rough estimates had to be made, and because the industry coverage was low, China was not included in the core sample of economies. China's total R&D-to-GVA ratio is below the OECD average in 2011; including data for China would decrease the average intensity in more than two thirds of industries. *computer, electronic and optical products* (ISIC 26), *transport equipment* (ISIC 29-30) and *chemicals and pharmaceuticals* (ISIC 20-21) would be particularly affected since China represents an important share of global GVA in these sectors whereas the corresponding R&D intensities are well below the sample average. Some sectors would be positively impacted though - namely *electrical equipment* (ISIC 27), *textiles* (ISIC 13), *electricity, gas and*

water supply, waste management and remediation (ISIC 35-39), *construction* (ISIC 41-43), *metals and metal products, except machinery and equipment* (ISIC 24-25), *paper, paper products, printing and reproduction of recorded media* (17-18) - in particular ISIC 24-25 and 27 where Chinese R&D expenditures exceed those cumulated by all the other economies of the sample. Regarding the impacts on the actual classification, the inclusion of China could raise *textile* (ISIC 13) from medium-low to medium and could downgrade *computer, electronic and optical products* (ISIC 26) and *other non-metallic mineral products* (ISIC 23). Nevertheless, more recent data would probably offset this latter effect given that China has partially reduced the R&D intensity gap with the OECD zone since 2011. These comparisons raise a number of possible questions about the nature of economic and R&D globalisation in some sectors, as well as on data issues such as data comparability and the relevance of basing the assessment of R&D intensity on intramural R&D within the sector. It may be the case that different economies rely to a different extent on R&D from sources outside the industries.

Time coverage

The robustness of the taxonomy over time cannot be completely verified as it is not possible to create a balanced sample across years. Although historical data are available in the National Accounts as National offices produce back-calculations when new industrial classifications are adopted, this is not generally the case for R&D data. The ANBERD database partially overcomes this problem by providing historical estimates, however, all countries and industries cannot be reliably extrapolated backwards drawing on the ISIC Rev.3 data, especially for services which are also known to have increased their R&D intensity over time. The problem is similar for detailed output data estimated with Structural business statistics. Consequently, robustness tests could not be performed over a long period of time, nor over a short period because of the data volatility induced by the economic crisis. Nonetheless, as shown in **Annex 5**, the comparison with the previous taxonomy based on 1999 data in ISIC Rev.3 demonstrates a relative stability of the rankings over time for manufacturing industries.

However, as noted earlier, it is not possible at present to fully test whether the rise in absolute levels of R&D intensity in some industries in the OECD area has been associated to a fall in their share of global value added.

Gross output vs value added

The proposed taxonomy is stable when considering the gross output (GO) as the denominator except for distinguishing between the medium and medium-low groups as mentioned above and except for the *coke and refined petroleum products* (ISIC 19). The R&D intensity in this industry decreases to the very low group when calculated in terms of GO. This is due to the share of intermediates which reaches 87% of GO, the highest rate across all ISIC industries. Note also that the coverage is slightly lower than using GVA as no GO data are available for Australia, Ireland and Japan. As a result, for instance, the R&D intensity in the *automobile industry* (ISIC 29) would be much higher if Japan was in the sample (as is the case for value-added-based ratios).

Industry orientation vs main activity

Another robustness test involved replacing main activity with industry-orientation/product field data. The substitution was only possible for seven countries that had both measures covered in ANBERD (Belgium, Czech Republic, Finland, France, the United Kingdom, Italy and Portugal) and differences would have been more pronounced if product field series had been available for more economies. Nevertheless, predictable differences are already noticeable: due to their specific nature (industries serving other activities), *scientific research and development industry* (ISIC 72) and *repair and installation of machinery and equipment* (ISIC 33) drop by one group. It would not be accurate to rely on product field

data to classify ISIC 72 as this industry is, by definition, highly R&D intensive. Concerning ISIC 33, it again highlights the unclear cut-off point between medium and medium-low groups. It is finally worth mentioning that *pharmaceuticals* (ISIC 21) is the most positively impacted industry when considering product field, which means that R&D services produced by firms in ISIC 72 are particularly oriented towards this industry. One challenge we cannot account for at present is the extent to which the reported R&D-using industry is actually located in a different country.

Gross value added compiled according to the SNA 2008 vs SNA 1993[11]

Using GVA compiled according to the new SNA 2008 does not modify the groupings. R&D intensities are impacted downwards, owing to the capitalisation of R&D. The more intensive the industries, the more impacted they are by the adoption of the new standard: R&D intensities drop by 20% on average in the highest group, by 6% in the medium-high group, by 3% in the medium and medium-low and 1% in the low group. Overall, total BERD intensity decreases from 1.75% to 1.70%. In a few cases the statistical benchmark revisions offset the impact of changeover to the SNA 2008, making R&D intensities increase (for instance in ISIC 325).

