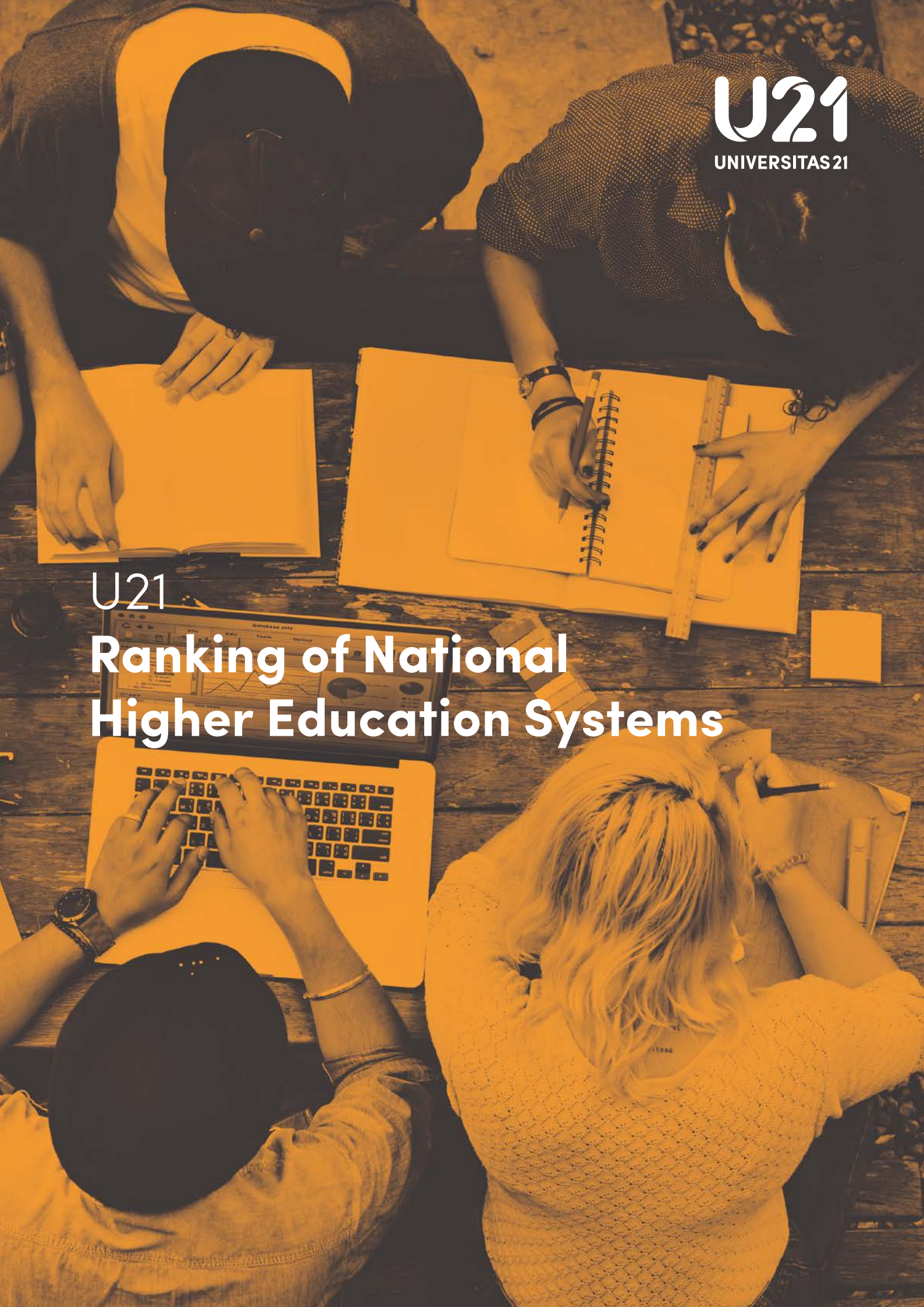


U21

# Ranking of National Higher Education Systems



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A project sponsored by

**UNIVERSITAS 21**

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# Contents

Overall Table of Rankings	4
Executive Summary	5
1. Introduction	6
2. Changes in data and methodology from the 2017 rankings	7
3. Measures and Results	8
4. Methodology of adjusting for levels of economic development	18
5. Results after adjusting for levels of economic development	19
6. Using the findings to improve performance	26
7. Research training	29
8. Concluding remarks	31
Appendixes and references	32
Country Summaries	35



Below:

## Overall U21 2018 Ranking

Rank (2018)	Rank (2017)	Country	Score	Score (2017)
1	1	United States	100.0	100.0
2	2	Switzerland	88.0	86.9
3	3	United Kingdom	82.6	85.5
4	5	Sweden	82.4	83.4
5	4	Denmark	81.7	83.5
6	9	Finland	79.7	79.9
6	8	Netherlands	79.7	80.0
8	7	Canada	79.6	80.2
9	6	Singapore	79.5	80.8
10	10	Australia	78.6	79.6
11	11	Austria	75.8	75.0
12	13	Norway	74.5	73.9
13	12	Belgium	73.3	74.2
14	15	New Zealand	71.1	72.1
15	16	Germany	69.2	68.8
16	18	France	68.5	67.5
17	14	Hong Kong SAR	67.8	73.7
18	16	Israel	66.3	68.8
19	19	Ireland	64.8	66.7
20	20	Japan	61.9	63.2
21	21	Taiwan-China	60.2	60.7
22	22	Korea	58.0	59.0
23	25	Saudi Arabia	57.0	56.7
24	27	Portugal	56.4	55.8
25	23	Spain	56.2	57.3

Rank (2018)	Rank (2017)	Country	Score	Score (2017)
26	25	Malaysia	55.7	56.7
27	24	Czech Republic	55.6	56.9
28	28	Italy	54.0	54.5
29	28	Slovenia	53.6	54.5
30	30	China	52.4	52.7
31	32	Poland	51.3	50.0
32	35	Greece	49.5	47.7
33	33	Russia	49.3	49.9
34	34	Chile	49.0	49.4
35	38	Slovakia	48.7	45.9
36	31	Hungary	48.3	50.8
37	37	South Africa	47.7	46.6
38	35	Ukraine	47.4	47.7
39	42	Brazil	45.0	43.1
40	41	Argentina	44.2	43.5
41	40	Turkey	44.0	44.0
42	39	Serbia	42.8	44.1
43	44	Romania	42.2	41.6
44	45	Bulgaria	42.0	40.2
45	43	Croatia	41.0	42.5
46	46	Mexico	40.3	40.0
47	47	Thailand	40.0	39.7
48	48	Iran	38.9	38.4
49	49	India	36.8	36.7
50	50	Indonesia	33.5	33.3

## Executive Summary

This report presents the results for the seventh annual ranking of national systems of higher education undertaken under the auspices of the Universitas 21 (U21) network of universities. Fifty national systems of higher education, from all continents, are evaluated across 24 attributes. The measures are standardised for population size. Countries are ranked overall and on each of four modules: Resources, Policy Environment, Connectivity and Output. Within each measure the highest achieving country is given a score of 100 and scores for other countries are expressed as a percentage of this highest score.

Resources and the Environment are input variables. Resources, whether private or public, are a necessary condition for a quality system of higher education but they must be complemented by a policy environment which facilitates their efficient use. The five measures in the Environment module include diversity of institutions, autonomy of institutions and the extent of external monitoring of institutional performance. The highest ranked countries for Resources, based on five expenditure measures, are Switzerland, Sweden, Singapore, Denmark, Canada and the United States. The countries with the most favourable Environment are judged to be the United States, Australia, New Zealand, Singapore, Finland, Hong Kong SAR and the United Kingdom.

Connectivity and Output are measures of outcomes. The worth of a national higher education system is enhanced if it is well connected domestically with other sectors of the economy and is linked internationally in education and research. The five Connectivity measures are: joint publications with international authors and with authors from industry, international student numbers, web connectivity and the views of business on the extent of knowledge transfer. The nine Output measures encompass research output and its impact, student throughput, the national stock of graduates and researchers, the quality of a nation's best universities, and the employability of graduates.

The top four nations for Connectivity are Switzerland, Austria, the United Kingdom and Sweden. The top country in the Output module is clearly the United States, followed by Australia, Switzerland, Denmark, Canada and Sweden.

An overall ranking is derived using a weight of 40 per cent for Output and 20 per cent for each of the other three modules. The top five countries, in rank order, are the United States, Switzerland, the United Kingdom, Sweden and Denmark. A subsidiary ranking compares how nations perform relative to countries at similar levels of GDP per capita. The top ranked countries are now Finland and the United Kingdom, followed by Serbia, Denmark, Sweden, Portugal, Switzerland and South Africa.

By comparing inputs and outcomes it is possible to provide advice on how performance can be improved. Regression results suggest that outcomes are equally dependent on Resources and the Environment and together they account for around three-quarters of the variation in outcomes. We allow for lagged behaviour using our rankings from previous years and find that current outcomes are best explained by Resource levels four years earlier. The impact of research articles is increased by joint authorship, with both international authors and industry. We observe patterns in institutional links with industry: in Eastern European countries, the links take the form of joint authorship whereas in East Asian countries, general knowledge transfer is more important.

We extend our work in two ways. First, we examine the concentration of research: the median level of publications attributable to the top 10 per cent of institutions in each country is 43 per cent. Secondly, we look at the importance of research training as measured by the number of PhD graduates, the income premium earned by those with a graduate degree, and the throughput of PhDs relative to the existing stock of researchers in higher education.

# 1. Introduction

This report presents the results for the seventh annual ranking of national systems of higher education undertaken under the auspices of the Universitas 21 (U21) network of universities.

The national ranking of systems complements the many international rankings of universities. The rankings of institutions are essentially rankings of research-intensive universities and as such encourage a bias in systems of higher education towards that type of institution.

The measures used in the ranking of national systems must reflect the aims of higher education. These include the education and training of a nation's people, contributing to innovation through research, and facilitating interconnections between tertiary institutions and external stakeholders, both domestic and foreign. A good system of higher education will encompass a range of institutions to meet personal desires and perceived national needs (Salmi, 2017a, p.237; Williams, 2018). Diversity can also be an effective way to improve enrolment rates as noted by Jamil Salmi (2017b, p.121), former tertiary education co-ordinator at the World Bank:

Spreading enrollment growth across a variety of tertiary institutions and non-universities, public and private –, instead of simply expanding the public university sub-sector, can be an effective strategy for reaching the country's enrollment targets in a more financially manageable way from a public resources perspective.

We use 25 measures of performance grouped into four modules: Resources, Environment, Connectivity and Output. The first two are input measures and the second pair measure outcomes. For each variable, the best performing country is given a score of 100 and scores for all other countries are expressed as a percentage of this highest score. Separate rankings are provided for each of the modules. A description of each variable is given in the

relevant section below and sources are given in Appendix 1.

Our methodology is set out in detail in Williams, de Rassenfosse, Jensen and Marginson (2013).

Resources, whether public or private, are a necessary condition for a well-functioning system of higher education, but they are not sufficient. A well-designed policy environment is needed to ensure that resources are used well. A consensus is emerging that the preferred environment is one where institutions are allowed considerable autonomy tempered by external monitoring and competition. The Environment module contains measures of these characteristics.

Turning to outcomes, our Output variables encompass attributes such as participation rates, research performance, the existence of some world class universities, and employability of graduates. There is a world-wide trend for governments to encourage institutions of higher education to strengthen relationships with business and the rest of the community. The Connectivity module includes variables which span this wider concept (see de Rassenfosse and Williams (2015)). In a new initiative, we examine performance in research training.

Our work extends well beyond ranking. Using our data, countries can benchmark performance over a range of attributes, noting strengths in some areas, weaknesses in others. To permit countries to benchmark performance against other countries at similar stages of development, we also present estimates of a country's performance relative to its level of GDP per capita. However, it is one thing to know where a nation ranks internationally; it is another to provide a template for improvement. The use of modules permits us to compare inputs with outcomes, through which we can suggest ways that outcomes can be improved.

# 2. Changes in Data and Methodology from the 2017 Rankings

The research output measures are now taken from InCites whereas in previous years we used data provided by SciMago. The underlying source of data has thus moved from the Scopus data base produced by Elsevier to the Web of Science data bank produced by Clarivate Analytics. The coverage of tertiary institutions in each country is broadly the same except that institutions which publish fewer than 100 papers in a year are now included – this change is quantitatively unimportant. The coverage of journals does differ, however. The new data base is used to calculate four variables: total number of documents produced (O1), documents per head (O2), average impact of articles (O3) and joint publications with international authors (C2). The research output data now relate to the year 2016, whereas in our last year's ranking data for 2014 was used; that is, the data are moved two years on.

Comparing the InCites and SciMago data for the common year of 2014, total publications for our 50 countries are four per cent higher for InCites. However, for several countries the InCites data are lower, significantly so for four countries: China, Iran, Malaysia and Mexico. Given that the journal coverage of data banks changes over time, there is no easy way to project the 2014 differences forward. In order not to unduly penalise countries for the data bank change, the approach adopted for countries that, on the raw data, would otherwise experience a fall in publications between our 2017 and 2018 rankings (based on SciMago 2014 data and InCites 2016 data, respectively) is as follows: if there has

been an increase in publications recorded by InCites between 2014 and 2016 then the values from our 2017 rankings are used; if there has been a fall in publications as recorded by InCites between 2014 and 2016 then the values from our 2017 rankings are scaled down proportionately. Another effect of the change in data source is to reduce the importance of joint international publications for Hong Kong SAR, presumably because of the different treatment of publications with mainland authors.

In the Environment module, the main change occurs in the Rating of Financial Autonomy (E4.3) arising from new ratings data published by the European University Association. Also, data for Croatia, Serbia and Slovenia have been collected for the first time.

In measuring web connectivity, the variable TRANSPARENCY has been dropped and the weight transferred to the VISIBILITY variable. The TRANSPARENCY measure is based on the top ten authors in each institution (excluding the most cited) as measured in Google Scholar citations. As such, it is not ideally suited to measuring national performance as it is influenced by average institutional size.

Data are now provided for Colombia, which on our original criterion of research publications would now be included. However, to trace the ranking of the original 50 countries over time, Colombia is not formally included in the ranking but we do indicate its place if it were to be included.

## 3. Measures and Results

### 3.1 Resources (weight of 20%)

A necessary condition for a well-performing higher education system is that it is adequately resourced, whether by government or the private sector. One measure is expenditure by tertiary institutions as a share of GDP. But for low-income countries, especially those with a large student-age population, a high share of GDP may not translate into high expenditure per student, so we also include the latter. In the absence of measures of the quality of teaching that are comparable across all our 50 countries, the measure of resources per student in part serves as a proxy. To measure the contribution of tertiary education to a nation's research effort we include measures of expenditure on R&D in tertiary institutions. In summary, our five measures of resources and their weights are:

**R1:** (5%) Government expenditure on tertiary education institutions as a percentage of GDP, 2014.

**R2:** (5%) Total expenditure on tertiary education institutions as a percentage of GDP, 2014.

**R3:** (5%) Annual expenditure per student (full-time equivalent) by tertiary education institutions in USD purchasing power parity, 2014.

