



U21
**Ranking of National Higher
Education Systems 2019**

U21

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UNIVERSITAS 21

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Executive Summary

This report presents the results for the eighth annual ranking of national systems of higher education undertaken under the auspices of the Universitas 21 (U21) group of universities. Fifty national systems of higher education, from all continents, are evaluated across 24 indicators. 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, in rank order, Switzerland, Sweden, Singapore, Denmark, Canada, Norway, Saudi Arabia and the United States. The countries with the most favourable Environment are judged to be the United States, Australia, New Zealand, Hong Kong SAR, Finland, the United Kingdom, Singapore and the Netherlands.

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

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 eight countries, in rank order, are the United States, Switzerland, the United Kingdom, Sweden, Denmark, Canada, Singapore and Australia. A subsidiary ranking compares how nations perform relative to countries at similar levels of GDP per capita. The top ranked countries after this adjustment are the United Kingdom, Finland, Serbia, South Africa and Denmark.

An indicator of domestic academic links is derived based on the prevalence of publications with authors from more than one university. In 2017 these linkages were greatest in France, Brazil, Singapore and the United States. There is a negative relationship between domestic and international joint publications: domestic links within the higher education sector tend to be more important for countries with large populations; international links are stronger for small countries.

Changes over the most recent seven-year period are presented for four measures: research expenditure, publications, international joint publications and qualifications of the workforce. The largest percentage increases in research expenditure have occurred in Malaysia, Thailand, Slovakia and China. Research expenditure has fallen in several Eastern European countries, Spain and Italy. Research publications have more than doubled in five countries: Saudi Arabia, Malaysia, Russia, China and Iran. Rates of growth tend to be inversely related to levels. Countries showing the largest increases in the share of publications that are joint with international authors are Saudi Arabia, Greece, the Netherlands, the United Kingdom, Australia and Singapore.

Below:

Overall U21 2019 Ranking

Rank (2019)	Rank (2018)	Country	Score (2019)	Score (2018)
1	1	United States	100.0	100.0
2	2	Switzerland	88.6	88.0
3	3	United Kingdom	84.5	82.6
4	4	Sweden	82.9	82.4
5	5	Denmark	82.5	81.7
6	8	Canada	81.9	79.6
7	9	Singapore	81.3	79.5
8	10	Australia	80.9	78.6
9	6	Finland	80.4	79.7
10	6	Netherlands	80.2	79.7
11	12	Norway	77.8	74.5
12	11	Austria	77.2	75.8
13	13	Belgium	73.6	73.3
14	14	New Zealand	71.5	71.1
15	17	Hong Kong SAR	70.2	67.8
16	15	Germany	69.6	69.2
17	16	France	67.6	68.5
18	18	Israel	67.3	66.3
19	19	Ireland	64.7	64.8
20	20	Japan	61.7	61.9
21	21	Taiwan-China	60.5	60.2
22	23	Saudi Arabia	59.3	57.0
23	22	Korea	57.4	58.0
24	25	Spain	57.3	56.2
25	24	Portugal	56.8	56.4

Rank (2019)	Rank (2018)	Country	Score (2019)	Score (2018)
26	27	Czech Republic	55.2	55.6
27	30	China	54.7	52.4
28	26	Malaysia	54.5	55.7
29	29	Slovenia	53.6	53.6
30	28	Italy	53.4	54.0
31	31	Poland	52.2	51.3
32	34	Chile	51.3	49.0
33	35	Slovakia	49.6	48.7
34	37	South Africa	48.7	47.7
35	36	Hungary	48.5	48.3
35	33	Russia	48.5	49.3
37	32	Greece	47.0	49.5
38	40	Argentina	45.1	44.2
38	38	Ukraine	45.1	47.4
40	39	Brazil	44.1	45.0
41	42	Serbia	43.4	42.8
42	41	Turkey	43.3	44.0
43	45	Croatia	42.1	41.0
44	44	Bulgaria	41.8	42.0
45	43	Romania	41.7	42.2
46	47	Thailand	41.2	40.0
47	46	Mexico	41.1	40.3
48	48	Iran	39.2	38.9
49	49	India	38.8	36.8
50	50	Indonesia	33.5	33.5

1. Introduction

This report presents the results for the eighth annual ranking of national systems of higher education undertaken under the auspices of the Universitas 21 (U21) group 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. One aim of our work is to redress this bias. By construction, the institutional rankings also favour large institutions and thus promote amalgamations of existing institutions and a consequent reduction in diversity.

The indicators 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 individual personal desires and perceived national needs (Salmi 2017a, p.237; Williams, 2018). Diversity can also be an effective way to improve enrolment rates and at a reduced per student cost (Salmi 2017b, p.121).

We use 24 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. 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. The Environment module includes measures of institutional autonomy, external monitoring of performance and the degree of diversity.

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 of governments encouraging institutions of higher education to strengthen relationships with business and society, both domestically and internationally. The Connectivity module includes variables which span this wider concept (see de Rassenfosse and Williams 2015).

Our work extends well beyond ranking. Using our data, countries can benchmark performance over a range of attributes. We also present estimates of a country's performance relative to its level of GDP per capita. In this year's Report, Connectivity is explored in more detail, including the calculation of an additional measure: academic research links across each nation's universities. This year we also go beyond presenting annual changes in performance. Most national systems of higher education evolve slowly over time. We examine longer term changes by looking at key attributes over the eight-year period covered by the U21 rankings. The indicators we choose are research expenditures, publications, joint international publications and the qualifications of the workforce.

2. Changes in Data and Methodology from the 2018 Rankings

In the 2018 rankings research output were taken from InCites, whereas in previous years we used data provided by SciMago. The underlying source of data thus moved from the Scopus data base produced by Elsevier to the Web of Science data bank produced by Clarivate Analytics. For this year's ranking there have been modifications to our use of InCites data. For the first time in our eight years of ranking we eliminate multiple counting of articles with authors from more than one university in a country. The effect is to reduce the number of publications for each country, but it affects the ranking only insofar as the share of joint articles varies by country.