Adjusting for multiple factors

The last column in **Table 2** reports on the estimated coefficients from a regression that seeks to isolate a common industry-specific R&D intensity effect by separating the impact on measured R&D intensity of different country-level effects. This includes practices concerning the breakdown of R&D services into using sectors. Gamma coefficients estimated from the following regression: $RDI_{cj} = \alpha + \beta_c + \gamma_j + \delta\, 1_{c \in C, j=72} + \varepsilon_{cj}$, where RDI is the R&D intensity (using GVA) of industry j in country c and C consists of countries for which independent R&D firms or R&D firms part of an enterprise group have been, entirely or partially, apportioned into the industry served. The resulting coefficient has a rank Spearman correlation with the baseline measure of 95.3%.

Expenditure vs personnel-based measures of R&D intensity

We further tested the robustness of our results by comparing our key reference measure based on expenditures normalised by GVA with a measure of R&D personnel by industry, normalised by total employment. This measure, although available for a smaller set of countries, reduces the risk that estimates may be distorted by one-off episodes of capital investment for R&D. The results, reported in **Annex 4**, indicate a significant elasticity between the two measures of more than 90%. We also find that country industries that have higher than average expenditure-based R&D intensity (relative to the industry and country norm) also tend to have higher than average R&D personnel-based intensity, with a statistically significant elasticity of 87%.

Table 2. Cluster robustness using alternative criteria

		Baseline: R&D over GVA, weighted mean[1]	Median instead of mean[2]	Gross output instead of GVA[3]	Partial Inclusion of Product Field data[4]	GVA compiled according to SNA 2008 instead of SNA 1993[5]	Estimated industry R&D intensity coefficients[6]
High R&D intensity industries	303: Air and spacecraft and related machinery	**31.69**	20.26	10.76	32.38	26.01	0.256
	72: Scientific research and development	**30.39**	25.08	15.72	13.88	18.97	0.279
	582: Software publishing	**28.94**	8.21	13.02	29.42	25.39	0.226
	21: Pharmaceuticals	**27.98**	13.57	12.81	31.67	23.24	0.221
	26: Computer, electronic and optical products	**24.05**	19.92	7.31	24.30	20.81	0.183
Medium-high R&D intensity industries	252: Weapons and ammunition	**18.87**	11.53	6.55	19.79	18.56	0.133
	29: Motor vehicles, trailers and semi-trailers	**15.36**	6.11	2.50	16.22	13.75	0.092
	325: Medical and dental instruments	**9.29**	4.31	4.83	9.59	9.47	0.033
	28: Machinery and equipment n.e.c.	**7.89**	4.85	2.42	7.90	7.54	0.016
	20: Chemicals and chemical products	**6.52**	3.54	1.27	6.90	5.67	0.005
	27: Electrical equipment	**6.22**	5.45	1.88	6.49	6.11	0.000
	62-63: IT and other information services	**5.92**	6.06	3.48	6.07	5.38	0.000
	30X: Railroad, military vehicles and transport n.e.c. (ISIC 302, 304 and 309)	**5.72**	6.72	1.63	5.86	5.06	0.005
Medium R&D intensity industries	22: Rubber and plastic products	**3.58**	2.28	0.94	3.67	3.56	-0.027
	301: Building of ships and boats	**2.99**	2.22	0.84	3.69	2.81	-0.029
	32X: Other manufacturing except medical and dental instruments (ISIC 32 less 325)	**2.85**	1.82	0.96	3.27	2.77	-0.025
	23: Other non-metallic mineral products	**2.24**	1.22	0.60	2.35	2.18	-0.038
	24: Basic metals	**2.07**	1.64	0.28	2.19	2.14	-0.043
	33: Repair and installation of machinery and equipment	**1.93**	1.23	0.75	1.34	1.78	-0.036
Medium-low R&D intensity industries	69-75X: Professional, scientific and technical activities except scientific R&D (ISIC 69 to 75 less 72)	**1.76**	1.50	0.94	1.16	1.63	-0.037
	13: Textiles	**1.73**	1.78	0.46	2.09	1.61	-0.034
	15: Leather and related products	**1.65**	1.04	0.43	1.76	1.64	-0.036
	17: Paper and paper products	**1.58**	0.95	0.44	1.62	1.60	-0.048
	61: Telecommunications	**1.45**	1.85	0.73	1.65	1.43	-0.045
	10T-12: Food products, beverages and tobacco	**1.44**	0.96	0.34	1.51	1.42	-0.048
	14: Wearing apparel	**1.40**	1.71	0.46	1.52	1.29	-0.042
	25X: Fabricated metal products except weapons and ammunition (ISIC 25 less 252)	**1.19**	1.39	0.41	1.23	1.20	-0.043
	19: Coke and refined petroleum products	**1.17**	0.99	0.16	1.28	1.20	-0.053
	31: Furniture	**1.17**	0.98	0.39	1.11	1.19	-0.047
	05-09: Mining and quarrying	**0.80**	0.55	0.36	0.84	0.73	-0.049
	16: Wood and products of wood and cork	**0.70**	0.70	0.19	0.75	0.71	-0.053
	18: Printing and reproduction of recorded media	**0.67**	0.50	0.21	0.67	0.68	-0.057
	581: Publishing of books and periodicals	**0.57**	0.36	0.24	0.66	0.48	-0.056
Low R&D intensity industries	64-66: Financial and insurance activities	**0.38**	0.30	0.16	0.37	0.41	-0.055
	35-39: Electricity, gas and water supply, waste management and remediation	**0.35**	0.29	0.14	0.39	0.36	-0.058
	59-60: Audiovisual and broadcasting activities	**0.32**	0.19	0.14	0.43	0.32	-0.050
	45-47: Wholesale and retail trade	**0.28**	0.37	0.16	0.21	0.28	-0.054
	01-03: Agriculture, forestry and fishing	**0.27**	0.12	0.13	0.43	0.27	-0.055
	41-43: Construction	**0.21**	0.11	0.07	0.21	0.21	-0.059
	77-82: Administrative and support service activities	**0.18**	0.13	0.09	0.15	0.17	-0.054
	90-99: Arts, entertainment, repair of household goods and other services	**0.11**	0.07	0.07	0.05	0.10	-0.055
	49-53: Transportation and storage	**0.08**	0.08	0.03	0.08	0.08	-0.056
	55-56: Accommodation and food service activities	**0.017**	0.002	0.008	0.014	0.017	-0.054
	68: Real estate activities	**0.008**	0.005	0.005	0.005	0.007	-0.055
Rank-correlation with baseline indicator		**1**	**0.972**	**0.975**	**0.986**	**0.953**	**0.998**