**R4:** (2.5%) Expenditure in tertiary education institutions for research and development as a percentage of GDP, 2015.

**R5:** (2.5%) Expenditure in tertiary education institutions for research and development per head of population at USD purchasing power parity, 2015.

The trend for private expenditure to replace public expenditure continues. Compared with last year's data, the median share of GDP devoted to higher education has risen marginally from 1.47

to 1.49 per cent but public expenditure has fallen from 1.02 to 0.99 per cent of GDP. There has been a modest increase in research expenditure, rising from 0.35 to 0.37 per cent of GDP.

The highest ranked countries for resources in the 2018 rankings are Switzerland, Sweden, Singapore, Denmark, Canada and the United States, in that order. Increases in research expenditure have seen Slovakia rise by six places, Greece by five places and Switzerland by four places. Mexico has risen five places following an increase in government expenditure. Reductions in government expenditure as a share of GDP have occasioned noticeable falls in the Resource rank for four countries: Hungary down eight places, Chile and Ukraine down seven places and Ireland down five places. Colombia would rank 39th if included.

Turning to the rankings of the five components, government expenditure on higher education is highest in Saudi Arabia at 2.4 per cent. The next ranked countries are, in alphabetical order, Austria, the four Nordic countries and Ukraine. The two lowest ranked countries are Japan and Indonesia, where government expenditure on tertiary education is only 0.5 per cent of GDP. Total expenditure as a share of GDP is highest in the United States, Canada, Saudi Arabia, Malaysia and Korea, in that order. Expenditure per student, which includes research expenditure, is estimated to be highest in Singapore. Then follow the United States, Switzerland, the United Kingdom and Sweden, in that order. Research expenditure by tertiary institutions as a share of GDP ranges from Denmark's 1.0 per cent to India's 0.025 per cent. In addition to Denmark, countries that rank highly in research expenditure are, in order, Switzerland, Sweden, Austria, Finland, Canada, the Netherlands and Australia.

Below:

### Resources Ranking

Rank	Country	Score
1	Switzerland	100.0
2	Sweden	99.3
3	Singapore	97.2
4	Denmark	97.1
5	Canada	96.6
6	United States	93.5
7	Norway	90.4
8	Austria	89.9
9	Finland	89.8
10	Saudi Arabia	89.6
11	Netherlands	83.1
12	Malaysia	81.5
13	Hong Kong SAR	74.9
14	Australia	74.7
15	Belgium	72.0
16	United Kingdom	71.7
17	France	69.0

Rank	Country	Score
18	Germany	66.7
19	Korea	65.8
20	New Zealand	63.6
21	Turkey	61.6
22	Israel	61.4
23	Japan	59.6
24	Portugal	59.4
25	Ukraine	59.1
26	Czech Republic	55.6
27	Greece	54.4
28	Serbia	53.7
29	Spain	53.1
30	Ireland	52.9
31	Slovakia	52.9
32	Taiwan-China	52.8
33	Poland	52.2
34	Brazil	50.5

Rank	Country	Score
35	Chile	49.0
36	Slovenia	48.0
37	Mexico	47.2
38	Italy	47.0
39	India	42.4
40	Argentina	41.7
41	South Africa	41.6
42	Russia	40.7
43	Croatia	39.6
44	China	38.7
45	Romania	37.7
46	Iran	37.0
47	Hungary	35.7
48	Bulgaria	31.4
49	Thailand	29.7
50	Indonesia	20.2

## 3.2 Environment (weight of 20%)

A consensus is emerging that for a quality higher education system, institutions need considerable financial autonomy, but there also needs to be appropriate diversity, competition between institutions and external monitoring of performance. The degree to which national systems possess these characteristics is measured by the results of three survey findings complemented by four quantitative measures.

The measures we use and their weights are:

**E1:** (1%) Proportion of female students in tertiary education, 2015.

**E2:** (2%) Proportion of academic staff in tertiary institutions who are female, 2015.

**E3:** (2%) A rating for data quality. For each quantitative series, the value is 2 if the data are available for the exact definition of the variable; 1 if some data are available which relate to the variable but some informed adjustment is required; and 0 otherwise.

**E4:** (10%) Qualitative measure of the policy environment comprising:

**E4.1** (2%) Diversity of the system comprising two components of equal weight: the percentage of tertiary students enrolled in private institutions (capped at 50 per cent) and the percentage of students enrolled in ISCED level 5 courses, 2015.

**E4.2** (4%) Survey results for the policy and regulatory environment (see Appendix 2).

**E4.3** (4%) Survey results for the financial autonomy of public universities (see Appendix 2).

**E5:** (5%) Responses to WEF survey question (7-point scale): "How well does the educational system in your country meet the needs of a competitive economy?".

The top-ranked countries in the Environment module are the United States, Australia, New Zealand, Australia, Singapore, Finland, Hong Kong SAR and the United Kingdom. The data for variables E1 to E3 move only slowly so changes in rank occur mainly due to the new rating of financial autonomy by the EUA (E4.3) and changes in the rating given by business (E5). The falls from the 2017 rankings for Croatia (-4) and Serbia (-3) arise from their inclusion in the EUA ratings for the first time. The reductions in financial autonomy largely explain the drop from 11th to 18th for Ireland. Canada's rank has improved from 20th to 13th following a rise in business approval (E5) and an increase in level 5 enrolments. For 60 per cent of countries the business rating fell, so that for those countries showing an improvement the rank improved more than usually. The improved business rating for India has led to an overall improvement in rank of four.

For the qualitative index (E4), the top-ranked countries are the United States, Australia, New Zealand, Taiwan-China, Hong Kong SAR and Singapore.

Only in four countries for which data are available does the percentage of female staff in tertiary institutions exceed 50 per cent: Finland, Malaysia, Thailand and Russia. The largest increase occurred in the Netherlands: 40 to 44 per cent. Business, as measured by the WEF survey, ranks the national education systems most highly in Switzerland, Singapore, Finland, the United States, the Netherlands and Ireland. The largest increase from last year's rankings occurred for the United States; the largest fall occurred for Belgium (4 to 12).

## Below: Environment Ranking

Rank	Country	Score
1	United States	100.0
2	Australia	94.3
3	New Zealand	93.9
4	Singapore	90.7
5	Finland	90.5
6	Hong Kong SAR	88.7
7	United Kingdom	88.5
8	Taiwan-China	87.4
9	Netherlands	87.4
10	Belgium	85.1
11	Switzerland	84.1
12	Sweden	82.7
13	Canada	81.5
14	Poland	81.4
15	Malaysia	81.2
16	China	81.2
17	Norway	81.0

Rank	Country	Score
18	Ireland	80.7
19	Israel	80.2
20	Chile	79.8
21	Japan	79.4
22	South Africa	79.2
23	Denmark	79.0
24	Austria	78.4
25	France	78.3
26	Mexico	77.7
27	Germany	76.7
28	Russia	76.6
29	Thailand	76.5
30	Romania	75.7
31	Indonesia	75.4
32	Argentina	75.0
33	Spain	74.6
34	Czech Republic	74.3

Rank	Country	Score
35	Portugal	73.6
36	Slovenia	72.7
37	Ukraine	71.4
38	Italy	70.9
39	Slovakia	69.3
40	Iran	67.3
41	Brazil	66.8
42	Hungary	66.3
43	Bulgaria	65.9
44	Korea	65.5
45	India	65.3
46	Saudi Arabia	64.8
47	Turkey	63.2
48	Croatia	60.7
49	Serbia	58.8
50	Greece	47.4

### 3.3 Connectivity (weight of 20%)

The worth of a national higher education system is enhanced if it is well connected with the rest of the nation's society and is linked internationally in education and research. Connectivity promotes technical change and economic growth. In this ranking we use only one measure of web connectivity instead of the two measures used in previous years but the single measure carries the weight of the two previous measures. There are now five measures each with equal weight:

**C1:** (4%) Proportion of international students in tertiary education, 2015.

**C2:** (4%) Proportion of articles co-authored with international collaborators, 2016.

**C3:** Webometrics TRANSPARENCY not used.

**C4:** (4%) Webometrics VISIBILITY index (external links that university web domains receive from third parties via MAJESTIC). Sum of data for 10,000 tertiary institutions divided by country's population, July 2017 edition.

**C5:** (4%) Responses to question 'Knowledge transfer is highly developed between companies and universities', asked of business executives in the annual survey by IMD World Development Centre, Switzerland, 2017.

**C6:** (4%) Percentage of university scientific research publications that are co-authored with industry researchers, 2013–15.

The top four nations for Connectivity are, in rank order, Switzerland, Austria, the United Kingdom and the Netherlands. Then come four countries with similar scores: Denmark, Finland, New Zealand and Sweden. Brazil exhibits the largest improvement rising nine places due to an increase in the recorded number of foreign students. Poland has risen six places owing to a much more favourable rating by business. Conversely,

Romania has fallen nine places and Mexico five places mainly due to more negative views held by business. The new data series for joint publications with international authors has occasioned a fall in overall rank of eight places for Hong Kong SAR, presumably due to a difference in the treatment of publications with mainland authors. Colombia would rank 38th if included.

The median percentage for joint international publications (C2) has risen to 48.8 percent. The top two countries are Saudi Arabia (76 per cent) and Switzerland (67 per cent). Next in rank order, all above 60 per cent, are Belgium, Austria, Chile, Singapore and the four Nordic countries. Countries with the largest increases in international authorship (above eight percentage points) are Slovenia, Hungary and Malaysia. For Malaysia, a contributing factor was the increase in scientific publications with foreign companies (C6), albeit from a low base. The six most highly ranked countries for the percentage of scientific articles written with industry are, in rank order, Austria, the Netherlands, Sweden, Denmark, Japan and Hungary. The shares for these countries are in the range 6 to 8 per cent. The median share of joint industry publications in science has increased to 4.7 per cent from 3.8 per cent in last year's ranking.

The top seven countries for knowledge transfer in the IMD survey of business executives (C5) are, in rank order, Switzerland, the United States, the Netherlands, Denmark, Israel, Ireland and the United Kingdom. In rank order, the highest percentage of international students in tertiary education are in New Zealand, Singapore, the United Kingdom, Switzerland, Austria and Australia. Malaysia has improved its rank by eleven to 17th; Australia has fallen three places owing to a fall-off in the share of international students in short-cycle tertiary programs. While there has been some compression of values for Web Impact (C4), the United States is still ranked a clear first followed by Switzerland, Canada, Finland and the United Kingdom.

Below:

### Connectivity Ranking

Rank	Country	Score
1	Switzerland	100.0
2	Austria	91.6
3	United Kingdom	87.5
4	Netherlands	84.2
5	Denmark	81.5
6	New Zealand	80.9
7	Sweden	80.4
8	Finland	80.1
9	Belgium	77.6
10	Singapore	76.8
11	United States	75.9
12	Canada	71.6
13	Germany	71.4
14	Australia	70.7
15	Ireland	70.4
16	Norway	69.2
17	France	65.4

Rank	Country	Score
18	Hungary	61.7
19	Hong Kong SAR	61.5
20	Israel	58.8
21	Czech Republic	57.9
22	Slovenia	54.9
23	Taiwan-China	54.5
24	Japan	52.4
25	Portugal	51.6
26	Saudi Arabia	51.3
27	Italy	50.9
28	Greece	49.2
29	Spain	48.3
30	Slovakia	47.3
31	Korea	44.8
32	South Africa	44.8
33	Malaysia	44.7
34	Bulgaria	43.5

Rank	Country	Score
35	Chile	42.5
36	Thailand	41.1
37	Ukraine	38.7
38	Serbia	37.1
39	Brazil	36.8
40	Poland	36.7
41	Romania	36.5
42	Croatia	36.0
43	Argentina	33.7
44	China	33.5
45	Indonesia	32.4
46	Russia	32.0
47	Mexico	30.4
48	Turkey	25.4
49	India	24.3
50	Iran	24.3



## 3.4 Output (weight of 40%)

The measures used in this module encompass research output and its impact, student throughput, the national stock of graduates and researchers, the quality of a nation's best universities, and employability of graduates. The variables are given below.

**O1:** (10%) Total research documents produced by higher education institutions, 2016.

**O2:** (3%) Total research documents produced by higher education institutions per head of population, 2016.

**O3:** (5%) Average impact of articles as measured by the Category Normalised Citation Impact for documents published 2012–16.

**O4:** (3%) The depth of world class universities in a country. This is calculated as the total scores for a nation's universities in the Shanghai Jiao Tong Index top 500 institutions, divided by population.

**O5:** (7%) The excellence of a nation's best universities calculated by totalling the 2017 Shanghai Jiao Tong Index scores for the nation's three best universities.

**O6:** (3%) Enrolments in tertiary education as a percentage of the eligible population, defined as the five-year age group following on from secondary education, 2015.

**O7:** (3%) Percentage of the population aged 25–64 with a tertiary qualification, 2016.

**O8:** (3%) Number of researchers (full-time equivalent) in the nation per million of population, 2015.

**O9:** (3%) Unemployment rates among tertiary educated aged 25–64 years compared with unemployment rates for those with only upper secondary or post-secondary non-tertiary education, 2016.

The top country in the Output module is clearly the United States. The United Kingdom is second, followed by Australia, Switzerland and Denmark. Canada and Sweden are equal sixth. The top ten countries remain the same as in the 2017 rankings with only minor reordering. The change in the source of the publications data, which affects three of the variables (O1, O2, O3), has not unduly disturbed the ranking in this module. For only three countries has the ranking changed by more than three places: Chile up by six places and Croatia down seven places, both due to changes in the scores on the Shanghai ranking (O4 and O5), and Turkey is up four places, primarily due to more recent data on the participation rate. Colombia would rank 47th if included.

Publications per head of population remain highest in Denmark, Switzerland and Australia, followed by Sweden and Singapore. Switzerland is clearly the top country for the average impact of publications, followed by the United States and the Netherlands. Next in rank order are the United Kingdom, Denmark, Singapore and Belgium. The United States and the United Kingdom clearly dominant the 'best three universities' variable (O5) followed by Canada, Switzerland and Japan. The variable O4 can be interpreted as a rough measure of how easy it is for a student to enrol in a world-ranked institution: Switzerland, Sweden Denmark and Australia are the highest ranked.

Canada and Russia have the most qualified workforce (O7), followed by Japan and Israel, and Ukraine and Korea. The national stock of researchers relative to population is highest in Israel followed by Denmark, Korea and Sweden. Unemployment of the tertiary educated relative to school leavers (O9) is lowest in South Africa, Hungary, the United States, Argentina and Poland. In six countries unemployment is higher for those with a tertiary qualification: Denmark, Malaysia, Mexico, Saudi Arabia, Taiwan-China and Thailand. This result has persisted over several years.