The second change in the publications data is that we can now use a slightly wider list of publications that includes more journals from regional areas. Inclusion of this Emerging Sources Citation Index (ESCI) increases total publications by around eight percent on average but favours lower income countries. For example, adding in ESCI increases the number of publications for Ukraine by 64 per cent and Indonesia by 18 per cent but by only 7 per cent for the United States. The revised publications data base is used for the total number of documents produced (O1), documents per head (O2), average impact of articles (O3) and joint publications with international authors (C2).

The coverage of universities included in the international ranking by Shanghai Jiao Tong University has been increased from 500 to 1000. The main effect has been to improve the ranking of countries with lower income levels. The number of countries scoring zero on the relevant measures (O4 and O5) has been reduced from seven to two. In deflating the Shanghai scores by population (O4), the deflator has been capped at 750 million for China and India. In the 1000 Shanghai universities, the Nordic countries and Switzerland have around one university per million of population. This is not mathematically possible (nor desirable) for China and India, hence the capping.

The data provide by CWTS at Leiden University relating to joint scientific publications with industry has moved forward two years rather than the usual one year: this year's data covers the period 2015–17.

While there remain data deficiencies that require estimates to be made, especially for non-OECD countries, the availability and quality of data continue to improve. Where a major improvement has affected a ranking markedly this is noted.

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 research and development 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, 2015.
- R2:** (5%) Total expenditure on tertiary education institutions as a percentage of GDP, 2015.
- R3:** (5%) Annual expenditure per student (full-time equivalent) by tertiary education institutions in USD purchasing power parity, 2015.
- R4:** (2.5%) Expenditure in tertiary education institutions for R&D as a percentage of GDP, 2016.
- R5:** (2.5%) Expenditure in tertiary education institutions for R&D per head of population at USD purchasing power parity, 2016.

Government expenditure as a share of GDP continues to fall: a median of 0.94 per cent compared with 0.99 per cent in last year's rankings. This fall is not offset by a rise in private expenditure so that both total expenditure and research expenditure fall as a share of GDP.

The highest ranked countries for resources are Switzerland, Sweden, Singapore, Denmark, Canada, Norway, Saudi Arabia and the United States, in that order. The top five countries are the same as in the 2018 ranking; Saudi Arabia has risen three places and the United States fallen two places. Note, however, that the data for Saudi Arabia are only estimates. Increases in government expenditure have led to noticeable improvements in rank for Brazil (up eight places), Slovakia (up eleven places) and South Africa (up seven places). Reductions in government expenditure have lowered the rank for Ireland and Malaysia (each down five places) and Ukraine (down eight places). Chile has risen ten places on the back of increases in both public and private expenditure. Greece has plummeted to 43rd with the availability of up-to-date statistics.

Turning to the rankings of the five components, government expenditure on higher education is highest in Saudi Arabia, Norway, Finland, Austria and Denmark, in that order. 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, Chile, Saudi Arabia, Canada, Australia and Malaysia in that order. The four lowest ranked countries for total expenditure as a share of GDP are, in alphabetical order, Hungary, Indonesia, Ireland and Italy. Expenditure per student, which includes research expenditure, is estimated to be highest in Singapore followed by the United States, Switzerland, the United Kingdom, Sweden and Hong Kong SAR, in that order. Research expenditure by tertiary institutions as a share of GDP is highest in the Nordic countries, Switzerland and Austria. On a per capita basis research expenditure is highest in Switzerland and Singapore.

Below: Resources Ranking

Rank	Country	Score
1	Switzerland	100.0
2	Sweden	96.7
3	Singapore	94.4
4	Denmark	93.7
5	Canada	93.5
6	Norway	92.9
7	Saudi Arabia	92.2
8	United States	91.5
9	Austria	89.3
10	Finland	86.9
11	Netherlands	82.3
12	Australia	78.3
13	United Kingdom	73.0
14	Hong Kong SAR	72.6
15	Belgium	72.1
16	France	68.5
17	Malaysia	68.1

Rank	Country	Score
18	Germany	66.8
19	New Zealand	63.4
20	Slovakia	61.5
21	Israel	58.2
22	Portugal	57.9
23	Turkey	57.9
24	Japan	57.1
25	Brazil	55.9
26	Chile	55.9
27	Korea	55.4
28	Taiwan-China	53.7
29	Poland	52.9
30	Spain	52.3
31	Serbia	50.5
32	Czech Republic	49.6
33	Ukraine	49.3
34	South Africa	45.4

Rank	Country	Score
35	Ireland	45.2
36	Mexico	44.8
37	Argentina	44.3
38	Slovenia	43.5
39	Italy	42.4
40	India	42.0
41	Croatia	41.6
42	China	41.5
43	Greece	38.5
44	Russia	37.2
45	Romania	36.8
46	Iran	36.2
47	Hungary	32.4
48	Bulgaria	31.1
49	Thailand	29.5
50	Indonesia	20.0

3.2 Environment (weight of 20%)

The policy environment under which tertiary institutions operate is an important determinant of outcomes. We define a good policy environment as one where institutions enjoy considerable financial and academic autonomy combined with transparent external monitoring of performance, and where policy settings foster diversity and competition between institutions. 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, 2016.

E2: (2%) Proportion of academic staff in tertiary institutions who are female, 2016.

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, 2016.

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 World Economic Forum (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, Hong Kong SAR, Finland, United Kingdom and Singapore. Relatively large revisions to data on institutional diversity (E4.1) account for the changes in the rank for Malaysia (up six places). India has improved seven ranks owing to greater autonomy being granted to selected institutions (E4.3).

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

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 Indonesia where the female share increased from 39 to 43 per cent. As measured by the WEF survey, business ranks national education systems most highly in Switzerland, Singapore, Finland, the United States, the Netherlands and Ireland.