1. *R&D allocated by main activity, as a percentage of GVA, weighted mean of countries' R&D intensity measures.*
2. *R&D allocated by main activity, as a percentage of GVA, median of countries' intensity measures.*
3. *R&D allocated by main activity, as a percentage of gross output, weighted mean of countries' intensities. Australia, Ireland and Japan are excluded as gross output data are not available.*
4. *R&D allocated by product field for Belgium, Czech Republic, Finland, France, the United Kingdom, Italy and Portugal (main activity for the other countries), as a percentage of GVA, weighted mean of countries' intensities.*
5. *R&D allocated by main activity, as a percentage of GVA compiled according to SNA 2008 instead of SNA 1993 (except Japan), weighted mean of countries' R&D intensity measures.*
6. *Gamma coefficients estimated from the following regression:* $RDI_{cj} = \alpha + \beta_c + \gamma_j + \delta\, 1_{c\in C, j=72} + \varepsilon_{cj}$, *where RDI is the R&D intensity (using GVA) of industry j in country c and C consists of countries for which independent R&D firms or R&D firms part of an enterprise group have been, entirely or partially, apportioned into the industry served. To avoid full colinearity, the following restrictions are added:* $\sum_c \beta_c = 0$, $\sum_j \gamma_j = 0$. *Observations are weighted according to each individual industry's GVA in PPP.*

Comparisons with previous classifications

Compared with previous "technology-based" classification in ISIC Rev.3, the taxonomy remains stable for manufacturing industries except for the following cases:

- *Coke and refined petroleum products* (ISIC 19): The continuous increase of oil prices[12] from 2001 pushed up the petroleum industry's gross output and GVA. Because growth in R&D expenditure failed to catch up, R&D intensity has significantly decreased.
- *Medical and dental instruments* (ISIC 325): This industry was previously mainly included in the m*anufacture of medical, precision and optical instruments, watches and clocks* (ISIC Rev.3 33).
- *Fabricated metal products except weapons and ammunition* (ISIC 25 less 252) was previously part of a broader group comprising more R&D intensive activities (basic metals, ISIC Rev.3 27).
- *Other manufacturing except medical and dental instruments* (ISIC 32 less 325) had been considered as partially comparable to ISIC Rev.3 36[13] (*manufacture of furniture; manufacturing n.e.c.*).

The differences between both classifications as well as the Eurostat technology classification in NACE Rev.2 are summarised in **Annex 5**. It is also worth noting that *repair and installation of machinery and equipment* (ISIC 33) was not defined as a single 2-digit industry in the previous ISIC version. It is allocated to the medium group.

5. Concluding remarks and possible future extensions

This report has presented a proposal for a classification of economic activities purely based on the R&D intensity of industries, covering all sectors. The results are fairly consistent with previous classifications for manufacturing and deliver new insights on the service and other non-manufacturing sectors.

A number of potential extensions to this work can be considered but would rely on significant extensions and improvements to the underlying data:

- Analysis of R&D intensity embodied in intermediates inputs. In addition to data requirements, established approaches like Papaconstantinou et al. (1996) and Hatzichronoglou (1997) require introducing a number of assumptions such as imposing that industries' R&D expenditure is entirely and homogeneously embodied in their output.[14] Direct and indirect R&D intensity effects may differ in relevance *vis a vis* explaining productivity or sectoral performance.[15]

- The taxonomy is defined from 2011 data only. Even if the classification shows consistency when compared to the previous one in ISIC Rev.3 (based on 1999 data), testing the robustness of the results over several years would be useful. Once data constraints are overcome, future calculations with more recent data would be desirable. Note that the latest National Accounts data are compiled according to the new SNA 2008 and would not be directly comparable with those employed here.