## Below: Output Ranking

Rank	Country	Score
1	United States	100.0
2	United Kingdom	70.1
3	Australia	64.7
4	Switzerland	64.4
5	Denmark	62.9
6	Sweden	62.1
7	Canada	62.1
8	Netherlands	59.7
9	Finland	56.9
10	Israel	55.5
11	Germany	55.0
12	Belgium	54.7
13	France	54.4
14	Norway	54.4
15	Singapore	54.2
16	Ireland	50.1
17	Japan	49.6

Rank	Country	Score
18	Korea	48.1
19	Austria	47.7
20	New Zealand	47.6
21	Hong Kong SAR	46.5
22	China	46.2
23	Taiwan-China	43.9
24	Spain	43.9
25	Italy	42.4
26	Russia	41.0
27	Greece	40.6
28	Portugal	40.1
29	Slovenia	38.0
30	Czech Republic	36.6
31	Poland	35.3
32	Hungary	31.5
33	Saudi Arabia	30.9
34	Slovakia	29.5

Rank	Country	Score
35	Chile	29.5
36	South Africa	29.2
37	Brazil	28.5
38	Argentina	28.4
39	Bulgaria	28.1
40	Turkey	28.0
41	Croatia	27.5
42	Malaysia	27.1
43	Iran	27.0
44	Ukraine	26.5
45	Serbia	25.6
46	Romania	24.2
47	India	20.5
48	Thailand	20.1
49	Mexico	16.9
50	Indonesia	14.7

## 3.5 Overall Ranking

An overall ranking is obtained by summing the module scores out of 100 using weights of 40 per cent on Output and 20 per cent on each of the other three modules. The top five countries, in order, are the United States, Switzerland, the United Kingdom, Sweden and Denmark. The only change from the 2017 rankings is that Denmark and Sweden have swapped positions. Finland and the Netherlands are equal sixth followed by Canada and Singapore with Australia rounding out the top ten. Finland has risen three places because of an improvement in relative performance for the Environment and Connectivity; Singapore has fallen three places owing to falls in the rank for Connectivity and Output.

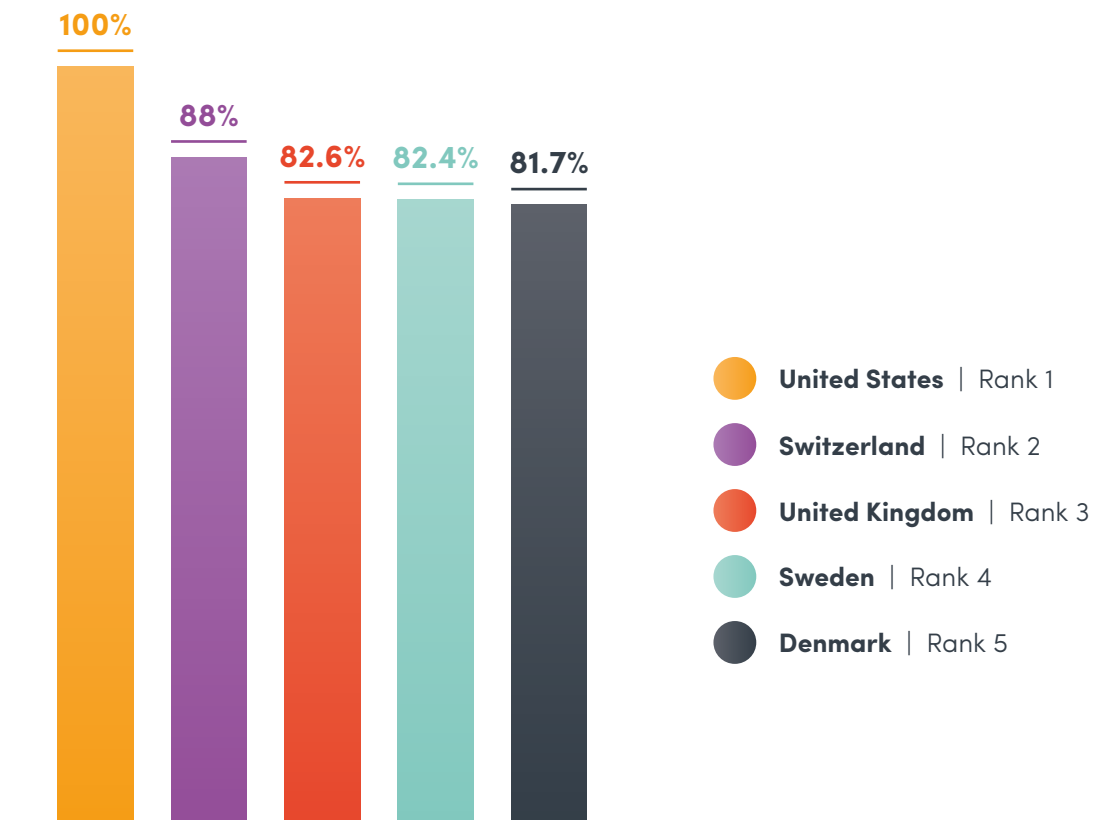
Systems evolve slowly over time. Compared with the 2017 rankings, for 33 of our 50 countries the rank change was at most one. The

largest change was a fall of five places for Hungary arising from reduced government funding. In addition to Singapore, four other countries fell by three places: the Czech Republic, Hong Kong SAR, Serbia and Ukraine. For two countries data changes were the cause of the fall: better information on the degree of autonomy of institutions in Serbia; change in the definition of joint international publications for Hong Kong SAR. In Ukraine, there was a decline in relative expenditure on higher education.

No country improved its rank by more than three. In addition to Finland, four countries improved their rank by three places: Brazil, Greece, Portugal and Slovakia. For Brazil, the rise in rank was due largely to a higher score for Connectivity; for the other three countries, there was an improvement across the board.

Below:

## Top 5 Overall U21 Ranking 2018



## 4. Methodology of adjusting for levels of economic development.

In our main rankings, the performance of a country is measured against world-best practice. But comparisons of performance should also be made with that of countries at similar levels of economic development. More precisely, how well does a country perform on each of our criteria relative to its level of per capita income? To adjust for national levels of income we regress the values for each variable, in original units, on GDP per capita using data for all 50 countries. The GDP we use is for 2015 in US dollars measured in Purchasing Power Parity (PPP) terms. Both linear and quadratic relationships are tried. Logarithmic models performed less well. Given the tenfold range in GDP per capita across our 50 countries, values for countries at the very top and bottom ends of the income range show some sensitivity to functional form. The values of all but one of our 19 variables in the Resources, Connectivity and Output modules increase significantly with GDP per head (the only exception is the unemployment variable, O9). The coefficient on the quadratic term was always negative, implying some tapering of increases at high levels of GDP per capita.

The fitted equation gives the expected value of a variable for a nation's level of income. The difference between the actual and expected value will be positive or negative depending on whether a country performs above or below the expected value. In the few cases where data are missing, we assume that the variable takes the expected value for that country's level of GDP per capita; that is, we assume a deviation value of zero. For the two Output variables based on the Shanghai rankings (O4 and O5) the presence of zero values limits the use of regression, so

instead, we rank the countries by GDP per capita and take a moving average of actual scores to derive more robust estimates of predicted values.

In aggregating over variables, we first express deviations from the regression line as a percentage of the average of the actual and predicted values. To use the percentage deviations from the line would ignore the fact that the predicted values below the line are capped at 100 per cent, whereas there is no limit above the line. Our method ensures symmetry in that values that are half what is expected at a given level of GDP per capita have the same influence as values that are double those expected. By construction, our calculated deviations lie in the range -200 per cent to +200 per cent. The average deviation for each module is a weighted sum of the deviations for each of the measures within the module. The method of measuring deviations needs to be borne in mind when interpreting the weighted average numerical scores for each module and for the overall ranking.

We use the same dependent variables and weights as described in section 3 with two exceptions. The exceptions are research expenditure (R4 and R5) and publication output (O1 and O2) where in each case we had a measure expressed in two different forms. This becomes unnecessary when we control for differences in income levels. We delete R5 and move the weight to R4, so that each of the four measures of Resources has a weight of 5 per cent in the overall ranking. In the output module, we use as a single publication measure the number of articles divided by (total) GDP, thus combining O1 and O2 (the weights are added).

## 5. Results after adjusting for levels of economic development

### 5.1 Resources

Expenditures are best described by a linear relationship with GDP except for research expenditure where a quadratic curve fits best. The highest ranked countries for resources are Malaysia and Serbia where expenditures are nearly 40 per cent more than what is expected given their income levels. Resources devoted to higher education are 25 to 30 per cent more than expected in Canada, Finland, Sweden and Ukraine and around 22 per cent above expected for Denmark and Saudi Arabia.

Compared with the non-adjusted rankings, the countries showing the largest increase in rank are South Africa (up 32 places to 9th), India (up 28 places to 11th), Serbia (up 27 places to first) and China (up 25 places to 19th). At the top end of the income range, Singapore falls from third to 32nd and the United States from sixth to 17th.

Turning to the four variables that are included in the Resources module, government expenditure and total expenditure on higher education show only slight increases as a share of GDP as income levels rise. For each ten-thousand-dollar increase in GDP per capita, government expenditure is estimated to increase by only 0.06 per cent of GDP and total expenditure by 0.08 per

cent. It follows that rankings are like those discussed in section 3.1. The top five countries for the level of government expenditure after adjusting for GDP per capita are Ukraine, Saudi Arabia, Finland, Austria and Malaysia. The highest ranked countries for total expenditure as a share of GDP are now Canada, Malaysia, the United States, Ukraine, Saudi Arabia, Korea and Chile. Expenditure (which includes research expenditure) per student increases markedly with income levels: on average by around USD352 for each USD1,000 increase in GDP per capita ( $R^2 = 0.73$ ). The top three countries on an income-adjusted basis are, in order, South Africa, Malaysia and Brazil (data for public institutions only). Next in rank are the United Kingdom, the United States, Sweden and India.

Research expenditure in higher education as a share of GDP increases with GDP per capita, but at a declining rate. The quadratic regression estimates imply that at GDP per capita of USD25,000 the expected expenditure on R&D is 0.31 per cent of GDP whereas the corresponding figure at GDP per capita of USD50,000 is 0.57. The top eight countries for research expenditure as a share of GDP are now Serbia, South Africa, Denmark, Portugal, Sweden, Switzerland, Finland, and Turkey.

### 5.2 Environment

In principle, the creation of a favourable environment is independent of income levels so we do not carry out regression analysis. Instead, we use mean values for expected values and calculate the percentage deviation from expected as was done in other modules. The rankings are necessarily very like those for the unadjusted data.

The scores for the top four countries (the United States, Australia, New Zealand and Singapore) are around 20 per cent above expected values.

## 5.3 Connectivity

All five connectivity measures are positively related to levels of GDP per head. For all but joint international publications (C2), the R2 values are in the range 0.37 to 0.55. The relationship between joint international publications and GDP, while significant, is weaker than in last year's ranking. Recall that a different data source is used this year. The top five countries for Connectivity, after adjusting for income levels, are, in rank order, Ukraine, the United Kingdom, New Zealand, Austria and Switzerland. Compared with the unadjusted data it is of course lower income countries that show the greatest improvement in rank. In addition to Ukraine, four countries increase their rank by around 20 places: South Africa (to 10th), Serbia (to 16th), Brazil (to 22nd) and India (to 26th). Conversely, at the high-income end, Norway, Saudi

Arabia and Singapore all fall by around 20 places.

The equation for international co-authorship (C2) implies that for each USD10,000 increase in GDP per capita, the percentage of articles that have an international co-author increase by approximately 4 percentage points. The top three countries are Chile, Saudi Arabia and South Africa, unchanged from the 2017 rankings despite the change in data source.

Knowledge transfer is rated most highly by business (C5) in Israel, Malaysia and China. Joint publications with industry are ranked highest in Ukraine, Hungary, Indonesia, and South Africa, after allowing for levels of income.

## 5.4 Output

All but one of the Output measures (unemployment, O9) show a significant increase with levels of GDP per capita but for most measures the increase flattens out at high income levels. Two Output measures show a particularly strong relationship with GDP per capita ( $R^2 > 0.6$ ): impact as measured by citations (O3) and researchers per head of population (O8). The impact measure picks up not only the quality of research but its nature: applied research in developing countries is less likely to be highly referenced despite its relevance for economic development.

The top five ranked countries for Output are Serbia, Israel, Portugal, Israel, Greece and the United Kingdom. For these countries, Output is more than 25 per cent above expected values for their levels of income. Compared with the unadjusted rankings, Serbia's rank increases by 44 places; the ranks of Iran, Greece, Portugal and South Africa improve by between 20 and 30 places; and the ranks of Brazil, Chile, China and India increase by between 10 and 20 places. The United States falls 14 places to 15th and similar falls in rank are recorded for Ireland, Germany, Japan and Saudi Arabia.

Turning to the components, the top seven countries for publications (measured as the number of research documents deflated by total GDP) are now Serbia, Portugal, Singapore, Slovenia, Denmark, Australia and India. After adjusting for differences in income levels, the impact of publications (O3) is highest for South Africa, India, the United Kingdom, Italy and Switzerland. China, the United States and the United Kingdom are ranked at the top for the quality of the best three universities; next in rank order are Russia and Brazil.

After allowing for income levels, Ukraine is ranked first on participation rates (O6), followed by Greece, Turkey, Chile, Argentina and Korea. Ukraine also comes first on tertiary qualifications of the workforce (O7), followed in rank order by Russia, Israel, Canada, Japan and Korea. Serbia and Israel are first for researchers per head of population; next in rank are Korea, Finland, Denmark, Sweden and China.

## 5.5 Overall Ranking

The overall score is calculated by weighting the percentage deviations for each module using the same weights as for the unadjusted data: Resources (20%), Environment (20%), Connectivity (20%) and Output (40%). The median aggregate score is minus 8.6 per cent so that a score above this level can be interpreted as being above average for the 50 countries we consider.

The top ranked countries after allowing for income levels are Finland and the United Kingdom, where the scores imply on overall performance of 20 per cent above the average level of achievement for countries at their income levels. Next in rank order are Serbia, Denmark, Sweden, Portugal, Switzerland and South Africa.

Compared with the original rankings in Section 3, nine countries

improve their ranking by more than ten places. Serbia, South Africa and India improve by more than 20 places. The countries that improve by between eleven and twenty places are Brazil, China, Greece, Iran, Portugal and Ukraine.

The largest fall in rank compared with the Section 3 results is that of Saudi Arabia. The United States is measured as performing above expected values but nevertheless falls to 15th position; similarly, Singapore, the country with the with the highest income levels now ranks only 21st. Ireland falls substantially in rank to 36th, but this is heavily influenced by its high GDP per capita measured in purchasing power parity: it is the third highest among our 50 countries. Given the large number of foreign companies in Ireland, Gross National Income would probably be a more appropriate measure than Gross Domestic Product.