Below: Environment Ranking

Rank	Country	Score
1	United States	100.0
2	Australia	96.6
3	New Zealand	93.7
4	Hong Kong SAR	92.6
5	Finland	91.3
6	United Kingdom	89.7
7	Singapore	89.1
8	Netherlands	87.3
9	Malaysia	86.7
10	Belgium	85.1
11	Taiwan-China	84.9
12	Switzerland	83.6
13	Canada	83.0
14	Sweden	82.6
15	Poland	81.2
16	China	80.9
17	Norway	80.8

Rank	Country	Score
18	Ireland	80.4
19	Israel	80.4
20	Chile	79.9
21	Japan	79.5
22	Denmark	78.9
23	South Africa	78.9
24	Austria	78.2
25	France	78.2
26	Mexico	78.2
27	Thailand	77.3
28	Germany	76.8
29	Russia	76.8
30	Indonesia	76.5
31	Romania	75.5
32	Argentina	75.1
33	Spain	74.8
34	Czech Republic	74.0

Rank	Country	Score
35	Portugal	73.8
36	Slovenia	73.1
37	Italy	70.8
38	India	70.5
39	Ukraine	70.4
40	Slovakia	69.0
41	Iran	67.3
42	Brazil	66.9
43	Bulgaria	65.9
44	Korea	65.8
45	Saudi Arabia	64.9
46	Hungary	62.5
47	Croatia	60.9
48	Turkey	59.7
49	Serbia	59.1
50	Greece	47.8

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. International connectivity is particularly important for small countries. There are five measures each with equal weight:

C1: (4%) Proportion of international students in tertiary education, 2016.

C2: (4%) Proportion of articles co-authored with international collaborators, 2017.

C3: Webometrics TRANSPARENCY not used.

C4: (4%) Webometrics VISIBILITY index. The number of external links that university web domains receive, divided by country's population. Cut off is top 10,000 tertiary institutions. July 2018 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, 2018.

C6: (4%) Percentage of university scientific research publications that are co-authored with industry researchers, 2015–17.

Switzerland is clearly the top nation for Connectivity, followed by Austria and the United Kingdom. Then come four countries with similar scores: the Netherlands, Denmark, Singapore and Sweden. The countries with lowest connectivity are, in alphabetical order, Brazil, India, Iran and Turkey. Croatia exhibits

the largest improvement from last year's ranking: up four places to 38th. Consequent on more accurate data on international student numbers, Brazil has fallen back to the level of the 2017 rankings. New Zealand and Slovakia have each fallen six places.

International students make up the highest share of tertiary enrolments in Singapore, New Zealand and the United Kingdom. The median value for the share of publications which include an international author is 45 per cent and is highest in Saudi Arabia (74 per cent) and Switzerland (67 per cent). But the international share is only around 20–25 per cent in China, India and Turkey.

The share of scientific research publications that have a co-author from industry is highest in Austria (9.5 per cent), followed by the Netherlands (8.7 per cent), Hungary (8.5 per cent) and Sweden (8.4 per cent). In contrast, the shares are below 2 per cent in Iran, Malaysia and Turkey. Compared with the 2018 rankings, increases in the share of scientific publications that have industry co-authors are greatest in Bulgaria, Austria, Greece and Hungary; decreases occurred in Slovakia, Slovenia and Ukraine.

The top seven countries for knowledge transfer in the IMD survey of business executives (C5) are, in rank order, Switzerland, the United Kingdom and the United States, followed by Denmark, the Netherlands, Israel and Canada. Relations with business improved markedly in the United Kingdom, France, the Czech Republic and Slovenia; relationships worsened noticeably in Brazil and Slovakia. Web visibility/impact is greatest in the United States followed by Switzerland; next come a group of four countries: Canada, Ireland, Finland and the United Kingdom.

Below:

Connectivity Ranking

Rank	Country	Score
1	Switzerland	100.0
2	Austria	93.6
3	United Kingdom	89.5
4	Netherlands	85.4
5	Denmark	84.7
6	Singapore	84.5
7	Sweden	83.2
8	Finland	81.3
9	Canada	80.8
10	Belgium	79.7
11	United States	77.8
12	New Zealand	77.2
13	Australia	73.3
14	Germany	72.9
15	Ireland	72.9
16	Norway	72.4
17	France	67.9

Rank	Country	Score
18	Hungary	66.2
19	Hong Kong SAR	62.8
20	Israel	62.3
21	Czech Republic	59.8
22	Taiwan-China	57.6
23	Portugal	55.1
24	Slovenia	54.5
25	Japan	53.7
26	Greece	53.0
27	Italy	52.3
28	Saudi Arabia	52.2
29	Spain	48.9
30	Korea	46.4
31	Malaysia	45.8
32	South Africa	44.3
33	Chile	43.4
34	Bulgaria	43.1

Rank	Country	Score
35	Thailand	42.9
36	Slovakia	40.1
37	Serbia	39.0
38	Croatia	38.1
39	Poland	38.0
40	China	36.2
41	Argentina	34.7
42	Romania	34.2
43	Ukraine	33.9
44	Russia	31.5
45	Mexico	31.4
46	Indonesia	29.4
47	Brazil	27.5
48	Turkey	26.7
49	India	25.9
50	Iran	24.7

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, 2017.

O2: (3%) Total research documents produced by higher education institutions per head of population, 2017.

O3: (5%) Average impact of articles as measured by the Category Normalised Citation Impact for documents published 2013–17.

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 top 1000 institutions, divided by population.

O5: (7%) The excellence of a nation's best universities calculated by totalling the 2018 Shanghai Jiao Tong 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, 2016.

O7: (3%) Percentage of the population aged 25–64 with a tertiary qualification, 2017.

O8: (3%) Number of researchers (full-time equivalent) in the nation per million of population, 2016.

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, 2017.

The top country in the Output module is clearly the United States. The United Kingdom is second, followed by Switzerland, Australia, Denmark, Canada and Sweden. As expected with slowly moving variables the changes from the 2018 rankings are limited. The largest movement is an increase of six places for Ukraine. Norway has improved across most variables and risen five places to ninth. Japan has fallen four places although the score is unchanged. The change in the counting of publications (see Section 2) has had limited effect. France, the country most affected, has fallen three places, but even using the new measure for both years, French publications fell by 5 per cent.