- Global value chains may distort the results since the R&D and the value added related to an enterprise's activities can be located in several different locations, some of which are outside the geographical scope of this exercise, due to data limitations. As numbers of MNEs increase, so too will this effect. It is hoped that this analysis can soon be extended to cover a number of large missing economies (especially among the BRIICS).

- A further challenge results from R&D being conducted in a parent unit, or a unit isolated and classified in the Scientific R&D industry (ISIC 72), where the R&D is used in other industries. The existing data only allow an imperfect proxy of this by using the product field information available in some countries. One challenge we cannot account for at present without using additional microdata is the extent to which the reported R&D-using industry is actually located in a different country from the one in which R&D intensity is computed.

- In many economies, published figures may not fully capture the range of industries, especially in services. They sometimes represent a mix of the distribution of R&D by main activity and their industry of use orientation. As new guidance proposed in the revised Frascati Manual is implemented, a more complete picture and a mapping of R&D performance against use may be possible. This also applies to R&D performed outside the business sector that firms pay for or draw upon to support their innovation activities.

Users of this classification should be cautious not to refer to it as a technology classification, and consider carefully its relevance for the intended uses. As clearly noted, a sector's reliance on technology can be much more considerable than implied by R&D performance. The same can be said for the link with innovativeness or knowledge intensity. Several industries with low R&D intensity invest considerably in various forms of knowledge-based capital and draw upon a very highly qualified workforce. For users interested in these broader notions, this classification offers some insight, but is not the sole, component needed. The OECD's Directorate for Science, Technology and Innovation is continuously working to develop comparable measures in these areas which can support such classification efforts in the future.

NOTES

1. See www.oecd.org/sti/innoserv.

2. Eurostat developed a transitional classification in NACE Rev. 2 based on a transposition of the previous OECD classification in ISIC Rev3/NACE Rev. 1.1, by applying correspondence tables between the two NACE versions. For more details, see Eurostat metadata, "High-tech industry and knowledge intensive services", annex 3, http://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an3.pdf

3. OECD Frascati Manual 2015, http://oe.cd/frascati For information on current reporting practices, see the OECD R&D Sources and Methods database. http://webnet.oecd.org/rd_gbaord_metadata/default.aspx

4. Within the group of economies used in this study (weighted average).

5. See www.oecd.org/industry/ind/stanstructuralanalysisdatabase.htm

6. See www.oecd.org/sti/anberd.

7. R&D data are reported to OECD and Eurostat in the framework of the joint OECD/Eurostat international data collection on resources devoted to R&D. These R&D data are collected at a national level through surveys and other sources following the recommendations of the OECD Frascati Manual, which is the internationally recognised standard in this area (www.oecd.org/sti/frascatimanual). The data are published in the OECD's Research and Development (RDS) database (www.oecd.org/sti/rds).

8. Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Mexico, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, the United Kingdom and the United States.

9. These borderline cases are the following: if the United States are excluded from the sample, *software publishing* (ISIC 582) and *pharmaceuticals* (ISIC 21) fall to medium-high and *publishing of books and periodicals* (ISIC 581) falls to low. As the cut-off point between the mediumlow and the medium categories is the most blurred, there are several borderline cases around these two groups, in particular: *repair and installation of machinery and equipment* (ISIC 33) becomes medium-low if Germany is excluded; *professional, scientific and technical activities except scientific R&D* (ISIC 69-75X) becomes medium-low if France is excluded and *telecommunications* (ISIC 61) increases to medium if the United States are removed from the sample.

10. For GVA, Chinese data come from the RIETI's China Industrial Productivity (CIP) Database Round 3.0 (2015). 2011 data have been estimated using 2010 CIP shares applied to 2011 sectoral aggregates from the OECD's Annual National Accounts database. R&D data come from ANBERD, with 2011 data in services estimated on the basis of 2009 shares.

11 . For more details on the impact of the SNA revision, see www.oecd.org/std/na/sna-2008-main-changes.htm

12. Oil prices continuously increased (except in 2009) from $24 per barrel in 2001 to $111 in 2011 (Source: IEA, Brent North Sea Spot Price FOB).

13. Concordances between ISIC Rev.3 and ISIC Rev.4 can be found on the UNSD website at http://unstats.un.org/unsd/cr/registry/regso.asp?Ci=60&Lg=1.

14. The Leontief inverse approach may further capture the n^{th} ripple effects, i.e. the incorporation of the R&D performed by the supplier of the input supplier itself (and so on).