Rank	Resources	% Dev	Environment	% Dev	Connectivity	% Dev	Output	% Dev
1	Serbia	39.1	United States	26.1	Ukraine	58.4	Serbia	37.5
2	Malaysia	37.9	Australia	20.1	United Kingdom	35.0	Israel	33.8
3	Ukraine	29.1	New Zealand	19.9	New Zealand	33.2	Portugal	32.7
4	Sweden	26.1	Singapore	16.2	Austria	31.8	Greece	32.3
5	Finland	25.9	Finland	15.8	Switzerland	27.2	United Kingdom	25.4
6	Canada	24.9	Hong Kong SAR	13.8	Finland	24.4	Denmark	18.8
6	Denmark	22.5	United Kingdom	13.7	Hungary	21.3	Australia	17.8
8	Saudi Arabia	21.0	Netherlands	12.4	Denmark	17.3	Finland	17.5
9	South Africa	19.0	Taiwan-China	12.1	Netherlands	17.0	South Africa	16.2
10	Turkey	17.7	Belgium	9.6	South Africa	16.6	China	15.0
11	India	17.3	Switzerland	7.4	Belgium	14.0	Sweden	13.9
12	Austria	17.0	Sweden	6.8	Sweden	11.4	Switzerland	11.1
13	Brazil	14.6	China	5.1	Czech Republic	9.9	Canada	9.2
14	Switzerland	11.3	Canada	5.0	Canada	5.4	New Zealand	6.4
15	Portugal	8.6	Malaysia	4.3	Australia	5.1	United States	4.9
16	Netherlands	6.8	Poland	4.2	Serbia	4.6	Netherlands	4.9
17	United States	1.5	Norway	3.9	Portugal	3.6	Belgium	2.9
18	Belgium	-0.5	Ireland	3.8	Greece	3.0	Singapore	1.2
19	China	-0.9	Israel	3.5	Bulgaria	2.1	Slovenia	-0.9
20	France	-0.9	Chile	1.8	Germany	1.9	France	-1.7
21	Norway	-1.2	Denmark	1.6	France	0.4	Brazil	-2.5
22	Israel	-1.4	France	1.1	Brazil	-0.4	Iran	-3.3
23	Mexico	-1.5	Austria	1.0	Israel	-6.4	Chile	-3.8
24	Greece	-2.1	Japan	0.7	United States	-9.3	Poland	-6.3
25	New Zealand	-3.9	South Africa	-0.7	Slovenia	-9.6	Spain	-8.3
26	Australia	-4.4	Mexico	-1.8	India	-11.2	Italy	-11.5
27	Poland	-4.7	Germany	-2.0	Slovakia	-11.6	Norway	-12.7
28	Korea	-5.3	Thailand	-2.1	Romania	-15.2	Korea	-13.7
29	Slovakia	-5.8	Russia	-2.2	Thailand	-16.3	Czech Republic	-14.2
30	United Kingdom	-6.0	Indonesia	-3.0	Ireland	-16.6	India	-16.0
31	Czech Republic	-6.7	Spain	-4.4	Singapore	-19.3	Germany	-18.2
32	Singapore	-9.3	Czech Republic	-4.6	Italy	-19.4	Austria	-20.1
33	Germany	-12.2	Argentina	-4.9	Hong Kong SAR	-20.4	Malaysia	-21.7
34	Hong Kong SAR	-13.7	Romania	-5.0	Taiwan - China	-21.5	Ireland	-23.7
35	Spain	-16.5	Portugal	-6.2	Spain	-22.7	Hong Kong SAR	-26.6
36	Japan	-19.2	Slovenia	-7.0	Malaysia	-23.1	Argentina	-27.2
37	Iran	-19.7	Ukraine	-8.9	China	-25.0	Japan	-29.9
38	Argentina	-19.9	Italy	-9.7	Norway	-26.0	Russia	-33.1
39	Chile	-21.9	Slovakia	-13.8	Japan	-30.1	Taiwan - China	-34.5
40	Croatia	-22.3	Iran	-14.4	Poland	-34.2	Turkey	-39.0
41	Slovenia	-22.4	Brazil	-17.5	Indonesia	-34.6	Croatia	-42.0
42	Italy	-29.6	Korea	-17.6	Chile	-40.8	Bulgaria	-47.6
43	Thailand	-35.0	Hungary	-18.0	Korea	-44.0	Ukraine	-47.9
44	Romania	-35.1	Bulgaria	-18.6	Croatia	-45.1	Hungary	-52.9
45	Taiwan - China	-37.8	Saudi Arabia	-19.5	Russia	-49.5	Slovakia	-56.2
46	Russia	-39.0	India	-19.7	Argentina	-58.9	Thailand	-61.2
47	Hungary	-42.4	Turkey	-23.0	Saudi Arabia	-61.1	Romania	-63.1
48	Ireland	-53.7	Croatia	-28.3	Mexico	-66.3	Saudi Arabia	-81.0
49	Bulgaria	-54.1	Serbia	-31.6	Turkey	-72.4	Mexico	-81.2
50	Indonesia	-62.4	Greece	-56.3	Iran	-73.9	Indonesia	-127.2

%dev = percentage deviation from expected value at nation's level of GDP per capita

Overleaf:

## National Rankings Controlling for Level of Economic Development



- **Resources:** Serbia | Rank 1
- **Environment:** United States | Rank 1
- **Connectivity:** Ukraine | Rank 1
- **Output:** Serbia | Rank 1

Above:

## Top National Rankings for Modules Controlling for Level of Economic Development

Below:

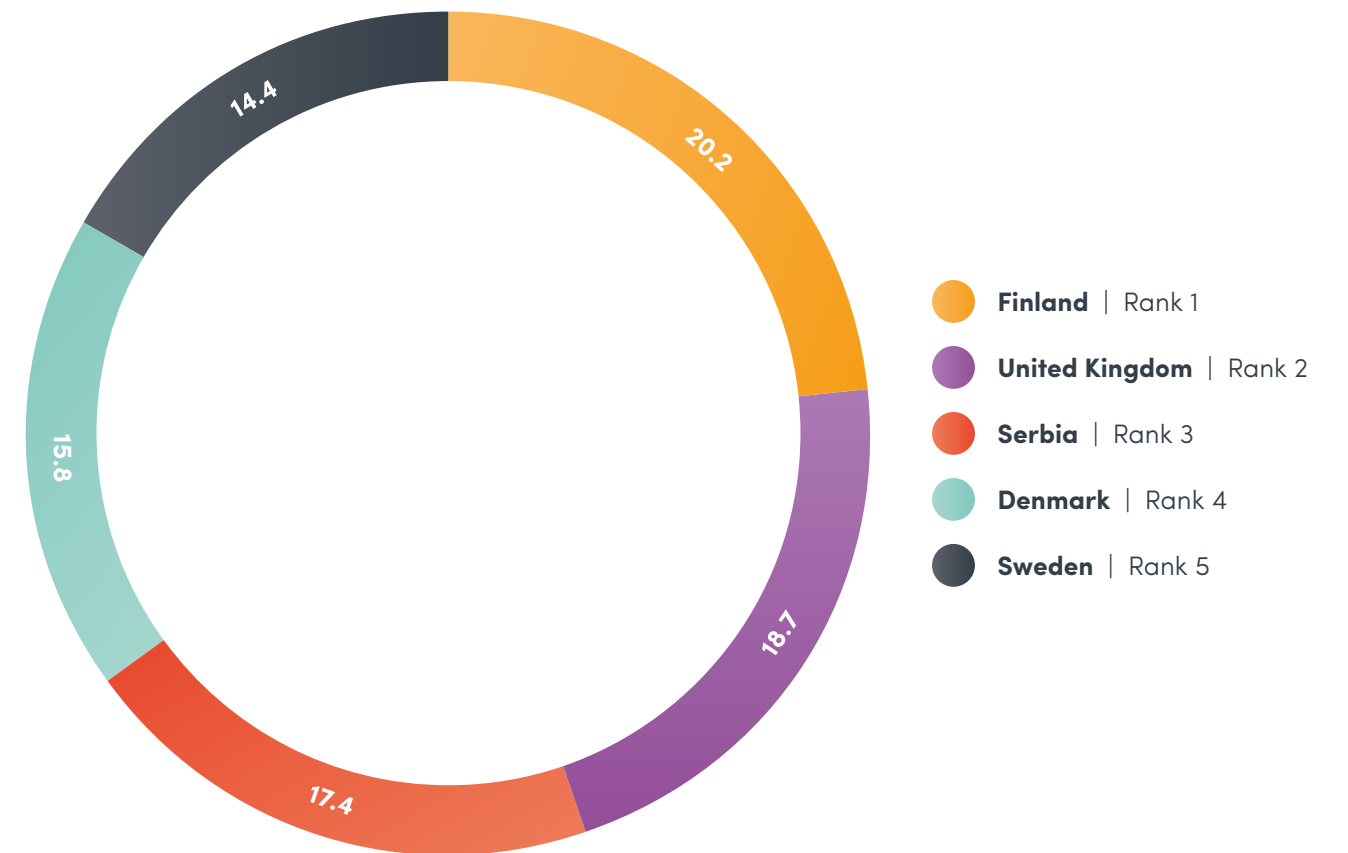
## Overall Ranking Controlling for Level of Economic Development

Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
1	Finland	20.2	18	China	1.8	35	Japan	-21.7
2	United Kingdom	18.7	19	France	-0.6	36	Ireland	-22.8
3	Serbia	17.4	20	Brazil	-1.6	37	Iran	-22.9
4	Denmark	15.8	21	Singapore	-2.0	38	Taiwan - China	-23.3
5	Sweden	14.4	22	Ukraine	-3.4	39	Argentina	-27.6
6	Portugal	14.3	23	Malaysia	-4.9	40	Slovakia	-28.7
7	Switzerland	13.6	24	Czech Republic	-6.0	41	Hungary	-29.0
8	South Africa	13.4	25	Slovenia	-8.1	42	Turkey	-31.1
9	Israel	12.7	26	India	-9.1	43	Russia	-31.4
10	New Zealand	12.4	27	Poland	-9.4	44	Bulgaria	-33.2
11	Australia	11.3	28	Norway	-9.7	45	Thailand	-35.2
12	Canada	10.8	29	Germany	-9.7	46	Croatia	-36.0
13	Netherlands	9.2	30	Spain	-12.0	47	Romania	-36.3
14	Belgium	5.8	31	Chile	-13.7	48	Saudi Arabia	-44.3
15	United States	5.6	32	Hong Kong SAR	-14.7	49	Mexico	-46.4
16	Austria	1.9	33	Italy	-16.3	50	Indonesia	-70.9
17	Greece	1.8	34	Korea	-18.9			

%dev = percentage deviation from expected value at nation's level of GDP per capita

Below:

## Top 5 Ranking Controlling for Level of Economic Development



# 6. Using the findings to improve performance.

Ranking provides a valuable indication of how a country benchmarks against other countries in a range of measures. But we can go further than this and look at the relationships between

our variables which can throw light on what makes a good higher education system. Moreover, we can use our seven years of data to explore lagged responses to change.

## 6.1 Aggregate Relationships

Of our four modules, two are inputs (Resources and Environment) and two measure outcomes (Output and Connectivity).

The relationship between inputs and outcomes provides an indicator of the efficiency of systems. Outcomes are measured by combining the scores for Resources and Connectivity using the same weights as before. There is a need to recognise that there will be a lag between an increase in Resources and an improvement in Outcomes. Because the Outcomes data relate primarily to 2016, whereas the data for Resources are heavily

weighted towards 2014, taking all data from the current ranking has an inbuilt lag of two years. We explore the lagged behaviour further by using, in turn, the Resources' scores for each year of previous rankings. The results are not especially sensitive to the choice of the lagged value for Resources, but the best fit is obtained by using the values from the 2016 ranking (data for 2012): an average lag of four years between an increase in Resources and subsequent improvements in Outcomes. The estimated equation, with standard errors in parentheses, is:

$$\text{Outcomes} = -27.79 + 0.593 \text{ Resources } (-4) + 0.573 \text{ Environment} \quad R^2 = 0.741, n = 50 \text{ countries}$$

(10.59) (0.079) (0.157)

Both Resources and Environment exert a significant effect on outcomes and together they explain 74 per cent of the variation in Outcomes. The point estimates imply that for each 1 point increase in the Resources score, the Outcomes score increases by 0.59; the corresponding effect for Environment is 0.57. The general conclusion is that Resources and the policy Environment are both key factors determining outcomes and they are roughly of equal importance.

Several commentators have emphasised the desirability of institutional financial autonomy. If the aggregate measure of the Environment is replaced by such a measure (E4.3) the coefficient is positive and significant (coefficient of 0.150 with a t-value of

2.0), but the explanatory power of the equation is reduced ( $R^2 = 0.695$ ). This implies that while financial autonomy matters, other features of the higher education environment, such as the monitoring of standards (E4.2), are also important.

Lagged effects will be picked up more precisely for subsets of measures. The time intervals between increases in inputs and resultant increases in outcomes will vary greatly with the type of outcome. For example, the lag between an increase in resources and the full effect on the percentage of the work force with a tertiary qualification will be measured in decades. In the next sub-section, we look at the lag between an increase in research funding and an increase in publications.

## 6.2 Research Output

### Quantity:

As expected, there is a strong positive relationship between research expenditure and publications, albeit the effect tails off a little at high levels of expenditure. Regressing publications per capita (O2) on research expenditure per capita (R5) and its square, we find that the best explanation is obtained by using research expenditure from our 2015 rankings. This implies an average lag of four years between an increase in research funding and publications. (The actual data relate to 2016 for publications and 2012 for funding.) Funding levels explain 86 per cent of the country differences in research publications. But some countries do very much better than expected. If we look at the 25 countries that are ranked highest for publications per head of population, six countries perform at more than 20 per cent above expected: Australia, Portugal, New Zealand, Slovenia and the United Kingdom. On the other hand, Germany and Austria fall more than 20 per cent below expected values. Factors that can cause divergence between funding and publications include the areas of research, the importance of performance based funding, the source of research funds, and whether government research funds are concentrated on selected institutions.

### Quality / Impact:

There is a relatively strong positive relationship between the number of articles published, O1, and their average impact as measured by standardized citations, O3 (correlation coefficient of 0.845). It follows that impact can also be increased by the same means as output: through research funding. But another factor that may increase the impact of research is joint publication with international authors. In this way research programs are more immediately known in more than one country. Our data confirm this hypothesis: the correlation between impact (O3) and joint international authorship (C2) is 0.64 (0.69 if the United States is excluded). There is also a similar positive correlation between impact and joint scientific research with industry ( $r = 0.64$ ).

### Does concentration of research in selected institutions matter?

In the absence of appropriate data on research funding we define concentration as the percentage of research output that is produced by the top 10 per cent of tertiary institutions. Incites data is again used for 2016. Institutions with less than 100 publications are excluded. For countries with fewer than ten institutions the share of the top university is calculated, for between ten and less than 20 institutions we take the top 2, and so on. The median level of publications attributable to the top ten per cent of institutions is 43.1 per cent. The performance of each country is as follows (in rank order):

**60%+:** Slovenia, Saudi Arabia, Croatia, Serbia

**50-60%:** Portugal, Norway, Bulgaria, Mexico, Brazil, China, Argentina, Belgium, France, USA

**40-50%:** Japan, UK, Canada, Sweden, India, Ireland, Chile, Russia, Thailand, Taiwan-China, Indonesia, Korea, Australia, Iran, Slovakia, Israel, Greece

**30-40%:** Malaysia, Hungary, South Africa, Spain, Czech Republic, Singapore, Turkey, Switzerland, Italy, Denmark, Poland, New Zealand, Romania, Austria, Finland, Germany

**<30%:** Hong Kong SAR, Netherlands, Ukraine

To test for the influence of this measure of research concentration we add it to research expenditure as a potential explanation of research publications. It does exert a positive effect on national publications but the coefficient is not statistically significant at conventional levels (t-value is 0.9). Our concentration measure fails to explain differences in the number of research publications. We note that several smaller western European countries have low concentration ratios but most institutions are relatively well funded.