The leading five countries for publications per head of population are, in rank order, Denmark, Switzerland, Sweden, Australia and Norway. Switzerland is clearly the top country for the average impact of publications. The next countries, in rank order, are the Netherlands and Denmark. Indonesia and Ukraine are the only countries without a university in the top 1000. The United States and the United Kingdom clearly dominate the 'best three universities' (O5). Then follow seven countries with similar scores: in alphabetical order these are Australia, Canada, China, France, Germany, Japan and Switzerland. The variable O4 measures the depth of world-class universities relative to population. Switzerland and then Sweden are the highest ranked. Making up the top ten in rank order are Denmark, Australia, Finland, Norway, the Netherlands, New Zealand, the United Kingdom and Israel. The United States is ranked 16th.

The top four countries with the most qualified workforces (O7) are Canada, Russia, Japan and Israel. The national stock of researchers relative to population is highest in Israel followed by Denmark, Sweden, Korea, Singapore and Finland. Unemployment of the tertiary educated relative to school leavers (O9) is lowest in South Africa, Ukraine, Hungary, Poland and Argentina. Unemployment remains higher for those with a tertiary qualification in Denmark, Malaysia, Mexico, Saudi Arabia, Taiwan-China and Thailand.

Below: Output Ranking

Rank	Country	Score
1	United States	100.0
2	United Kingdom	72.1
3	Switzerland	66.0
4	Australia	65.7
5	Denmark	64.9
6	Canada	63.5
7	Sweden	63.2
8	Netherlands	60.6
9	Norway	59.4
10	Finland	58.8
11	Israel	57.4
12	Singapore	56.7
13	Germany	55.0
14	Belgium	54.2
15	Ireland	52.5
16	France	51.4
17	Korea	50.8

Rank	Country	Score
18	Hong Kong SAR	50.7
19	New Zealand	50.7
20	Austria	50.6
21	Japan	49.6
22	China	49.0
23	Spain	46.5
24	Taiwan-China	43.9
25	Italy	42.5
26	Russia	41.1
27	Greece	40.7
28	Slovenia	40.3
29	Portugal	39.8
30	Czech Republic	37.9
31	Poland	36.3
32	Saudi Arabia	34.5
33	Hungary	33.2
34	Slovakia	31.0

Rank	Country	Score
35	Chile	30.8
36	South Africa	30.0
37	Turkey	29.5
38	Ukraine	29.1
39	Argentina	28.9
40	Croatia	28.5
41	Brazil	28.3
42	Bulgaria	28.1
43	Iran	27.9
44	Serbia	27.5
45	Malaysia	27.5
46	Romania	24.7
47	India	21.9
48	Thailand	21.9
49	Mexico	19.3
50	Indonesia	15.7

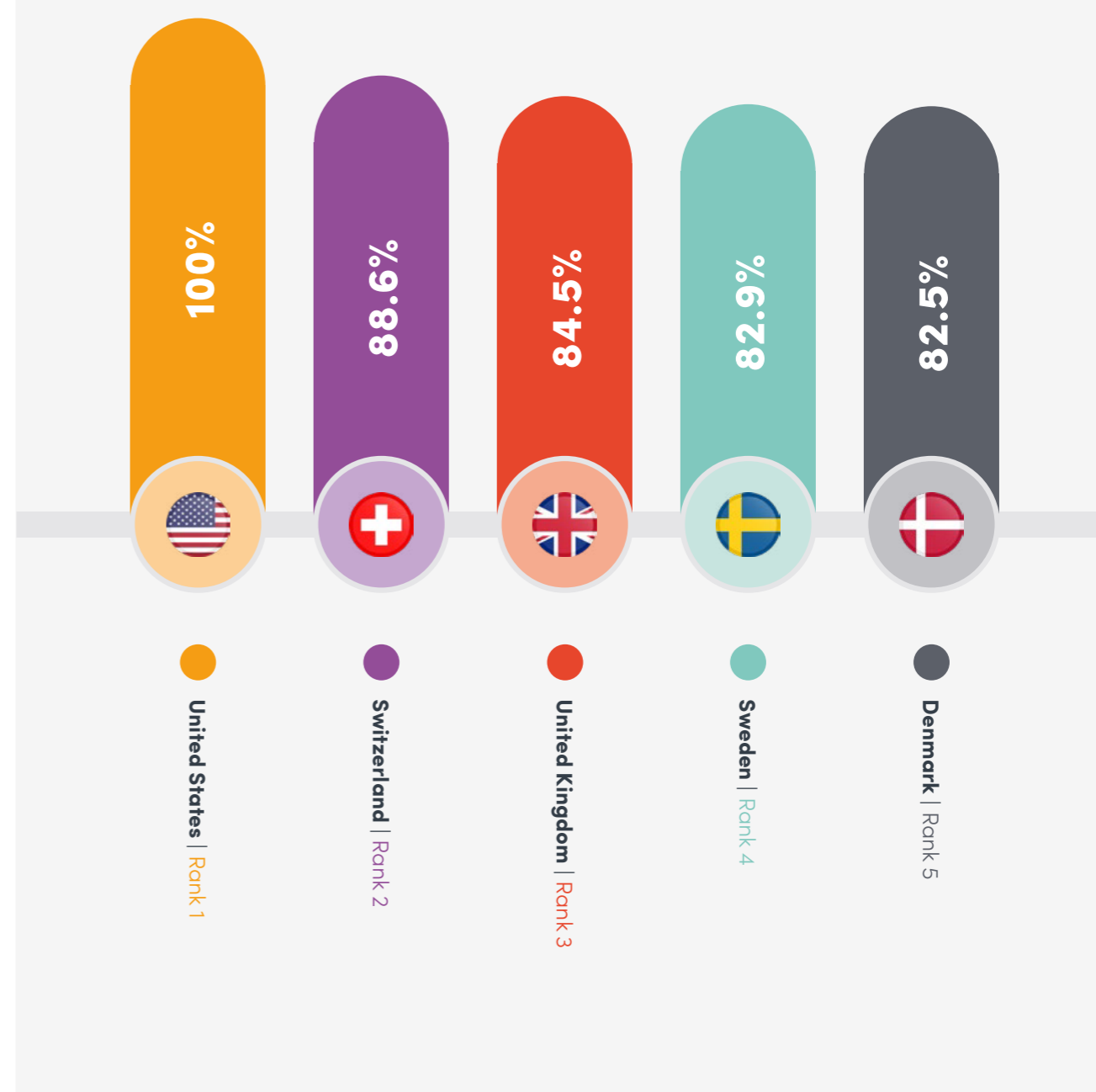
3.5 Overall Ranking

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 three countries, in order, are the United States, Switzerland and the United Kingdom. The other seven countries that make up the top ten have scores within a narrow band of 80 to 83. In rank order these seven countries are Sweden, Denmark, Canada, Singapore, Australia, Finland and the Netherlands. For two of these countries this year's changes in rank have reversed the changes in last year's ranking: Singapore (up two places) and Finland (down three places). But competition is tough at the top: the Netherlands has fallen four places even though its score has improved by 0.5.