15. Indirect R&D components are shown to have differentiated (marginal) impacts on productivity growth.

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ANNEXES

Annex 1. Coverage of industries and economies

	ISIC Rev. 4	AUS	AUT	BEL	CAN	CZE	DEU	DNK	ESP	EST	FIN	FRA	GBR	GRC	HUN	IRL	ITA	JPN	KOR	MEX	NLD	NOR	POL	PRT	SGP	SVK	SVN	SWE	TWN	USA
Agriculture, forestry and fishing	01-03	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
Mining and quarrying	05-09	*	*	*	*	*	*	*	*		*	*	*	*	*		*	*	*	*	*	*	*	*		*	*	*		*
Food products, beverages and tobacco	10-12	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
Textiles	13		*	*	*	*	*	*	*		*	*	*	*			*		*	*	*	*	*	*	*		*		*	
Wearing apparel	14		*	*	*	*	*		*		*	*	*				*	*	*	*	*	*	*	*	*		*		*	
Leather and related products	15		*	*	*	*	*		*		*	*	*				*	*	*	*	*	*	*	*	*		*		*	
Wood and products of wood and cork	16	*	*	*	*	*	*	*	*		*	*	*		*	*	*	*	*	*	*	*	*	*	*		*		*	*
Paper and paper products	17	*	*	*	*	*	*	*	*	*	*	*	*		*		*	*	*	*	*	*	*	*	*		*	*	*	*
Printing and reproduction of recorded media	18	*	*	*	*	*	*	*	*		*	*	*		*		*	*	*	*	*	*	*	*	*		*		*	*
Coke and refined petroleum products	19	*	*	*	*	*		*			*	*	*		*		*	*	*	*	*		*	*	*		*		*	*
Chemicals and chemical products	20	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*		*	*
Pharmaceuticals	21	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*
Rubber and plastic products	22	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other non-metallic mineral products	23	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Basic metals	24	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Weapons and ammunition	252		*	*		*	*		*		*	*					*		*				*							
Fabricated metal products except weapons and ammunition (ISIC 25 less 252)	25X		*	*		*	*		*		*	*					*		*				*							
Computer, electronic and optical products	26	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Electrical equipment	27	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Machinery and equipment n.e.c.	28	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Motor vehicles, trailers and semi-trailers	29	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Building of ships and boats	301	*				*	*	*	*			*	*	*			*	*	*	*	*	*	*	*	*		*		*	
Air and spacecraft and related machinery	303	*	*	*	*	*	*		*			*	*				*	*	*	*	*		*		*		*			*
Railroad, military vehicles and transport n.e.c. (ISIC 302, 304 and 309)	30X	*				*	*		*			*	*				*	*	*	*	*		*		*		*			
Furniture	31	*	*	*	*	*	*	*	*	*	*	*	*		*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
Medical and dental instruments	325		*	*	*	*	*	*	*	*	*	*	*		*		*		*		*	*	*	*	*		*		*	*
Other manufacturing except medical and dental instruments (ISIC 32 less 325)	32X		*	*	*	*	*	*	*	*	*	*	*		*		*		*		*	*	*	*	*		*		*	
Repair and installation of machinery and equipment	33		*	*		*	*	*	*	*	*	*	*		*	*	*				*	*	*	*		*	*	*	*	
Electricity, gas and water supply, waste management and remediation	35-39	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Construction	41-43	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Wholesale and retail trade	45-47	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*
Transportation and storage	49-53	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*		*	*	*	*		*	*		*	*	*	*
Accommodation and food service activities	55-56	*	*	*	*	*	*	*	*	*	*	*	*				*		*	*	*			*	*	*	*	*	*	
Publishing of books and periodicals	581					*		*	*	*		*	*		*		*		*			*		*			*			*
Software publishing	582					*		*	*			*	*		*		*		*			*		*			*			*
Audiovisual and broadcasting activities	59-60		*	*	*	*		*	*	*	*	*	*		*	*	*		*			*		*	*		*		*	
Telecommunications	61		*	*		*	*	*	*	*	*	*	*	*	*	*	*		*		*	*		*	*		*		*	*
IT and other information services	62-63		*	*		*	*	*	*	*	*	*	*	*	*	*	*		*		*	*		*	*		*		*	*
Financial and insurance activities	64-66	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*		*	*	*	*
Real estate activities[1]	68		*	*	*	*	*	*		*		*			*		*					*		*	*	*		*	*	
Scientific research and development	72		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*		*	*	*	*	*	*	*	*		
Professional, scientific and technical activities except scientific R&D (ISIC 69 to 75 less 72)	69-75X		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*		*	*	*	*	*	*	*	*		
Administrative and support service activities	77-82	*	*	*	*	*	*	*	*		*	*	*		*	*	*		*		*	*	*	*	*	*	*	*	*	
Arts, entertainment, repair of household goods and other services	90-99		*	*	*	*	*	*	*	*	*	*	*		*		*		*				*	*	*		*			

**: 2011 data available (2010 data for Singapore).*

1: Imputed rent of owner-occupied dwellings has been excluded from ISIC 68.