## 6.3 Engagement with Industry

The two measures that we use for engagement with industry are business ratings of the degree of knowledge transfer (C5) and joint scientific publication (C6). Links measured by C5 are likely to cover a wider range of businesses and activities than those in C6; they may also be more embedded in the operations of firms. If the two measures are combined, the best performing countries are the small western European nations of the Netherlands, Austria, Switzerland, Denmark, Sweden, Belgium and Finland. In countries with smaller populations, academics and business people, through personal interaction, are more able to know the needs and capabilities of each other. Next in order for combined strength in engagement with industry are the large industrialised countries of Germany, the United States, the United Kingdom and Japan. Countries where overall engagement with industry is lowest are Brazil, Iran and Turkey. Engagement is also relatively low in India, Mexico and Russia.

Relationships with industry reveal different emphasis between countries on informal links through knowledge transfer (C5)

versus 'basic research links' as exhibited through joint publications (C6). While there is an overall positive correlation between the two measures ( $r = 0.51$ ), in many countries the strength of engagement lies much more in one of the measures. An interesting pattern emerges with knowledge transfer ranking much higher than joint publications in many East Asian countries, whereas the converse is true for Eastern Europe. Of the eight countries where knowledge transfer ranks at least 15 positions better than joint publications, five are in East Asia: Malaysia, Singapore, Hong Kong SAR, China and Taiwan-China. The other three countries are Ireland, Saudi Arabia, and Israel. Of the nine countries where the rank for joint publications is at least 15 better than for knowledge transfer, seven are in Eastern Europe: Hungary, Slovenia, Croatia, Bulgaria, Czech Republic, Slovakia and Ukraine. The other two countries are Greece and Japan. Relating these findings to economic growth, while it is preferable to engage with industry on all fronts, for economic development it appears that knowledge transfer in all its forms is more important than joint publications.

## 7. Research Training

Research training is an important function of institutions of higher education. Through the training of new researchers, universities provide the innovators of the future and thus contribute to improvements in standards of living. A highly skilled labour force is particularly important for countries near the technology frontier where growth requires new inventions and innovations (Vandenbussche, Aghion and Meghir (2006)).

We concentrate analysis on PhD students: the ISCED level 8 classification. While many masters programs have a significant research training component, the ISCED classification 7 covers a wide range of programs which make the data less suitable for our purposes. National PhD programs provide future researchers for both the nation and, increasingly, other nations, through the enrolment of foreign students. This complicates the definition of what is a good national system of higher education. A good PhD program contributes to both future national and non-national growth. Of course, many international students remain in their country of training; many of those who return home will maintain links with the host country to the benefit of all parties.

The first three data columns of the Research Training table look at the scale and composition of PhD degree programs. We use graduation numbers as the measure. The data are taken from the OECD and UNESCO data bases. Data are not provided for Hong Kong SAR, Singapore and Taiwan-China. For the 47 included countries, the mean number of PhD graduates per hundred thousand population is 20.7. The top seven countries on this measure are, in rank order, Switzerland, the United Kingdom, Slovenia, Denmark, Ireland, Australia and Germany. But one-half of the Swiss PhD graduates are non-nationals, the highest of any country for which we have the data; similarly, 43 per cent of PhD graduates in the United Kingdom are international students. The other countries where over one-third of PhDs are granted to international students are Australia, Belgium, France,

the Netherlands, New Zealand, Sweden, and the United States. (The percentages for France and the United States relate to PhD enrolments.) The ability to attract international students to PhD programs is in itself a measure of the quality of faculty and programs.

One measure of the worth of a PhD training is salary levels. The fourth data column contains data on earnings of those with a master's or doctorate compared with earnings by those with a bachelor's degree. In all the 25 countries for which we have data, those with the advanced degree earn more and the median earnings premium is 35 per cent. The highest earnings premiums (80 to 100 per cent) are in Austria, Brazil, Mexico and Chile. The lowest earnings premiums (20 per cent or less) are in Poland, Germany, Ireland, the United Kingdom and Switzerland.

PhD students are trained by research-active academics. OECD estimates of researchers in higher education are given in the middle section of the table for 33 countries. The caveat to the data is that there seem to be some differences across countries on the classification of qualified support staff and classification of academic staff. Notwithstanding these difficulties, countries that rank the highest on researchers in higher education are Denmark, Australia, the United Kingdom, Portugal, Finland and Switzerland. Not surprisingly, there is negative correlation ( $r = -0.41$ ) between the earnings premium and the stock of PhD researchers in higher education.

By combining the data on PhD completions and researchers it is possible to obtain estimates of PhD graduates per researcher. This is done in the last two columns of the table. The countries which have the highest values here are Mexico, Slovenia, Russia, Korea and Germany. The ratio is a measure of the speed with which the number of researchers in the nation is being increased.



Country	PhD Completions (2015 or latest)			PhD and Master's Earnings vs Bachelor's	HE Researchers (fte)		PhD graduates per researcher	
	Per 100k pop	Rank	% International		Per 100k pop	Rank	Ratio	Rank
Argentina	4.8	40	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Australia	35.9	6	37.2	1.25	285.4	2	0.13	26
Austria	25.1	15	30.0	2.01	155.9	15	0.16	18
Belgium	23.0	17	38.5	1.38	210.4	9	0.11	30
Brazil	8.2	37	2.4	1.91	n.a.	n.a.	n.a.	n.a.
Bulgaria	20.2	25	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Canada	21.1	22	23.4	1.29	168.3	13	0.13	28
Chile	3.4	43	5.0	1.78	22.2	31	0.15	20
China	4.0	42	2.4*	n.a.	21.7	32	0.18	15
Croatia	20.9	23	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Czech Republic	22.8	18	14.1	1.26	107.8	22	0.21	9
Denmark	38.4	4	32.1	1.49	286.0	1	0.13	24
Finland	33.7	9	25.1	1.35	223.7	6	0.15	21
France	21.4	21	40.1*	1.49	114.1	20	0.19	13
Germany	35.8	7	16.7	1.17	125.1	17	0.29	5
Greece	14.7	31	n.a.	1.23	210.7	8	0.07	33
Hungary	12.2	33	7.1	1.36	56.9	28	0.21	8
India	1.8	46	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Indonesia	2.1	45	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Iran	9.3	36	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Ireland	37.3	5	22.3	1.19	202.2	11	0.18	14
Israel	19.2	28	3.8	1.31	115.1	19	0.17	16
Italy	17.2	29	11.4	n.a.	79.4	26	0.22	7
Japan	12.4	32	18.2*	n.a.	108.0	21	0.11	29
Korea	25.3	14	8.7*	1.31	80.1	25	0.32	4
Malaysia	11.4	34	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Mexico	5.0	39	n.a.	1.89	11.9	33	0.42	1
Netherlands	27.5	12	41.8	1.40	131.7	16	0.21	10
New Zealand	28.6	11	51.2	1.30	210.9	7	0.14	23
Norway	26.5	13	26.4	1.38	207.6	10	0.13	25
Poland	10.0	35	1.9*	1.16	105.6	23	0.09	31
Portugal	22.6	19	16.3	n.a.	253.8	4	0.09	32
Romania	20.1	26	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Russia	20.7	24	2.8	n.a.	64.5	27	0.32	3
Saudi Arabia	1.4	47	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Serbia	15.3	30	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Slovakia	35.3	8	7.3	1.42	156.9	14	0.22	6
Slovenia	39.3	3	6.3	n.a.	100.3	24	0.39	2
South Africa	4.1	41	n.a.	n.a.	28.8	30	0.14	22
Spain	24.4	16	16.2	n.a.	123.0	18	0.20	12
Sweden	30.5	10	41.1	n.a.	184.1	12	0.17	17
Switzerland	46.5	1	54.3	1.20	227.7	5	0.20	11
Thailand	2.9	44	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Turkey	6.6	38	4.1	n.a.	52.4	29	0.13	27
Ukraine	19.4	27	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
United Kingdom	40.5	2	43.4	1.20	259.1	3	0.16	19
United States	21.5	20	37.8*	1.40	n.a.	n.a.	n.a.	n.a.

\* Percentage of enrolments (2015); n.a. indicates not available

## 8. Concluding Remarks

The paper has considered a range of measures for evaluating the quality of national systems of higher education. In our core ranking we measure performance under four headings: Resources, Environment, Connectivity and Output. We recognise that a nation's performance should be measured both against best practice and against that of countries at similar levels of economic development.

It is beyond the scope of this paper to measure the contribution of the higher education sector to economic growth. However, we can note the importance of time lags. The quality and quantity of new graduates can be improved through funding and the monitoring of performance, but new graduates are only a relatively small percentage of the labour force. It will be several decades before most of the labour force reflect the new model. The effect can be speeded up, though, by appropriate further education for older workers. On the other hand, investment in research activity may contribute to economic growth relatively quickly. The constraint may be a labour force that cannot use innovation wisely. There is evidence that an educated workforce more readily accepts and adapts to new ways of doing things.

In section 7 we noted the relatively large number of international graduates from PhD programs, especially in high-income countries. The same is true at the undergraduate level. More generally, internationalisation affects most of the activities of tertiary institutions. In our rankings, we partly deal with this through our connectivity measures, but there is another

dimension: national systems educate and train non-nationals, thus contributing to growth in other countries, at least for those who return home. Another aspect of internationalisation that we do not explicitly refer to is the setting up of foreign campuses by some of a nation's institutions. We treat them the same as other institutions in the destination country. This seems appropriate as they are akin to a nation sub-contracting part of its education system.

Finally, some remarks on what is a good system of higher education: There is no single best model. Resources are very important but it is not crucial where they come from. Salmi (2017b, p.120) points to three types of relatively well-funded systems:

- (i) public provision to public institutions (the Nordic countries, Saudi Arabia and Switzerland);
- (ii) predominantly public institutions with both public and private funding (Australia, Canada, England, Hong-Kong SAR, the Netherlands and New Zealand);
- (iii) mixed system of private and public institutions both resourced by a mixture of private and public funding (Chile, China, Japan, Malaysia, Korea and the United States).

On top of this overlays the policy environment, which should combine financial and academic autonomy for institutions, combined with external monitoring of performance. Efficiency is promoted by a diverse system, and institutional competition for students and resources.

Overleaf:  
Research Training Ranking

## Appendix 1. Sources

**R1 and R2:** OECD, Education at a Glance, 2017, Table B2.3 and UNESCO, Institute for Statistics ([www.uis.unesco.org](http://www.uis.unesco.org))

**R3:** OECD, Education at a Glance, 2017, Table B1.1; UNESCO, Institute for Statistics; and IMF, Data and Statistics. UNESCO student numbers converted to full-time equivalents using average for countries where both sets of student data exist

**R4 and R5:** UNESCO, Institute for Statistics and IMF, Data and Statistics

**E1 and E2:** UNESCO, Institute for Statistics

**E4:** OECD, Education at a Glance 2017; UNESCO; surveys as described in Appendix 2

**E5:** World Economic Forum, The Global Competitiveness Report 2016–17, Table 5.03.

**C1:** OECD, Education at a Glance 2017, Table C4.1; UNESCO

**C2:** InCites based on Web of Science databank ([www.clarivate.com/products/incites](http://www.clarivate.com/products/incites))

**C4:** Webometrics ([www.webometrics.info](http://www.webometrics.info)), July 2017 version.

**C5:** IMD World Competitiveness Report 2017, Table 4.3.23, World Competitiveness Center, Institute for Management Development, Lausanne, Switzerland.

**C6:** CWTS, Leiden University

**O1, O2 and O3:** InCites based on Web of Science databank ([www.clarivate.com/products/incites](http://www.clarivate.com/products/incites))

**O4 and O5:** Shanghai Jiao Tong University Rankings, 2017 ([www.shanghairanking.com](http://www.shanghairanking.com))

**O6:** UNESCO, Institute for Statistics

**O7:** OECD, Education at a Glance, 2016, Table A1.1; ILOSTAT ([www.ilo.org](http://www.ilo.org)); UNESCO, Institute for Statistics

**O8:** UNESCO, Institute for Statistics

**O9:** OECD ([www.stats.oecd.org](http://www.stats.oecd.org)) and ILOSTAT ([www.ilo.org](http://www.ilo.org))

## Appendix 2: The Survey Components of E4: Qualitative measure of the environment

The qualitative measures of the environment are based on responses to questionnaires. Replies were obtained from U21 representatives, government agencies and educational research institutes. The survey for E4.2 was originally carried out in 2012; the survey for E4.3 was undertaken in 2015. The responses have been updated as appropriate.

**E4.2:** The eight survey questions cover the following areas:

- Are there agencies that monitor standards of public tertiary institutions?
- If agencies exist are their findings made public?
- Are there agencies that monitor standards of private tertiary institutions?
- If agencies exist are their findings made public?
- The degree to which academics in public tertiary institutions are not government employees.
- Are academics in public research universities free to move to another university without government approval?
- Degree of freedom institutions have in choosing the CEO of a public research university.
- Degree of freedom to appoint foreign academics to ongoing positions?

**E4.3:** This was a survey primarily of the financial autonomy of publicly funded institutions.

The categories of responses draw on those used by the European University Association (EUA) given on the EUA Autonomy in Europe website ([www.university-autonomy.eu](http://www.university-autonomy.eu)).

The six survey questions cover the following areas:

- To what extent is core public funding untied?
- Can institutions make market-adjustment allowances for academic staff in high demand?
- To what extent are institutions permitted to keep cash surpluses?
- What ability do institutions have to borrow money?
- To what extent can public institutions levy tuition fees for national (domestic) students?
- What freedom do institutions have over Bachelor degree programs offered?

# References and Further Reading

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# Country Summaries

## Argentina

Argentina ranks 40th overall, which combines ranks of 40 in Resources, 32 in Environment, 43 in Connectivity and 38 in Output. In the Resources category, the level of government expenditure on higher education as a share of GDP is ranked at 19 but total expenditure per student is ranked much lower at 45. The difference is explained by the high enrolment rate, ranked at 14. Among the Connectivity variables, the best ranking (29th) is for articles written jointly between academics and international collaborators and the worst rank is (45th) for articles written jointly with researchers from industry. Published articles per head are ranked at 44 and their average impact is ranked at 41. Argentina is ranked highly at 4 for employment of graduates compared with school leavers. When the rankings are adjusted for differences in GDP per capita Argentina is ranked at 39; its overall score is below that expected for its level of income.