Turning to countries outside the top ten, the largest change is a fall of five places for Greece, arising from the availability of new and better data on expenditure. China and South Africa have each improved three places. Other changes include an improvement of two places by Argentina, Chile, Croatia, Hong Kong SAR and Slovakia. Four countries fell by two places: Italy, Malaysia, Romania and Russia.

Below:

Top 5 Overall U21 Ranking 2019



4. Methodology of adjusting for levels of economic development

In our main rankings, the performance of a country is measured against world-best, usually high-income countries. But it is neither possible nor desirable for low-income countries to match the performance of rich countries. 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 GDP per capita? 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 2016 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 or near-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.

Annual changes in ranking depend on both changes in the variables relating to higher education and changes in GDP per head. Thus, a country showing improvement in higher education can fall back in the adjusted rankings if economic growth has been exceptionally fast. Conversely if economic growth has been slow or negative, a country can rise in the adjusted rankings because of built-in lags in the higher education system.

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 regress on income per head of population. We delete R5 and move the weight to R4 (R&D expenditure as a share of GDP), 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 Serbia and South Africa where expenditures are around 35 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 Brazil, Canada, Finland, Malaysia, Saudi Arabia and Sweden.

Compared with the non-adjusted rankings, the largest improvers are South Africa (up 32 places to second), Serbia (up 30 places to first), India (up 28 places to 12th) and China (up 25 places 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. The relationship has become flatter with each successive year of ranking. This implies some convergence across countries at different levels of development in the level of resources devoted to higher education. For each ten-thousand-dollar increase in GDP per capita, government expenditure is estimated to increase by only 0.05 per cent of GDP and total expenditure by 0.07 per cent. The top five countries for the level of

government expenditure after adjusting for GDP per capita are Saudi Arabia, Ukraine, Finland, Austria and Denmark. The highest ranked countries for total expenditure as a share of GDP are now Chile, the United States, Canada, Saudi Arabia and Malaysia. Expenditure (which includes research expenditure) per student increases markedly with income levels: on average by around USD352 (PPP) for each USD1,000 (PPP) increase in GDP per capita ($R^2 = 0.73$). The top two countries on an income-adjusted basis are, Brazil (public institutions only) and South Africa. Then, in rank order, are the United Kingdom, the United States, Malaysia 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 0.28 per cent of GDP whereas the corresponding figure at GDP per capita of USD50,000 is 0.55. The top ten countries for research expenditure as a share of GDP are now Serbia, South Africa, Portugal, Denmark, Sweden, Switzerland, Finland, Austria, Turkey and Canada.

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 average 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 Hong Kong SAR) 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), GDP per capita explains 40 to 50 per cent of the variations across countries. The relationship with income levels is weaker for joint international publications because population size is also important: researchers in large countries such as China and the United States have a larger internal population to undertake joint work. To correct for this, we use both income and (log) population to explain joint publications. When this is done the explanatory power increases to 53 per cent.

The top eight countries for Connectivity, after adjusting for income levels, are, in rank order, Ukraine, the United Kingdom, Austria, New Zealand, Hungary, Switzerland, South Africa and Canada. Compared with the unadjusted data it is of course lower income countries that show the greatest improvement in rank. India, for

example, improves from 49th to 18th, China from 46th to 30th. Conversely, at the high-income end, Norway, Saudi Arabia and Singapore all fall by around 20 places.

The top three countries for international co-authorship are Saudi Arabia, Chile and South Africa, where values are around one-third higher than expected given their income levels. Population size has a significant negative effect on international co-authorship and is more important than GDP per capita as an explainer of national differences.

Knowledge transfer is rated most highly by business (C5) in Israel, China, the United Kingdom, India and Malaysia. Joint publications with industry are highest in Ukraine, Hungary, India, South Africa, Austria and Indonesia 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 with an explanatory power of nearly 70 per cent: 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 six ranked countries for Output are Serbia, Israel, the United Kingdom, Greece, Portugal and Denmark. For these countries Output is more than 20 per cent above expected values for their levels of income. Compared with the unadjusted rankings, the countries that increase by more than 20 places are, in rank order, Serbia, South Africa, Portugal, Greece and Brazil. The largest falls in rank compared with the original data occur for Germany, Ireland, Japan and Taiwan-China, each down by around 20 places.

Turning to the components, the top ten countries for publications (measured as the number of research documents deflated by total GDP) are now, in rank order, Serbia, Denmark, Portugal, Ukraine, Croatia, Slovenia, New Zealand, Australia, Sweden and Finland. After adjusting for differences in income levels, the impact of publications (O3) is highest for South Africa, India, Greece, Denmark, Switzerland, Belgium and the United Kingdom. China is clearly ranked first for the quality of the best three universities; next in rank order are the United States, the United Kingdom, Russia and Israel.

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

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 seven 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 the United Kingdom and Finland, where the scores imply an overall performance of 20 per cent above the average level of achievement for countries at their income levels. Next in rank order are Serbia, South Africa, Denmark and Canada.

Compared with the original rankings in Section 3, seven countries improve their ranking by more than ten places. Serbia shows the

largest increase (38 places) followed by South Africa (up 30) and Ukraine (up 22). Five countries improve by between nine and 16 ranks: India, Brazil, Portugal, China and Greece.

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 17th position. Similarly, Singapore, the country with the highest income levels, now ranks only 23rd. Ireland falls substantially but is disadvantaged by our use of Gross Domestic Product as a measure of income levels. Foreign ownership is relatively large in Ireland and a better measure of domestic income levels for this country would be Gross National Income.