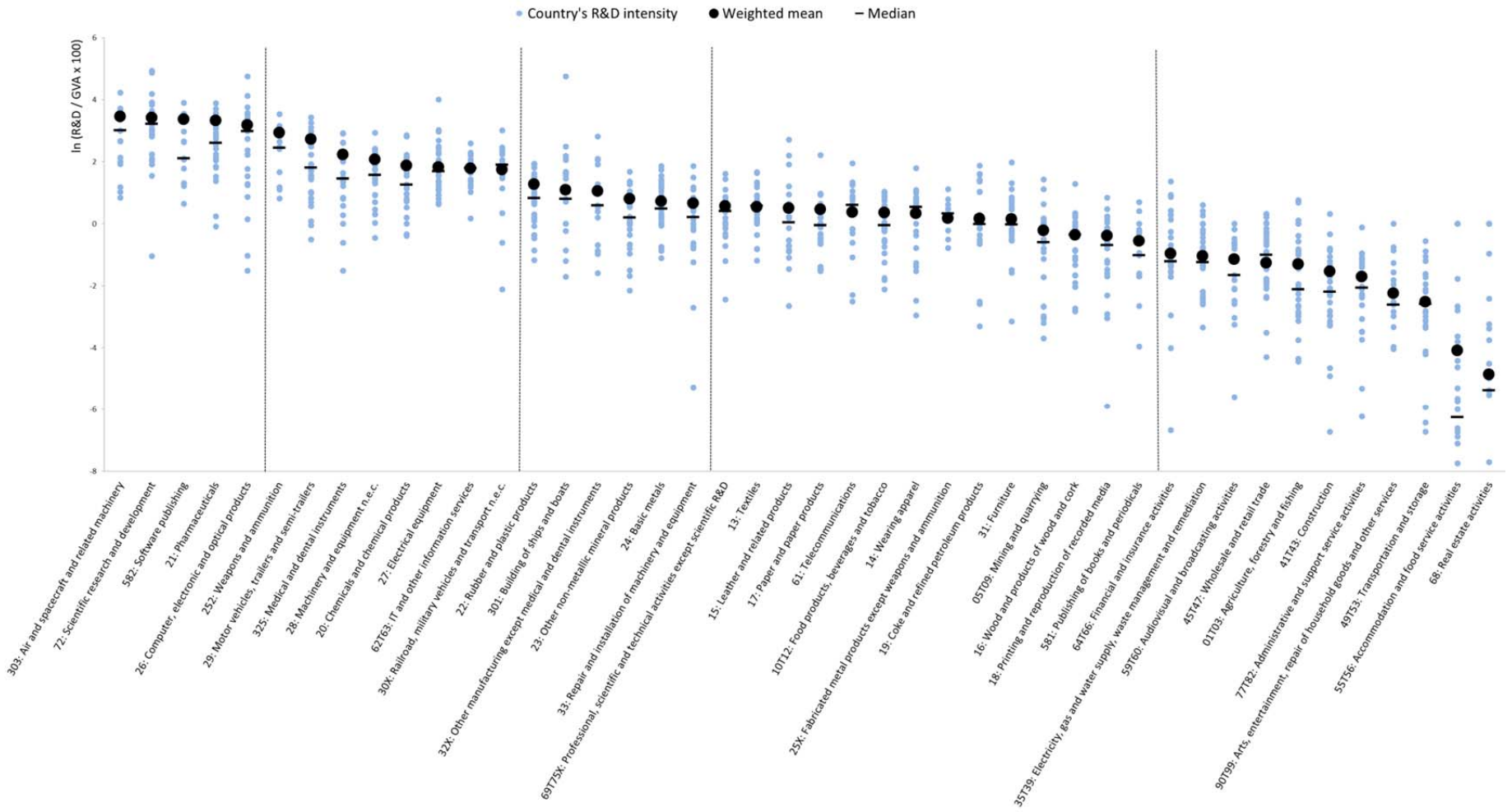
Annex 2. R&D intensity classification at a two-digit level

	Manufacturing	R&D over GVA (%)	Non-manufacturing	R&D over GVA (%)
High R&D intensity	21: Pharmaceuticals	27.98	72: Scientific research and development	30.39
	26: Computer, electronic and optical products	24.05		
Medium-high R&D intensity	30: Other transport equipment	20.44	58: Publishing activities	13.80
	29: Motor vehicles, trailers and semi-trailers	15.36	62-63: IT and other information services	5.92
	28: Machinery and equipment n.e.c.	7.89		
	20: Chemicals and chemical products	6.52		
	27: Electrical equipment	6.22		
Medium R&D intensity	22: Rubber and plastic products	3.58		
	32[1]: Other manufacturing	3.52		
	23: Other non-metallic mineral products	2.24		
	24: Basic metals	2.07		
	33: Repair and installation of machinery and equipment	1.93		
Medium-low R&D intensity	13: Textiles	1.73	69-75X: Professional, scientific and technical activities except scientific R&D (ISIC 69 to 75 less 72)	1.76
	25: Fabricated metal products, except machinery and equipment	1.68	61: Telecommunications	1.45
	15: Leather and related products	1.65	05-09: Mining and quarrying	0.80
	17: Paper and paper products	1.58		
	10-12: Food products, beverages and tobacco	1.44		
	14: Wearing apparel	1.40		
	19: Coke and refined petroleum products	1.17		
	31[1]: Furniture	1.17		
	16: Wood and products of wood and cork	0.70		
	18: Printing and reproduction of recorded media	0.67		
Low R&D intensity			64-66: Financial and insurance activities	0.38
			35-39: Electricity, gas and water supply, waste management and remediation	0.35
			59-60: Audiovisual and broadcasting activities	0.32
			45-47: Wholesale and retail trade	0.28
			01-03: Agriculture, forestry and fishing	0.27
			41-43: Construction	0.21
			77-82: Administrative and support service activities	0.18
			90-99: Arts, entertainment, repair of household goods and other services	0.11
			49-53: Transportation and storage	0.08
			55-56: Accommodation and food service activities	0.02
			68: Real estate activities	0.01

1. If ISIC 31 and 32 are not separately available (as in the SNA A*64 list), it is advisable to attribute *furniture and other manufacturing* (ISIC 31 to 32) to the medium group (R&D intensity equal to 2.43%).