## Australia

Australia ranks 10th overall, which combines ranks of 14 for Resources, 2 for Environment, 14 for Connectivity and 3 for Output. The ranking for Resources is pulled down by the low ranking (41st) for government expenditure on higher education, although the official data do not reflect the full cost of the student loans scheme. Private expenditure exceeds public expenditure and total expenditure as a share of GDP is ranked 8th, an improvement from 17th last year following an expansion in total enrolments. Expenditure per student is static at 11th. In the Connectivity measures, Australia has fallen to 6th on international student numbers owing to a fall in their share of non-university tertiary enrolments. Links with the private sector are at average levels: 31st for joint publications with industry and 20th for knowledge transfer. Australia is ranked ninth on total publications and 14th on their average impact. On a per capita basis, it ranks third on research publications compared with tenth on research expenditure—an indicator of efficiency. Australia ranks tenth for the (tertiary) educational qualifications of the labour force but fourth for enrolment rates. On a per capita basis, the national

stock of researchers is ranked 14th but the annual number of PhD completions is ranked sixth, 37 per cent of whom are international. The unemployment rate for graduates compared with school leavers is around the median value. Australia is ranked 11th when levels of GDP per capita are taken into account and the score is above that expected at its income level.

## Austria

Austria ranks 11th overall, which combines ranks of 8 for Resources, 24 for the Environment, 2 for Connectivity and 19 for Output. In Connectivity it ranks in the top five for three of the components: the share of international students, articles co-authored with international researchers and articles co-authored with industry researchers. Austria ranks fourth for government expenditures and 14th for total expenditure as a share of GDP. Within Output, the highest rank is for the number of national researchers per head of population (tenth). It ranks 15th for PhD graduates per head. Austria ranks 19th on published articles per head of population, which compares unfavourably with research expenditure per head which is ranked fifth. Publications rank 17th on their average impact. When the rankings are adjusted for levels of GDP per capita, Austria's ranking falls to 16th overall, but its score is around what is expected at its income level.

## Belgium

Belgium ranks 13th overall, which combines ranks of 15 for Resources, 10 for Environment, 9 for Connectivity and 12 for Output. The Output ranking has improved four places over the past six years. Total expenditure as a share of GDP is ranked 28th but government expenditure is ranked ninth and expenditure per student is ranked 16th. Within the Connectivity module, Belgium is ranked third for the proportion of articles co-authored with international collaborators. It has good links with industry: ranked seventh for joint publications and 14th for knowledge transfer. In Output, Belgium is ranked 13th for publications per head and seventh for their impact. It is ranked 13th on the quality of its top three universities and 17th for PhD completions per head of

# Country Summaries

## (continued)

population. Belgium's overall ranking is 14th when performance is adjusted for levels of GDP per capita and its score is above that expected for a country at its level of income.

### **Brazil**

Brazil ranks 39th overall, which combines ranks of 34 for Resources, 41 for Environment, 39 for Connectivity and 37 for Output. The absence of official data on private expenditure and R&D expenditure means that the ranking for Resources is only an approximation. Government expenditure on higher education as a share of GDP is ranked 34th. In Connectivity, Brazil has risen to 14th in the proportion of students who are international, but collaboration with international researchers and with local business are ranked in the bottom quintile. In the Output module, Brazil is 12th on total publications but only 41st on publications per head and 46th for the average impact of papers. Around half of the publications are produced by the top 10 per cent of institutions. The country ranks 27th for the quality of its best three universities but is in the bottom 20 per cent for participation rate and the qualification of its workforce. It is ranked 37th for PhD completions. When the country standings are adjusted for levels of GDP per capita, Brazil rises to 20th in the rankings and its score is around that expected at its income level.

### **Bulgaria**

Bulgaria ranks 44th overall, which combines a ranking of 48 for Resources, 43 for Environment, 34 for Connectivity and 39 for Output. Bulgaria ranks 45th for government expenditure on higher education as a share of GDP, a rise of five places from last year, and 44th for total expenditure. Bulgaria is ranked seventh for employment of those with a tertiary qualification relative to school leavers. Enrolment rates and the educational attainments of its workforce are around median levels. The absence of a university in the Shanghai top 500 lowers the rank for Output. Publications per head are ranked at 38. Joint publications with international authors continue to increase relative to other countries and now rank 23rd. Joint publications with industry have similarly increased and are

now ranked at 24, but business ranks knowledge transfer with tertiary institutions at a low 47th. Taken together, these results imply that Connectivity is limited to specialised groups. PhD completions per head of population are ranked 25th. When account is taken of the level of GDP per capita in each country, Bulgaria is ranked 44th and its score is well below the expected level.

### **Canada**

Canada is ranked 8th overall, which combining ranks of 5 for Resources, 13 for Environment, 12 for Connectivity and 7 for Output. The rank for Environment has increased seven places owing to an improvement in rank from 16th to 7th in the WEF rating of educational systems by business. In Resources, Canada ranks second for total expenditure as a share of GDP and seventh for expenditure per student. In the Output category, Canada is ranked eighth for total publications and tenth for publications deflated by population. Its best three universities are ranked third. Canada is ranked first for the formal educational qualifications of its workforce. In Connectivity, Canada ranks third for web impact and 24th for joint publications with international authors. Engagement with industry is above average: ranked 12th for knowledge transfer and 17th for joint publications. Canada ranks 22nd for PhD completions per capita. When levels of GDP per capita are taken into account, Canada ranks twelfth overall and the score is above that expected at its income level.

### **Chile**

Chile ranks 34th overall, which combines ranks of 35 for Resources, 20 for Environment, 35 for Connectivity and 35 for Output. In the Resources category, Chile is always ranked highly on total expenditure as a share of GDP (7th this year) but much lower on expenditure per student (currently 40th). However, public expenditure varies markedly across years. In the current ranking government expenditure as a share of GDP (data relate to 2015) has fallen 12 places to 39th. In the Connectivity category, Chile ranks fifth in the share of articles co-authored with international collaborators but 42nd in joint articles with industry.

However, the score by business on the extent of knowledge transfer has risen eight places to 28th. In Output, Chile does best on the tertiary enrolment rate (sixth) which is gradually leading to a higher rank on the (tertiary) educational qualifications of its workforce (now 35th). However, the high enrolment rate is not seen at the PhD level where Chile ranks 43rd on completions. Chile ranks 36th for published articles per head of population. When levels of GDP per capita are allowed for, Chile ranks 31st overall; although an improvement of five places this year, its score remains below that expected at its income level.

### **China**

China ranks 30th overall, a rise of 10 places over the last six years. The overall rank combines ranks of 44 for Resources, 16 for Environment, 44 for Connectivity and 22 for Output. In the Resources category, total expenditure on higher education as a share of GDP is ranked 32th. Within the Connectivity category, knowledge transfer with business is ranked 22nd and the share of articles co-authored with industry is ranked 39th. Although the proportion of articles written with international collaborators is the third lowest of all countries it has risen by five percentage points to 23 per cent. In Output, China is ranked second on total publications but 43rd when population is allowed for. Around half of the publications are produced by the top 10 per cent of institutions. China ranks in the top quartile for the quality of its best three universities. It ranks second on PhD completions but 42nd on a population adjusted basis. When levels of GDP per capita are taken into account, China's overall rank improves to 18th and its score is above that expected at its income level.

### **Croatia**

Croatia ranks 45th overall, which combines ranks of 43 for Resources, 48 for Environment, 42 for Connectivity and 41 for Output. The Output rank has fallen by seven places because Croatia no longer has a university in the Shanghai top 500. Public expenditure on higher education as a share of GDP has risen 11 places to 25th. Environment has fallen four places

following the availability of the new EUA data on autonomy of institutions. External joint publications are the highest ranked components in Connectivity: international co-authored papers are ranked at 26 and those co-authored with industry are ranked at 22. However, knowledge transfer with business is ranked at 48, suggesting that external links are with specialised groups. The Output category includes a rank of 29 for publications per head and their average impact is ranked at 36. 60 per cent of publications emanate from one university (Zagreb). Enrolment rates are at median levels and it is ranked 23rd for PhD completions. Croatia scores well (rank 16) for employment of those with a tertiary qualification compared with school leavers. Croatia's overall rank is 46 when allowance is made for income differences across countries and its overall score is less than expected at its level of income.

### **Czech Republic**

The Czech Republic ranks 27th overall, which combines ranks of 26 for Resources, 34 for Environment, 21 for Connectivity and 30 for Output. Expenditure (both public and private) as a share of GDP is ranked 39th and research expenditure 16th. The highest ranking in Connectivity is for the international student share (10th). Joint publications with international authors ranks 32nd. The Czech Republic is ranked 18th for joint publications with industry but business views on knowledge transfer give a much lower rank of 39. This suggests that external engagement is specialised. Most of the Output variables yield values around median levels, except that the country performs well on the criterion of unemployment levels for those with a tertiary qualification compared with school leavers (ranked 12th). Publications adjusted for population are ranked equal 20th and their impact 25th. The Output rank has remained remarkably stable over six years of ranking. PhD completions per capita are ranked 18th. When levels of GDP per capita are taken into account the Czech Republic is ranked 24th and its score is about that expected at its level of income.



# Country Summaries

## (continued)

### Denmark

Denmark is ranked fifth overall, which combines ranks of 4 for Resources, 23 for Environment, 5 for Connectivity and 5 for Output. Within the Resources category, it is ranked sixth for government expenditure as a share of GDP and 17th for total expenditure (public plus private) per student. Denmark is ranked first for spending on research and development by tertiary institutions (as a share of GDP) and second for the number of national researchers per head of population. It ranks fourth for PhD completions per capita. In the Connectivity module, Denmark is ranked fourth for both joint publications with industry and knowledge transfer, and ninth for joint publications with international authors. In Output it is ranked first for publications per head of population and fifth for their average impact. Denmark is ranked third for the overall quality of its universities. Denmark maintains its overall ranking of fourth when adjustment is made for different levels of GDP per capita. Its score is well above that expected at its level of income.

### Finland

Finland ranks sixth overall, which combines ranks of 9 for Resources, 5 for Environment, 8 for Connectivity and 9 for Output. It ranks third in government expenditure on higher education as a share of GDP and 11th on total expenditure (public plus private) per student. It ranks fifth in the number of national researchers per head of population and PhD completions per head are ranked ninth. Allowing for population, Finland ranks sixth on publications which roughly matches its rank on research expenditure of 8th. The average impact of papers is ranked 15th. Enrolment rates are ranked seventh which compares with a rank of 11 for the tertiary qualifications of the workforce. In Connectivity, Finland is ranked fourth for Web impact and eighth for knowledge transfer with business. In joint publications it is ranked tenth for those with international authors and ninth for those with industry. When levels of GDP per capita are taken into account Finland is ranked in first place and its score is well above what is expected given its level of income.

### France

France ranks 16th overall, which combines ranks of 17 in Resources, 25 in Environment, 17 in Connectivity, and 13 in Output. Within the Resources category it is ranked 16th for government expenditure as a share of GDP and 18th for total expenditure per student. (Private expenditure is about 20 per cent of total expenditure.) In Connectivity, France ranks 12th for joint publications with industry and 14th for joint publications with international authors. France ranks 12th for international students. In the Output module, France is ranked equal sixth for the standing of its best three universities. The total number of publications by the country's universities is ranked fifth but this falls to equal 20th when adjusted for population, compared with a rank of 11 for research expenditure. Around one-half of publications emanate from the top 10 per cent of institutions. The average impact of publications is ranked 16th. France is ranked 20th for researchers per head and 21st for PhD completions per head. When levels of GDP per capita are taken into account, France's overall rank is 19 and its score is around the level expected at its level of income.

### Germany

Germany is ranked 15th overall, which combines ranks of 18 for Resources, 27 for Environment, 13 for Connectivity and 11 for Output. In the Resources category it ranks 38th on total expenditure (public plus private) as a share of GDP but 14th on expenditure per student. The difference is explained by the lower rank (27th) for the participation rate in higher education. In Connectivity Germany performs well on links with industry: ranked eighth for joint publications and tenth for knowledge transfer. It ranks 21st for the share of publications that have international co-authors. In Output, German universities are ranked fourth for total publications and 23rd for publications deflated by population even though research expenditure is ranked 11th. The average impact of publications is ranked 11th. Germany ranks equal sixth for the standing of its best three universities and seventh for PhD completions per capita. The Environment score is pulled

down in part because the points awarded for national policy disadvantage federations. When levels of GDP per capita are taken into account Germany's overall ranking falls to 29th and its score is just below what is expected given its level of income.

### Greece

Greece is ranked equal 32th overall, which combines ranks of 27 for Resources, 50 for Environment, 28 for Connectivity and 27 for Output. It ranks 11th for government expenditure on higher education as a share of GDP but 41st for expenditure per student. This difference is explained by the high recorded participation rate in tertiary education (ranked 1st). The low Environment rank occurs because of an excessively centralised system and low grade from business. In Connectivity, Greece is ranked 26th for joint publications with industry but the tertiary system is rated lowly by business for knowledge transfer (45th). This suggests that external links are specialised. Web connectivity is around median levels. Other than for the highly-ranked participation rate, the rankings for all the Output measures lie around median values: ranging from a rank of 20 for the average impact of research articles to 31st for the quality of its best three universities. On a per head basis, the rank for publications (27th) roughly matches that for research expenditure (29th). Greece ranks 31st for PhD completions per head. When account is taken of levels of per capita GDP, Greece's overall ranking improves to 17th and is at the level expected at its level of income.

### Hong Kong SAR

Hong Kong SAR is ranked 17th overall, which combines ranks of 13 for Resources, 6 for Environment, 19 for Connectivity and 21 for Output. The Environment score is high reflecting a system that gives significant autonomy to institutions while maintaining overall surveillance. Government expenditure on higher education as a share of GDP has fallen and is now ranked 22nd, a fall of eight places. Total expenditure per student is ranked sixth. In Connectivity, Hong Kong SAR is ranked ninth for articles co-authored with international collaborators. The higher education sector is ranked 16th for business satisfaction with the extent of

knowledge transfer but is ranked lower at 35th for articles written with industry. Web-based connectivity is ranked 12th. In the Output category, Hong Kong SAR is ranked 14th on publications per head and equal ninth on the average impact of articles. Publications are relatively evenly spread over institutions and it ranks 11th for depth of its universities. When account is taken of levels of GDP per capita Hong Kong's ranking falls to 32nd and its score is a little below that expected at its relatively high income level.

### Hungary

Hungary is ranked 36th overall, which combines ranks of 47 for Resources, 42 for Environment, 18 for Connectivity and 32 for Output. Government expenditure on higher education as a share of GDP ranks 44th. Declines in both public and private expenditure has this year seen total expenditure as a share of GDP decline fifteen places to 48th. Total expenditure per student ranks 38th. The Connectivity ranking includes sixth in joint publications with industry but business ranks knowledge transfer lower at 33. Joint publications with international authors rank 16th. Within the Output category, Hungary is ranked second for employment of the tertiary educated workforce compared with those who left after completing final year of schooling. It is ranked 31st on publications per head and equal 27th for their impact. PhD completions per head are ranked 33rd. The Output rank is pulled down by the absence of a university in the Shanghai top 500. When account is taken of relative levels of GDP per capita, Hungary's ranking is 41st and its score is below that expected at its income level.