Overleaf:
'National Results of
the Four Measures
Controlling for Level of
Economic Development'

Rank	Resources	% Dev	Environment	% Dev	Connectivity	% Dev	Output	% Dev
1	Serbia	36.4	United States	26.5	Ukraine	59.9	Serbia	37.5
2	South Africa	35.4	Australia	22.8	United Kingdom	37.9	Israel	32.3
3	Saudi Arabia	28.1	New Zealand	20.0	Austria	30.3	United Kingdom	23.9
4	Brazil	27.0	Hong Kong SAR	18.4	New Zealand	26.6	Greece	22.1
5	Sweden	25.6	Finland	17.3	Hungary	25.7	Portugal	21.8
6	Canada	25.2	United Kingdom	15.4	Switzerland	23.6	Denmark	21.7
6	Finland	25.1	Singapore	14.8	South Africa	22.4	Finland	17.4
8	Malaysia	24.8	Netherlands	12.8	Canada	20.2	Australia	15.6
9	Denmark	22.7	Malaysia	12.1	Finland	19.9	South Africa	14.3
10	Ukraine	19.9	Belgium	10.1	Denmark	16.5	Sweden	13.7
11	Austria	19.7	Taiwan-China	9.9	Netherlands	14.2	New Zealand	10.7
12	India	19.0	Canada	7.5	Serbia	13.1	Switzerland	10.4
13	Turkey	13.6	Switzerland	7.2	Belgium	13.0	Canada	10.0
14	Switzerland	13.5	Sweden	7.1	Czech Republic	10.7	China	10.0
15	Portugal	8.8	China	5.3	Sweden	9.6	Slovenia	5.7
16	Netherlands	7.7	Poland	4.4	Portugal	7.7	Netherlands	4.3
17	China	6.4	Israel	4.3	Australia	7.3	Belgium	1.7
18	Norway	4.6	Norway	4.1	India	5.3	Brazil	-0.3
19	Belgium	3.0	Ireland	3.9	Greece	4.6	United States	-1.3
20	Australia	2.4	Chile	2.4	France	3.9	Norway	-4.0
21	Slovakia	2.1	Denmark	2.0	Germany	3.0	Croatia	-4.1
22	France	2.0	France	1.4	Bulgaria	-0.7	Spain	-4.6
23	United States	1.7	Austria	1.4	Thailand	-1.2	Czech Republic	-4.8
24	Poland	-0.7	Japan	1.4	United States	-6.5	Poland	-5.8
25	New Zealand	-1.6	Thailand	-0.6	Israel	-7.2	Singapore	-7.1
26	United Kingdom	-3.9	South Africa	-0.6	Slovenia	-12.6	Iran	-8.1
27	Israel	-4.7	Mexico	-0.7	Singapore	-16.7	Korea	-10.7
28	Mexico	-4.9	Indonesia	-1.2	Italy	-17.2	Chile	-12.1
29	Germany	-9.4	Russia	-1.4	Taiwan-China	-18.5	Hungary	-13.2
30	Argentina	-10.8	Germany	-1.4	China	-18.8	Austria	-13.2
31	Chile	-10.8	Spain	-3.7	Ireland	-19.2	India	-16.3
32	Singapore	-11.6	Argentina	-4.3	Malaysia	-20.8	Hong Kong SAR	-16.5
33	Croatia	-12.7	Czech Republic	-4.6	Romania	-21.9	Italy	-16.7
34	Hong Kong SAR	-14.2	Romania	-4.8	Hong Kong SAR	-22.7	France	-16.7
35	Czech Republic	-16.2	Portugal	-5.5	Spain	-24.4	Ireland	-19.1
36	Spain	-16.8	Slovenia	-6.1	Poland	-27.2	Germany	-21.4
37	Korea	-18.2	Italy	-9.4	Norway	-28.0	Bulgaria	-21.9
38	Iran	-21.7	India	-9.6	Japan	-28.2	Ukraine	-22.9
39	Japan	-22.2	Ukraine	-10.0	Slovakia	-29.6	Russia	-24.8
40	Slovenia	-29.2	Slovakia	-13.9	Argentina	-29.6	Romania	-27.0
41	Taiwan-China	-31.3	Iran	-13.9	Indonesia	-37.3	Malaysia	-27.2
42	Greece	-31.8	Korea	-16.8	Chile	-40.7	Turkey	-29.3
43	Thailand	-32.2	Brazil	-17.0	Russia	-43.2	Slovakia	-33.3
44	Italy	-37.2	Bulgaria	-18.4	Korea	-44.4	Japan	-34.3
45	Romania	-41.5	Saudi Arabia	-18.8	Brazil	-45.7	Argentina	-35.5
46	Russia	-42.9	Hungary	-24.3	Croatia	-49.4	Taiwan-China	-41.4
47	Hungary	-51.0	Croatia	-27.8	Saudi Arabia	-61.2	Thailand	-47.9
48	Bulgaria	-55.6	Turkey	-29.4	Mexico	-63.4	Saudi Arabia	-72.7
49	Indonesia	-58.1	Serbia	-31.0	Turkey	-68.4	Mexico	-74.3
50	Ireland	-67.2	Greece	-55.6	Iran	-75.4	Indonesia	-106.8

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

Below:

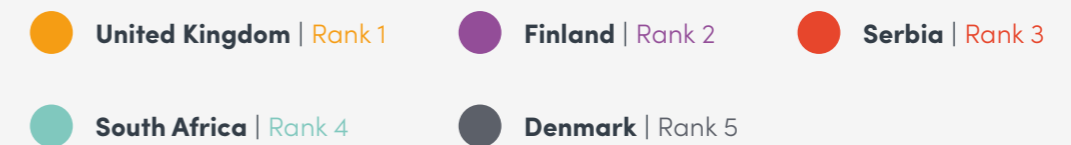
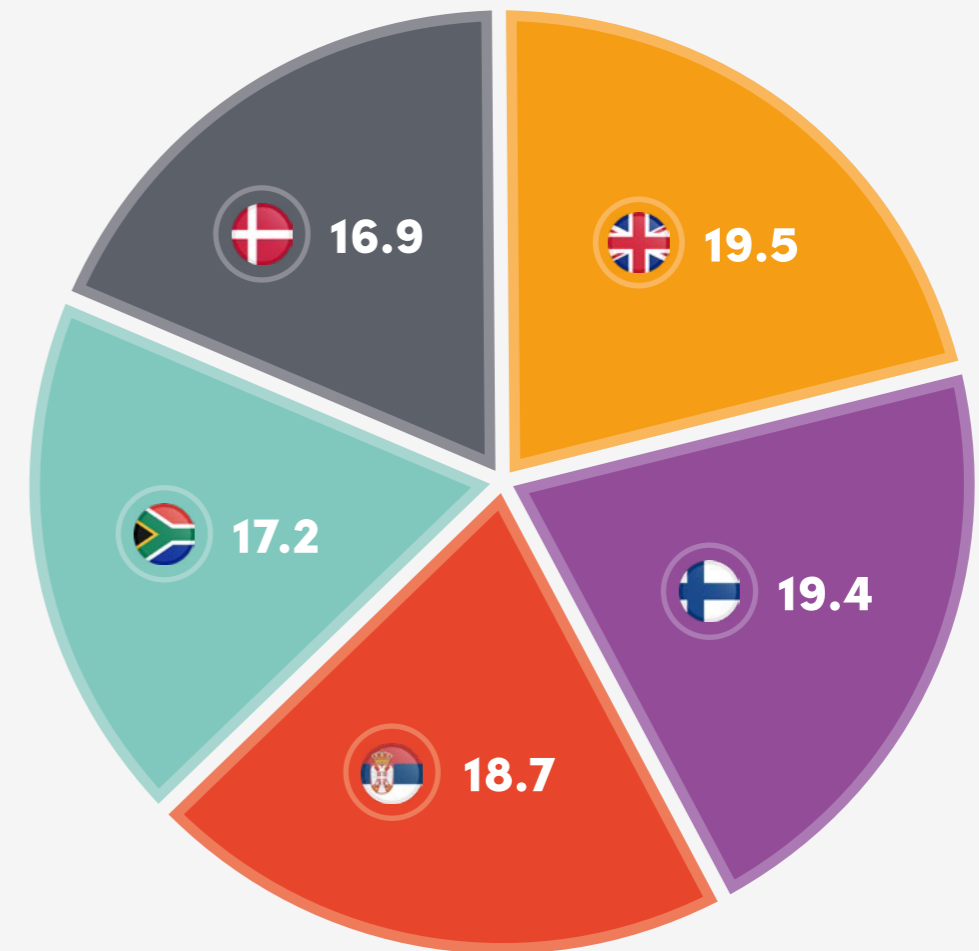
Overall Ranking Controlling for Level of Economic Development

Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
1	United Kingdom	19.5	18	China	2.6	35	Croatia	-19.6
2	Finland	19.4	19	India	-3.6	36	Korea	-20.2
3	Serbia	18.7	20	Czech Republic	-4.0	37	Slovakia	-21.6
4	South Africa	17.2	21	France	-5.2	38	Argentina	-23.1
5	Denmark	16.9	22	Norway	-5.5	39	Japan	-23.5
6	Canada	14.6	23	Singapore	-5.6	40	Bulgaria	-23.7
7	Sweden	13.9	24	Poland	-7.0	41	Ireland	-24.1
8	New Zealand	13.3	25	Brazil	-7.3	42	Romania	-24.4
9	Switzerland	13.0	26	Slovenia	-7.3	43	Taiwan - China	-24.5
10	Australia	12.7	27	Malaysia	-7.7	44	Iran	-25.5
11	Israel	11.4	28	Greece	-7.7	45	Thailand	-25.9
12	Portugal	10.9	29	Germany	-10.1	46	Russia	-27.4
13	Netherlands	8.7	30	Hong Kong SAR	-10.3	47	Turkey	-28.6
14	Belgium	5.9	31	Spain	-10.8	48	Saudi Arabia	-39.5
15	Austria	5.0	32	Chile	-14.7	49	Mexico	-43.5
16	Ukraine	4.8	33	Hungary	-15.2	50	Indonesia	-62.0
17	United States	3.8	34	Italy	-19.4			

%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. Research Connectivity

The U21 rankings include two measures of research connectivity: with international researchers and industry. The InCites data base permits a third measure: domestic research connectivity across tertiary institutions. The index of domestic connectivity is constructed by comparing gross and net measures of publications. Under the gross measure, publications with authors from more than one institution are credited separately to each named institution. Net publications measure the total number of publications that contain at least one author from the country. The ratio of gross to net publications therefore provides a measure of joint authorship across domestic institutions: the higher the ratio the greater are the cross-institutional research links. The measure can, however, be unduly distorted by umbrella-type linkages. This is a particular problem for Argentina and India. Argentina is excluded because of the complex links between CONICET and universities; for India we have deducted from the gross data the joint publications with the Institute of Technology Systems.

The first column of the table of research connectivity displays the national ranks on domestic connectivity across the higher education section. France is ranked first, followed by Brazil, Singapore and the United States. It is in these countries that joint inter-institutional authorship is greatest. The next column of the table shows national ranks for international joint authorship (C2). It has been argued earlier in the Report that researchers in countries with small populations have greater need to seek international collaboration, whereas researchers in large countries are able to draw on a large domestic research base for collaboration. The data offer some support to this view. The rank correlation between international and domestic connectivity is -0.16 . The nine countries where the domestic rank is at least 25 places higher than the international rank are Brazil, China, India, Iran, Japan, Korea, Taiwan-China, Turkey and the United States. Conversely, seven of the eight countries where the international rank is at least 25 places higher than the domestic rank have small populations: Austria, Belgium, Denmark, New Zealand, Norway, Slovenia and Switzerland.

Another aspect of research connectivity is joint research with industry. The third column in the table ranks countries by the percentage share of scientific articles written jointly with industry (C6) as derived by CWTS, Leiden University. A domestic and international split is also possible. If an article has at least one industry co-author with a domestic address it is classified as domestic, otherwise it is classified as international. The last column shows the difference between the domestic and international rank. The four countries which rank at least 30 places higher for links with domestic rather international companies are China, Japan, Korea and the United States – a hardly surprising result when these countries are the home of so many internationally focussed companies! The results at the other end also contain few surprises. The five countries where links with international firms rank highest relative to links with domestic firms are Bulgaria, Hong Kong SAR, Indonesia, Ireland and Saudi Arabia.