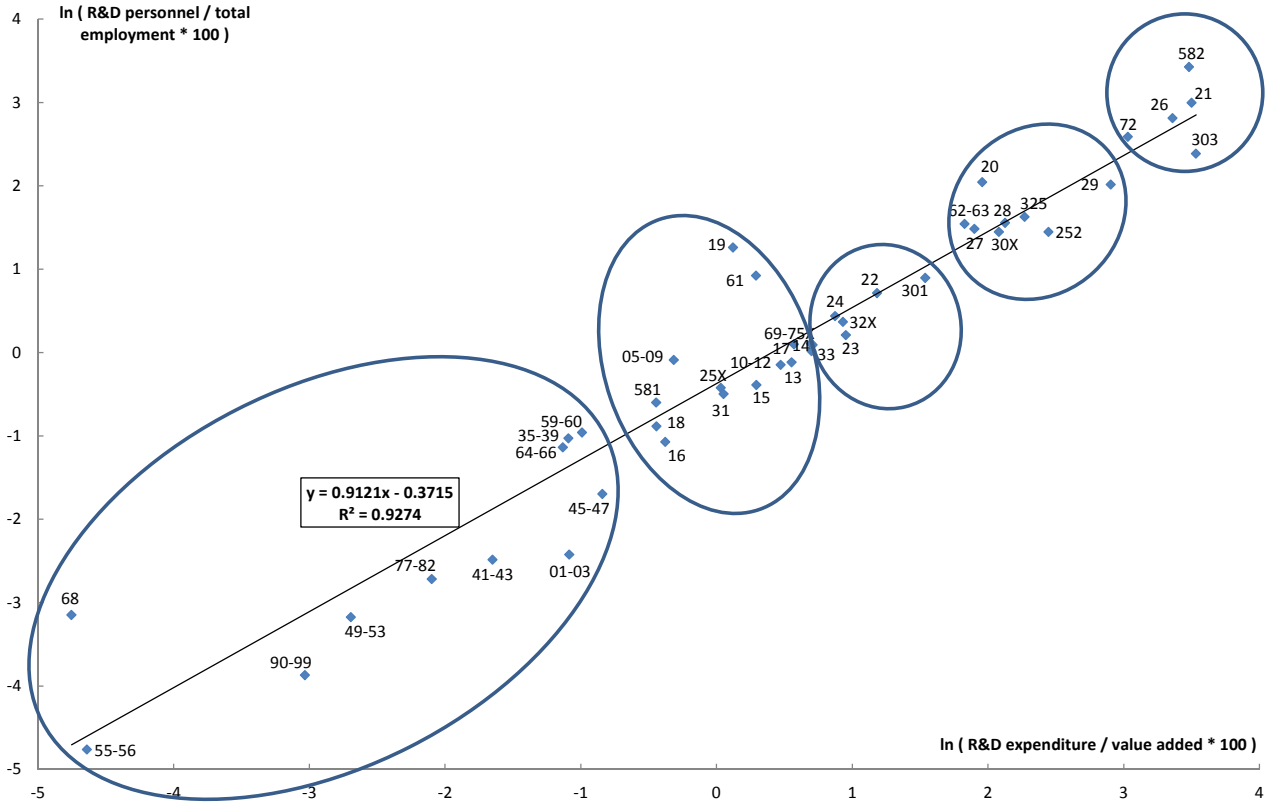
Annex 3. Cross-country heterogeneity within economic activities, 2011

This figure can be explored and customised online at www.oecd.org/sti/anberd



Annex 4. Comparison of expenditure and personnel-based measures of R&D intensity

Based on subset of economies with common support, weighted average



Notes:

Calculations are based on a smaller sample due to data unavailability for R&D personnel series for Australia, the United Kingdom, Greece, Korea, Mexico, Singapore and Chinese Taipei. This reduced coverage explains differences observed in average industrial R&D intensities compared to headline results.

R&D personnel includes researchers as well as technicians and other support staff participating in R&D.

Annex 5. Comparison with Eurostat and former OECD classifications for manufacturing industries