### India

India is ranked 49th overall, which combines ranks of 39 for Resources, 45 for Environment, 49 for Connectivity and 47 for Output. It is ranked 18th for government expenditure on higher education as a share of GDP but 47th for expenditure on research by tertiary institutions. Under Environment, India scores low grades for institutional autonomy and data quality. Within the Connectivity category, India ranks well down for joint publications:

# Country Summaries

## (continued)

both with international authors (50th) and with industry (46th). It is scored a little higher by business on knowledge transfer (35th). It rates lowly for web connectivity. Within the Output category, India ranks 10th on total publications but 49th on publications per head, which roughly matches the research expenditure rank of 47. Nearly half the articles emanate from the top 10 per cent of institutions. The average impact of articles is ranked at 42. PhD completions per head rank 46th. When account is taken of relative levels of GDP per capita, India's overall ranking rises to 26th owing mainly to a large increase in the ranking for Resources (now 11th). India's GDP-adjusted overall score is around the level expected at its income level.

### Indonesia

Indonesia is ranked 50th overall, which combines ranks of 50 for Resources, 31 for Environment, 45 for Connectivity and 50 for Output. It is ranked 50th for government expenditure on higher education as a share of GDP. In Connectivity, Indonesia ranks, 32nd for joint publications with industry, 43rd for joint publications with international authors and 29th for knowledge transfer with business. Indonesia ranks in the bottom 20 per cent for all Output measures (except employment rates of the tertiary educated compared with school leavers) and loses points for not having a university in the Shanghai top 500. It ranks 45th for PhD completions per head. When allowance is made for levels of per capita GDP, Indonesia's overall ranking remains at 50 and the score is well below that expected at its income level.

### Iran

Iran is ranked 48th overall, which combines ranks of 46 for Resources, 40 for Environment, 50 for Connectivity and 43 for Output. Government expenditure on higher education as a share of GDP is ranked 36th, an improvement of seven places. Connectivity remains very low. Iran ranks 50th for joint publications with industry and 47th for joint publications with international authors. Web-based impact is ranked 45th. The number of articles published by Iranian authors is ranked 16th,

but this falls to 39th when population differences are allowed for; the average impact of articles is ranked 44th. Iran ranks 23rd for enrolment rates, 39th for the (tertiary) educational qualifications of its workforce, and 36th for PhD completions per head. When account is taken of levels of GDP per capita, the rank for Output improves to 22nd and is about the level expected at Iran's level of income. However, the improvement in the overall rank is less dramatic (to 37th) and the score is below that expected.

### Ireland

Ireland is ranked 19th overall, which combines ranks of 30 for Resources, 18 for Environment, 15 for Connectivity and 16 for Output. Improvements in the ranking of outcomes (Connectivity and Output) have offset deteriorations in inputs (Resources and Environment) to keep the overall rank unchanged. Government expenditure as a share of GDP has fallen 15 places to 35th and the Environment rank has fallen four places to 15 because of reductions in the financial autonomy of institutions. Expenditure per student is ranked 21st. In Connectivity, the business rating of knowledge transfer has improved markedly to sixth. Joint publications with industry are ranked 23rd and with international authors 18th. Under Output, Ireland is ranked 11th on publications per head of population and 21st on their average impact. It ranks 14th for the educational levels of its workforce and sixth for employment of those with a tertiary qualification compared with school leavers. PhD completions per head are ranked fifth. When account is taken of relative levels of GDP per capita the ranking is 36th but because of the importance of foreign firms in Ireland the rank would be higher if Gross National Income was used as a measure of income.

### Israel

Israel is ranked 18th overall, which combines ranks of 22 for Resources, 19 for Environment, 20 for Connectivity and 10 for Output. Israel ranks 32nd for government expenditure on higher education as a share of GDP, which improves to 22nd when private expenditure is added. Expenditure per student is also

ranked 22nd. Expenditure in tertiary institutions on R&D as a percentage of GDP is ranked 13th. Israel is ranked first for the number of researchers in the country per head of population although PhD completions per head are ranked lower at 28th. Israel is ranked seventh for the depth of quality universities. Research output per head of population is ranked 17th and the average impact of articles is ranked 19th. Israel is ranked fifth for knowledge transfer with business and 20th for joint articles with industry. Web impact is ranked 18th. Israel is ranked fourth for the educational qualifications of its workforce. When account is taken of relative levels of GDP per capita, the ranking improves to ninth and the score is above that expected at Israel's income level.

### Italy

Italy is ranked equal 28th overall, which combines ranks of 38 for Resources, 38 for Environment, 27 for Connectivity and 25 for Output. The indicators show very little change from last year. Government expenditure on higher education (75 per cent of total expenditure) as a share of GDP is ranked 40th and expenditure per student is ranked 28th. In Connectivity, joint publications of academics with industry are ranked 19th and joint publications with international authors 27th. Knowledge transfer with firms is ranked 30th. In the Output category, Italian tertiary institutions publish the seventh largest number of journal articles but this rank falls to 22 when deflated by population size, roughly matching the rank of 24 for research expenditure per head. The average impact of articles is ranked 12th. The three best performing universities are ranked equal 20th. Italy ranks 42nd on the education qualifications of its workforce, 34th on number of researchers per head of population, and 29th on PhD completions per head. When account is taken of relative levels of GDP per capita, Italy's ranking falls to 33rd and its score is below that expected at its income level.

### Japan

Japan is ranked 20th overall, which combines ranks of 23 for Resources, 21 for Environment, 24 for Connectivity and 17 for

Output, little changed from last year. Total expenditure on higher education (of which two-thirds is private) as a share of GDP is ranked 21st but, because the participation rate is a little below average, expenditure per student is ranked 12th. Connectivity is predominantly internal: Japan ranks fifth for the percentage of articles written jointly with industry collaborators, and knowledge transfer with domestic business is ranked 24th. In contrast, the international student share is ranked 33rd and the percentage of articles co-authored with international researchers is ranked a lowly 44th. In Output, Japan ranks sixth on total articles published but 32nd when population size is allowed for, lower than the rank for research expenditure of 20. Nearly half the articles emanate from the top 10 per cent of institutions. The average impact of articles is ranked equal 35th. Japan ranks fifth on the quality of its best three universities. It ranks third on the educational qualifications of its workforce, ninth for the number of researchers in the country but 32nd for the number of completing PhDs. When account is taken of relative levels of GDP per capita, Japan's rank falls to 35 and is below the level expected at its income level.

### Korea

Korea is ranked 22nd overall, which combines ranks of 19 for Resources, 44 for Environment, 31 for Connectivity and 18 for Output. Government expenditure as a share of GDP has improved by five places to 24th, but it still represents only 45 per cent of total expenditure on higher education. Total expenditure as a share of GDP ranks seventh but expenditure per student ranks much lower at 33rd because Korea has the third highest participation rate. The rank for Environment is pulled down by the relatively low proportion of students and staff who are female. Korean links with industry are ranked 13th for joint publications but 26th for knowledge transfer. Joint publications with international authors are ranked 46th. In the Output category, Korea ranks 11th on total publications but 25th when adjusted for population size, the same rank as for research expenditure. The average impact of publications is ranked at 33. Korea ranks sixth on the education qualifications of its workforce; third on total researchers in the

# Country Summaries

## (continued)

nation (adjusted for population); and 14th for PhD completions per head. When account is taken of relative levels of GDP per capita, Korea's overall rank falls to 34 and is a little below that expected at its income level.

### Malaysia

Malaysia is ranked 26th overall, which combines ranks of 12 for Resources, 15 for Environment, 33 for Connectivity and 42 for Output. Malaysia is ranked eighth for government expenditure on higher education as a share of GDP; expenditure per student ranks tenth. Expenditure on R&D in tertiary institutions as a share of GDP was abnormally high in last year's rankings (11th) and has now returned to more typical values (ranked 24th). In Connectivity, Malaysia is ranked 17th for knowledge transfer with business, but 48th for joint publications with industry. Joint publications with international authors have risen in rank to 34th. Using the new data base, Malaysian institutions are ranked 23rd for total publications and 34th for both publications per head of population and the average impact of articles. The country is ranked 37th for the educational attainment of the workforce and 31st for the number of researchers in the nation (adjusted for population). PhD completions per head are ranked 34th. When account is taken of relative levels of GDP per capita, Malaysia's overall ranking improves to 23rd and the estimated overall score is around the level expected at Malaysia's income level.

### Mexico

Mexico is ranked 46th overall, which combines ranks of 37 for Resources, 26 for Environment, 47 for Connectivity and 49 for Output. Both public and private expenditure on higher education has increased noticeably since last year's ranking: the rank of total expenditure as a share of GDP has increased ten places to 27th. Expenditure per student has improved five places to 35th. Mexico ranks 40th for expenditure by tertiary institutions on R&D as a share of GDP. In Connectivity, Mexico ranks 47th for joint publications with industry and 36th for knowledge transfer. Joint publications with international authors are ranked 36th.

Web connectivity is well below average. In Output, Mexico is ranked equal 33rd for total publications but 47th when adjusted for population. Tertiary enrolment rates are ranked 48th; PhD completions per head are ranked 39th. When account is taken of levels of GDP per capita Mexico's overall rank is 49 and the overall score is well below that expected at Mexico's level of income. The recent increase in resources can be expected to improve outcomes in future years.

### Netherlands

The Netherlands is ranked sixth overall, which combines ranks of 11 for Resources, 8 for Environment, 4 for Connectivity and 8 for Output. It is ranked 13th for total expenditure on higher education (which is 70 per cent government funded) as a share of GDP, an increase of five places. Expenditure per student is ranked ninth. It ranks highly for Connectivity with business: second for joint publications and third for knowledge transfer. Joint publications with international authors are ranked 11th and web connectivity is above average. In Output, the Netherlands performs strongly in research publications per head (seventh, which exactly matches the research expenditure rank) and their average impact is ranked third. The participation rate is ranked 19th, and the education qualifications of the workforce 20th. The standing of its universities is high: ranked fifth for depth (the Netherlands has the most even spread of publications across institutions) and 10th for its best three universities. The Netherlands ranks 13th for the national stock of researchers per head and 12th for PhD completions per head. When account is taken of levels of GDP per capita the overall rank is 13. The scores for each of the four broad categories and overall are above those expected at the Netherlands' income levels.

### New Zealand

New Zealand is ranked equal 14th overall, which combines ranks of 20 for Resources, 3 for Environment, 6 for Connectivity and 20 for Output. For expenditure as a share of GDP, New Zealand is ranked 29th for government expenditure and 9th for total

expenditure. In Connectivity, New Zealand's highest score is for the percentage of students who are international, where it is ranked first. International students make up a third of short-cycle tertiary programmes. It ranks 11th for the annual number of PhD completions, 51 per cent of whom are international (ranked second). New Zealand is ranked 12th for publications with international researchers and 25th for publications with industry. The rank for business views on knowledge transfer is 19, a fall of nine places from last year's ranking. On a per capita basis, New Zealand is ranked 15th for publications per head but 26th for research expenditure: the difference is indicative of high productivity. It ranks 18th on the average impact of publications. New Zealand's tertiary enrolment rate is ranked 10th and the tertiary educational qualifications of its workforce 19th. When account is taken of relative levels of GDP per capita, New Zealand's rank improves to tenth and its score is above the level expected at its income level.

### Norway

Norway is ranked 12th overall, which combines ranks of 7 for Resources, 17 for Environment, 16 for Connectivity and 14 for Output. In expenditure as a share of GDP, Norway is ranked 5th for public expenditure (95 per cent of total expenditure) and 17th for total expenditure. Expenditure per student is ranked eighth. In Connectivity, co-authorship with international collaborators is ranked eighth and with industry 15th. Web connectivity is ranked eighth. There is a matching of research expenditure as a share of GDP (10th) with research publications per head (ranked ninth). Norway ranks ninth for both the average impact of publications and the depth of quality universities. It is ranked 20th for participation rates in higher education, 12th for the tertiary educational qualifications of the workforce and eighth for the number of national researchers per head. It ranks thirteenth for PhD completions per head. Norway's overall rank falls to 28th when account is taken of levels of GDP per head and the overall score is around that expected at its high income level.

### Poland

Poland is ranked 31st overall, which combines ranks of 33 for Resources, 14 for Environment, 40 for Connectivity and 31 for Output. In expenditure as a share of GDP, Poland is ranked 17th for public expenditure, 33rd for total expenditure and 31st for research expenditure. Connectivity with industry is below average: Poland ranks 38th in joint articles with industry and 34th in knowledge transfer with business, but the latter has improved 13 places since last year. In joint articles with international collaborators Poland is ranked 40th. Web connectivity is a little below the median. In Output, Poland is ranked 18th on published articles but this falls to 30th when adjusted for population. The average impact of articles is ranked at 27. Participation rates are ranked 28th and the tertiary educational qualifications of the workforce 26th. PhD completion rates (per head) rank 35th. Poland performs well (fifth) on the employment rates of those with a tertiary qualification compared with those who only complete final year of schooling. Poland's rank improves to 27th when account is taken of levels of GDP per capita and its score is around that expected at its income level.

### Portugal

Portugal is ranked 24th overall, an improvement of three places. The component ranks are 24 for Resources, 35 for Environment, 25 for Connectivity and 28 for Output. In expenditure as a share of GDP, Portugal is ranked 31st for both public expenditure, an improvement of six places from last year's ranking, and total expenditure. Under the heading of Connectivity, Portugal is ranked 19th for joint publications with international researchers and 37th for publications with industry. Knowledge transfer with business is ranked 25th. In the Output module, publications per head are ranked 12th whereas research expenditure per head ranks only 19th, which is an indicator of efficiency. Portugal ranks 30th in the tertiary educational qualifications of the workforce, but the tertiary enrolment rate is ranked lower at 36th. After allowing for population, Portugal ranks 22nd for the number of researchers in the country and 19th for PhD completions. When

# Country Summaries

## (continued)

account is taken of relative levels of GDP per capita, Portugal's ranking jumps to sixth (third on Output) and its score is above that expected at its level of income.

### Romania

Romania is ranked 43rd overall, which combines ranks of 45 for Resources, 30 for Environment, 41 for Connectivity and 46 for Output. The Connectivity score has fallen nine places as a consequence of the score recorded by business for knowledge transfer falling to 42nd. Total expenditure as a share of GDP is ranked 41st and research expenditure 43rd. The Environment measure benefits from institutions having a relatively high percentage of female staff (ranked fifth). In the Connectivity measures, joint publications with international authors are ranked 42nd and those with co-authors from industry are ranked 36th. The absence of a university in the top 500 lowers the Output score. Romania is ranked 37th on research articles per head and 40th on their average impact. The number of PhD completions (per head) is ranked 26th. When account is taken of relative levels of GDP per capita Romania is ranked 47th and its score is well below that expected at its level of income.

### Russia

Russia is ranked 33rd overall, which combines ranks of 42 for Resources, 28 for Environment, 46 for Connectivity and 26 for Output. For expenditure as a share of GDP, Russia is ranked 37th for public expenditure, 35th for total expenditure and 42nd for research expenditure. In the Connectivity module, Russia is relatively weak on interactions with industry: it is ranked 43rd for each of joint publications with industry and knowledge transfer with firms. It ranks 35th for joint publications with international researchers. In the Output module, Russia is ranked second for the educational qualifications of its workforce and ninth for the employment rates of those with a tertiary qualification compared with school leavers. The annual number of PhD completions ranks 24th. Total research publications rank 20th, publications per head 45th and their average impact 32nd. Over the last six years Russia has improved

six places on Output. When account is taken of relative levels of GDP per capita the rank is 43 and the GDP adjusted score for Russia is well below that expected at its income level.