ISIC Rev.4	Proposed OECD R&D intensity classification in ISIC Rev. 4	Eurostat technology classification in NACE Rev. 2	OECD technology classification in ISIC Rev. 3[1]
303: Air and spacecraft and related machinery	High	High	High
21: Pharmaceuticals	High	High	High
26: Computer, electronic and optical products	High	High	High
252: Weapons and ammunition	Medium-High	Medium-High	Medium-High
29: Motor vehicles, trailers and semi-trailers	Medium-High	Medium-High	Medium-High
325: Medical and dental instruments	Medium-High	Medium-High	**High**
28: Machinery and equipment n.e.c.	Medium-High	Medium-High	Medium-High
20: Chemicals and chemical products	Medium-High	Medium-High	Medium-High
27: Electrical equipment	Medium-High	Medium-High	Medium-High
30X: Railroad, military vehicles and transport n.e.c. (ISIC 302, 304 and 309)	Medium-High	Medium-High	Medium-High
22: Rubber and plastic products	Medium	**Medium-low**	**Medium-low**
301: Building of ships and boats	Medium	**Medium-low**	**Medium-low**
32X: Other manufacturing except medical and dental instruments (ISIC 32 less 325)	Medium	**Low**	**Low**
23: Other non-metallic mineral products	Medium	**Medium-low**	**Medium-low**
24: Basic metals	Medium	**Medium-low**	**Medium-low**
33: Repair and installation of machinery and equipment	Medium	**Medium-low**	
13: Textiles	Medium-low	**Low**	**Low**
15: Leather and related products	Medium-low	**Low**	**Low**
17: Paper and paper products	Medium-low	**Low**	**Low**
10-12: Food products, beverages and tobacco	Medium-low	**Low**	**Low**
14: Wearing apparel	Medium-low	**Low**	**Low**
25X: Fabricated metal products except weapons and ammunition (ISIC 25 less 252)	Medium-low	Medium-low	Medium-low
19: Coke and refined petroleum products	Medium-low	Medium-low	Medium-low
31: Furniture	Medium-low	**Low**	**Low**
16: Wood and products of wood and cork	Medium-low	**Low**	**Low**
18: Printing and reproduction of recorded media	Medium-low	**Low**	**Low**

1. *The following concordances between ISIC Rev.3 (i3) and ISIC Rev.4 (i4) were used in order to compare both classifications,: the allocation of i4 303 was compared to the allocation of i3 353 in the previous classification; i4 21 to i3 2423; i4 26 to i3 30, 32 and 33; i4 252 to i3 29; i4 29 to i3 34; i4 325 to i3 33, 29 and 2423; i4 28 to i3 29; i4 20 to i3 24 except 2423; i4 27 to i3 31; i4 30X to i3 352+359; i4 22 to i3 25; i4 301 to i3 351; i4 32X to i3 36; i4 23 to i3 26; i4 24 to i3 27; i4 13 to i3 17; i4 15 to i3 19; i4 17 to i3 21; i4 10-12 to i3 15-16; i4 14 to i3 18; i4 25X to i3 28; i4 19 to i3 23; i4 31 to i3 36; i4 16 to i3 20; i4 18 to i3 23. ISIC Rev.4 33 has no rough equivalent in ISIC Rev.3.*

Annex 6. Impact of including data for China

Cluster	Industry	R&D over GVA, weighted mean: Without China in the sample	R&D over GVA, weighted mean: With China in the sample	Percentage point increase
High R&D intensive industry	26: Computer, electronic and optical products	24.05	18.09	-5.96
Medium-high R&D intensity industry	28: Machinery and equipment n.e.c.	7.89	6.90	-0.99
Medium-high R&D intensity industry	27: Electrical equipment	6.22	6.75	0.53
Medium R&D intensity industry	22: Rubber and plastic products	3.58	3.30	-0.28
Medium R&D intensity industry	23: Other non-metallic mineral products	2.24	1.71	-0.53
Medium-low R&D intensity industry	13: Textiles	1.73	1.91	0.18
Medium-low R&D intensity industry	10-12: Food products, beverages and tobacco	1.44	1.40	-0.04
Medium-low R&D intensity industry	19: Coke and refined petroleum products	1.17	1.03	-0.15
Medium-low R&D intensity industry	05-09: Mining and quarrying	0.80	0.90	0.10
Medium-low R&D intensity industry	16: Wood and products of wood and cork	0.70	0.51	-0.19
Low R&D intensity industry	64-66: Financial and insurance activities	0.38	0.30	-0.09
Low R&D intensity industry	35-39: Electricity, gas and water supply, waste management and remediation	0.35	0.37	0.02
Low R&D intensity industry	45-47: Wholesale and retail trade	0.28	0.22	-0.06
Low R&D intensity industry	01-03: Agriculture, forestry and fishing	0.27	0.09	-0.18
Low R&D intensity industry	41-43: Construction	0.21	0.29	0.07
Low R&D intensity industry	90-99: Arts, entertainment, repair of household goods and other services	0.11	0.07	-0.04
Low R&D intensity industry	49-53: Transportation and storage	0.08	0.08	-0.01
Low R&D intensity industry	55-56: Accommodation and food service activities	0.02	0.01	-0.01
	29-30[1]: Transport equipment	15.36	10.98	-4.39
	20-21[1]: Chemicals and pharmaceuticals	13.23	9.98	-3.25
	58-63[1]: Information and communication	4.69	4.32	-0.37
	69-82[1]: Real estate, renting and business activities	1.87	1.77	-0.10
	24-25[1]: Metals and metal products, except machinery and equipment	1.72	2.67	0.95
	14-15[1]: Wearing apparel, leather and related products	1.47	0.99	-0.47
	17-18[1]: Paper, paper products, printing and reproduction of recorded media	1.15	1.34	0.19

1. Data for detailed industries are not available and are presented at a more aggregated level.