### Saudi Arabia

Saudi Arabia is ranked equal 23rd overall, which combines ranks of 10 for Resources, 46 for Environment, 26 for Connectivity and 33 for Output. It is ranked first for government expenditure on higher education as a share of GDP. In the Connectivity module, Saudi Arabia is ranked first for the share of publications that have an international collaborator but it is ranked only 40th for joint publications with industry. Web connectivity is in the lowest quintile. The highest score in the Output module is for the quality of its best three universities which are ranked 16th and account for two-thirds of publications in the country. Saudi Arabia is ranked 40th for publications per head and 22nd for their average impact. The annual number of PhD completions is ranked 47th. High government expenditure is now showing up in the Output rank that has improved 12 places over the last six years, the largest improvement for any country. However, Saudi Arabia's high level of GDP per capita inevitably means that its ranking falls (to 48th) when income levels are allowed for. The GDP adjusted score for Saudi Arabia is well below that expected at its income level.

### Serbia

Serbia is ranked 42nd overall, which combines ranks of 28 for Resources, 49 for Environment, 38 for Connectivity and 45 for Output. Government expenditure on higher education as a share of GDP is ranked 13th and expenditure by institutions on R&D is ranked 27th. Using the new EUA rating for Serbia for the financial autonomy of institutions has lowered the score for the policy Environment. Serbia ranks 41st on joint publications with industry and 35th on joint publications with international authors. In the Output module, Serbia ranks 33rd in publications per head and 47th in their average impact. Serbia ranks 29th for the average quality of its universities but 60 per cent of publications emanate

from one university (Belgrade). It is ranked 36th for the tertiary education qualifications of the work force and 37th for the tertiary enrolment rate. In per capita terms, Serbia ranks 33rd for the national stock of researchers and 30th for the annual number of PhD completions. When account is taken of relative levels of GDP per capita Serbia's rank jumps to third place and the score is well above that expected for its level of income.

### Singapore

Singapore is ranked ninth overall, which combines ranks of 3 for Resources, 4 for Environment, 10 for Connectivity and 15 for Output. It ranks 23rd for government expenditure on tertiary education as a share of GDP but first for total expenditure (public plus private) per student. Singapore ranks second for R&D expenditure by universities per head of population and this is reflected in the ranking of fifth for publications per head and sixth for their average impact. In the Connectivity category, it ranks second for the relative importance of international students and sixth for joint publications with international authors. In engagement with the private sector, Singapore ranks ninth for knowledge transfer with firms but 33rd for joint scientific publications with industry. The (tertiary) educational qualifications of the workforce is ranked 13th and the number of national researchers per head is ranked sixth. When allowance is made for national levels of GDP per head Singapore's ranking falls to 21st but the score is around what is expected at its high income level.

### Slovakia

Slovakia is ranked 35th overall, which combines ranks of 31 for Resources, 39 for Environment, 30 for Connectivity and 34 for Output. Total expenditure on higher education (of which nearly 80 per cent is by government) as a share of GDP is ranked 45th; government expenditure at 33rd. Research expenditure by tertiary institutions as a share of GDP has risen 19 places to 12th. This can be expected to flow through to research performance in later years. Currently, Slovakia is ranked 28th

for publications per head and 26th for their average impact. Within the Connectivity module, Slovakia is ranked 33rd for joint publications with international researchers, 21st for joint scientific publications with industry and 40th for knowledge transfer with firms. The Output score is lowered by the absence of any university in the Shanghai top 500. On a per capita basis, the national stock of researchers ranks 28th which can be expected to increase as the annual number of PhD completions ranks eighth. Slovakia ranks seventeenth for the employment rate of those with a tertiary qualification compared with school leavers. When account is taken of relative levels of GDP per capita, Slovakia's rank falls to 40th and its score is well below that expected at its income level.

### Slovenia

Slovenia is ranked 29th overall, which combines ranks of 36 for Resources, 36 for Environment, 22 for Connectivity and 29 for Output. It is ranked around the median level for many of the indicators. Government expenditure on higher education as a share of GDP is ranked 27th but because private expenditure is low (14 per cent) total expenditure is ranked 43rd. On a per capita basis, publications per head rank 16th, a creditable performance given that R&D expenditure by tertiary institutions ranks only 32nd. Nearly 70 per cent of publications emanant from one university (Ljubljana). In the Connectivity module, joint scientific papers with industry are ranked 11th but business ranks knowledge transfer at a low 37th. This suggests engagement is specialised. The share of publications that are joint with international authors is ranked 13th. Slovenia has slipped five places in the Output ranking over the last six years. The tertiary qualification rate of the labour force is ranked 24th, but this will increase as the participation rate in higher education is ranked 13th. On a per capita basis Slovenia is ranked 23rd for the number of researchers in the nation but this is likely to rise as annual PhD completions are ranked third. When allowance is made for levels of GDP per capita, Slovenia is ranked 25th and the score is around that expected at its income level.



# Country Summaries

## (continued)

### South Africa

South Africa is ranked 37th overall, which combines ranks of 41 for resources, 23 for Environment, 32 for Connectivity and 36 for Output. Government expenditure on higher education as a share of GDP is ranked 47th and research expenditure 35th. The Environment score is dragged down by a very low score on the World Economic Forum rating by business (ranked 47th) and its rank of 37 for data quality. In Connectivity, South Africa is 17th for the percentage of joint publications with international researchers, 29th for joint publications with industry and 32nd for knowledge transfer with firms. But web-based connectivity is in the bottom decile. South Africa's rank in the Output module has improved six places over the last six years. The tertiary education sector is ranked equal 28th for total publications, 42nd for publications per head and 24th for their average impact. Both enrolment rates and the educational qualifications of the workforce are in the bottom decile. South Africa ranks 41st on the annual number of PhD completions. It ranks first for the employment of those with a tertiary qualification compare with school leavers. When allowance is made for differences in GDP per head, South Africa's rank jumps to eighth and the score is well above that expected at its level of income.

### Spain

Spain is ranked 25th overall, which combines ranks of 29 for Resources, 33 for Environment, 29 for Connectivity and 24 for Output. As a share of GDP, Spain is ranked 30th for government expenditure on higher education (about 70 per cent of total expenditure), 34th for total expenditure and 29th for research expenditure. In engagement with the private sector, Spain ranks 27th for joint scientific publications with industry and 38th for knowledge transfer. Joint publications with international collaborators are ranked 25th. Spain's tertiary institutions are ranked 23rd for web connectivity. In Output, Spain is ranked 13th for total publications and 26th on a per capita basis. The average impact of published articles is ranked 23rd. In the educational qualifications of the workforce, Spain is ranked

21st but this will increase as the participation rate in tertiary education is ranked fifth. On a per capita basis, the national stock of researchers is ranked 28th and the annual number of PhD completions 16th. When allowance is made for differences in GDP per head, Spain's rank is 30 and its score is a little below that expected at its level of income.

### Sweden

Sweden is ranked fourth overall, which combines ranks of 2 for Resources, 12 for Environment, 7 for Connectivity and 6 for Output. In Resources as a share of GDP, Sweden is ranked seventh for government expenditure (about 90 per cent of total expenditure), 16th for total expenditure and third for research expenditure. Expenditure per student is ranked fifth. Sweden's lowest rank is for the policy Environment which owes to its score for institutional autonomy being only around median values. Sweden performs well in engagement with industry: ranks third for joint publications and 13th for knowledge transfer. It ranks seventh for joint publications with international researchers and is in the top ten for web connectivity. In Output, Sweden is ranked fourth for publications per head and eighth for their average impact. Its university sector is ranked second for average quality. It is ranked 16th for the (tertiary) educational qualifications of its workforce. On a per capita basis, Sweden ranks fourth for the number of researchers in the nation and tenth for the annual number of PhD completions. When allowance is made for levels of GDP per capita, Sweden is ranked fifth overall and its score is well above that expected at its level of income.

### Switzerland

Switzerland is ranked second overall, which combines ranks of 1 for Resources, 11 for Environment, 1 for Connectivity and 4 for Output. Government expenditure on higher education as a share of GDP ranks 12th and expenditure per student third. Connectivity within the nation and externally is high. It is rated first for knowledge transfer with firms, 10th for joint publications with industry, and second for joint publications with international

researchers. It is fourth for the proportion of students who are international. At the PhD level it ranks first for the annual number of PhD completions, 54 per cent of whom are international. Web-based impact is ranked second. On a per capita basis, Switzerland is ranked second for publications which reflects its number one rank for R&D expenditure. Publications are ranked number one for average impact. Its universities are ranked first for average quality. Switzerland ranks 15th for the (tertiary) educational qualifications of its workforce and 16th for the number of researchers in the nation per head of population. When levels of GDP per capita are taken into account, Switzerland is ranked seventh and its score is well above that expected at its level of income.

### Taiwan-China

Taiwan-China is ranked 21st overall, which combines ranks of 32 for Resources, 9 for Environment, 23 for Connectivity and 23 for Output. Expenditure on higher education as a share of GDP is ranked 24th, of which 55 per cent is private. In Connectivity, knowledge transfer with firms is ranked 18th but joint scientific publications with industry are ranked lower at 34th. Joint publications with international researchers are rated lowly at 45th. Taiwan-China ranks 13th for Web connectivity. In Output, it is ranked 17th for total publications and 39th for their average impact. It is ranked seventh for the educational qualifications of its workforce and 12th for the enrolment rate in higher education. Taiwan-China is well provided with researchers per head of population where it is ranked seventh. When levels of GDP per capita are taken into account, Taiwan-China slips to 38th in the ranking and is below the level expected at its income level.

### Thailand

Thailand is ranked equal 47th overall, which combines ranks of 49 for Resources, 29 for Environment, 36 for Connectivity and 48 for Output. Government expenditure on higher education as a share of GDP is ranked 46th and expenditure on R&D is ranked 41st. In Connectivity, knowledge transfer with industry is ranked

27th, joint publications with industry 28th, and joint articles with international researchers 30th. The Output score is negatively impacted by Thailand having no university in the Shanghai top 500. Publications per head are ranked 46th and their average impact 38th. The (tertiary) educational qualifications of the workforce is ranked 45th. The annual number of PhD completions is ranked 44th. When levels of GDP per capita are taken into account, Thailand ranks 45th and the adjusted score is well below that expected at its level of income.

### Turkey

Turkey is ranked equal 41st overall, which combines ranks of 21 for Resources, 47 for Environment, 48 for Connectivity and 40 for Output. Calculated as shares of GDP, government expenditure on higher education ranks tenth, total expenditure ranks 12th, and research expenditure by tertiary institutions ranks 19th. Connectivity is weak: the highest rank is 39 for Web impact. Knowledge transfer as viewed by business is ranked 41st, a fall of 12 places from last year's ranking. Joint articles with international authors and with industry are each ranked 49th. In Output, Turkish institutions of higher education rank 15th for total publications but 36th for publications per head. Citations per article are ranked 45th. Participation rates are ranked second but it will take time for this to flow through fully to the educational qualifications of the workforce (currently ranked 41st). On a per capita basis, the number of researchers is ranked 39th and the annual number of PhD completions is ranked 38th. When levels of GDP per capita are taken into account, Turkey's rank is 42nd and its score is well below that expected at its level of income.

### Ukraine

Ukraine is ranked 38th overall, which combines ranks of 25 for Resources, 37 for Environment, 37 for Connectivity and 44 for Output. Ukraine is second for government expenditure on higher education as a share of GDP. However, because of the relatively high participation rate (ranked 16th) expenditure per student is in the lower decile. R&D expenditure by tertiary institutions as a

# Country Summaries

## (continued)

share of GDP has a low ranking of 45. In Connectivity, Ukraine ranks 30th for joint scientific publications with industry but only 46th for knowledge transfer. It ranks 31st for joint publications with international authors. In Output, Ukraine loses points for not having a flagship university in the Shanghai top 500. Ukraine ranks 50th for total publications, 48th for publications per head of population, and 50th for their average impact. The Output rank has fallen nine places over the last six years. The level of (tertiary) educational qualifications of its workforce is ranked fifth. Using per capita figures, the number of national researchers is ranked 40th and the annual number of PhD completions is ranked 27th. When levels of GDP per capita are taken into account, Ukraine's overall ranking improves to 22nd and its score is about that expected at its income level.

### United Kingdom

The United Kingdom is ranked third overall, an improvement of seven places over the last seven years. The overall rank combines ranks of 16 for Resources, 7 for Environment, 3 for Connectivity and 2 for Output. Total expenditure on higher education as a share of GDP is ranked tenth. The OECD method of splitting total expenditure between public and private is not consistent over time, but in the current data public expenditure ranks 48th. Expenditure per student is ranked fourth which reflects the lower than average participation rate (ranked 39th). Connectivity with industry is relatively strong: the United Kingdom ranks seventh for knowledge transfer with business and 14th for joint scientific publications. The rank for joint publications with international authors is 15. The United Kingdom ranks third for the percentage of students who are international and fifth for the number of times external users access websites. In the Output category, the United Kingdom ranks third for total publications and fourth for the average impact of articles. On a per capita basis, research publications rank eighth compared with a rank of 18 for research expenditure, which implies an above-average level of efficiency. Nearly half the articles emanate from the top 10 per cent of institutions. The United Kingdom ranks second for

the quality of its best three universities. It is ranked ninth for the (tertiary) educational qualifications of the workforce. In per capita terms, the United Kingdom ranks 17th for the national stock of researchers but second for the annual number of PhD completions, 43 per cent of whom are international. When levels of GDP per capita are taken into account, the United Kingdom is ranked second and its score is well above the level expected at its income level.

### United States

The United States is ranked first overall, which combines ranks of 6 for Resources, 1 for Environment, 11 for Connectivity and 1 for Output. Expenditure on higher education as a share of GDP is ranked first (public expenditure has fallen to one-third of the total) and expenditure per student second. Links with the private sector are strong: knowledge transfer is rated second and joint scientific publications 16th. However, as is expected for other large countries, the percentage of publications that are joint with international authors ranks much lower at 38. Although the United States has the largest absolute number of international students, as a share of its total students it ranks only 26th. It ranks first for the number of times external users access websites of tertiary institutions even when adjusted for population. In Output, the United States is first for total publications and fourth for the average impact of articles. On a per capita basis it ranks 18th for publications, similar to the rank for research expenditure of 14. Around 50 per cent of publications emanate from the top 10 per cent of institutions. The United States ranks eighth for participation rates and ninth for the (tertiary) educational credentials of its workforce. It is ranked first for the quality of its best three universities. On a per capita basis it is ranked 19th for the national stock of researchers and 20th for the annual number of PhD completions. When levels of GDP per capita are taken into account, the overall rank for the United States falls to 15th but its score is above the level expected at its income level.





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