The different measures of research connectivity have different implications for impact as measured by standardised citation (O3). Domestic institutional connectivity does not seem to increase citations, at least on our measure. Indeed, there is a small negative correlation between citations and domestic connectivity within the higher education sector. This is in marked contrast to joint publications with international authors and with industry where there are very significant positive correlations with citations.

Overleaf: Research Connectivity Ranks

Country	Domestic Tertiary Institutions 2017	International Joint Authorship 2017	Joint Authorship with Industry 2015-17	Industry: Domestic versus International 2015-17*
Argentina	n.incl	35	47	-4
Australia	15	14	27	-11
Austria	44	6	1	-11
Belgium	34	3	6	-18
Brazil	2	38	43	6
Bulgaria	13	29	21	-30
Canada	24	21	15	-13
Chile	11	8	41	-8
China	18	46	36	35
Croatia	36	31	20	6
Czech Republic	40	30	18	-15
Denmark	41	7	5	0
Finland	26	9	10	4
France	1	12	12	7
Germany	10	23	8	11
Greece	23	20	22	-17
Hong Kong SAR	49	33	32	-30
Hungary	19	18	3	10
India	16	49	45	20
Indonesia	47	50	37	-23
Iran	14	47	50	10
Ireland	37	16	23	-23
Israel	20	24	24	-7
Italy	9	26	19	-3
Japan	8	42	7	43
Korea	7	43	13	36
Malaysia	27	32	49	-6
Mexico	28	36	46	-6
Netherlands	25	10	2	-8
New Zealand	45	13	25	1
Norway	38	11	14	-3
Poland	29	41	39	-12
Portugal	21	15	34	3
Romania	22	45	38	3
Russia	31	44	44	-3
Saudi Arabia	42	1	40	-19
Serbia	46	27	42	-3
Singapore	3	4	33	-4
Slovakia	43	34	31	5
Slovenia	48	19	17	23
South Africa	32	22	28	-17
Spain	30	25	26	2
Sweden	12	5	4	-3
Switzerland	35	2	9	-8
Taiwan-China	5	39	30	18
Thailand	33	28	29	-8
Turkey	6	48	48	1
Ukraine	39	40	35	29
United Kingdom	17	17	11	-5
United States	4	37	16	45

*Positive values mean domestic links stronger than international and vice-versa for negative values

Overleaf:
Research Expenditure
and Publications

7. Seven-year Trends

Trend movements, especially for selected attributes, are most accurately measured by using current definitions and re-estimating values for earlier years. This controls for changes in definitions and coverage and revision to official data. We choose

a seven-year period which corresponds to the data used in the first and current U21 rankings. Four measures are chosen: research expenditure, publications, international research links and the educational qualifications of the workforce.

7.1 Research expenditure and publications

Research Expenditure

Research expenditure is measured in constant PPP dollars over the period 2009–16 or, for a few countries, 2008–15. The source is UNESCO. Data limitations necessitate excluding five countries: Brazil, Indonesia, Iran, Saudi Arabia and Taiwan-China. The greatest increase occurred in Malaysia where research expenditure in 2015 was more than three times that of 2008 and the country's ranking on this measure improved by 15 places. The next largest increases were for Thailand and Slovakia. The three countries with the largest increase were coming off a low base. China is ranked fourth and was already ranked third for absolute expenditure in the base year. By contrast, research expenditure over the period 2009–16 was static in Japan and the United Kingdom, countries ranked second and fifth in the base year. The biggest falls in research expenditure occurred in eastern European countries, even though expenditure was low in the base year.

Research Publications

The trend data for publications is based on the document coverage of the Web of Science as presented by InCites. Over time, some journals are closed and new ones appear, and existing journals are added to the data base but usually not retrospectively. Widening of the journal coverage over time tends to favour countries with less developed research programs. These

changes cloud comparisons a little, but the effect is limited over a seven-year period. We note where they seem to be important. The total number of publications by academic institutions in each country are calculated for 2010 and compared with the 2017 data (O1). The percentage changes and ranks are given in the second panel of the accompanying table. Four countries have more than doubled their publications over the seven-year period: in order of the percentage increase they are Saudi Arabia, Malaysia, Russia, China and Iran. (A very large increase in publications for Indonesia occurred in 2017 but these seems to owe to changes in journal coverage and we do not rank).

Not unexpectedly, the largest increases tend to be from countries coming off a low base; in other words, there is convergence. Countries with well-developed research activity in 2010, as measured by publications, show the smallest increases: Switzerland, Germany, Japan and France make up four of the lowest ranked six countries; the United States is ranked 42nd.

In previous reports we have noted the strong correlation between lagged funding for research and publications. The data in the table offer some support for this conclusion, but precise quantification is not possible here because the country coverages differ and the lag between the two sets of data is short.

Research Expenditure, 2009-16						Publications, 2010-17				
Rank	Country	% change total	% change annual	Base year rank	Change in rank	Country	% change total	% change annual	Base year rank	Change in rank
1	Malaysia*	224.0	18.3	31	15	Saudi Arabia	288.1	21.4	43	11
2	Thailand**	148.1	16.4	36	4	Malaysia	139.4	13.3	38	14
3	Slovakia	127.2	12.4	44	6	Russia	136.8	13.1	21	6
4	China	85.2	9.2	3	1	China	110.2	11.2	2	0
5	Turkey*	67.7	7.7	13	2	Iran	105.4	10.8	22	5
6	South Africa*	55.9	6.5	29	3	India	97.6	10.2	14	5
6	Singapore***	53.0	7.3	22	3	South Africa	82.7	9.0	33	8
8	Poland	52.9	6.3	20	3	Chile	80.8	8.8	42	2
9	Czech Republic	51.2	6.1	34	1	Ukraine	65.2	7.4	44	0
10	Switzerland*	49.9	6.0	16	1	Thailand	63.4	7.3	41	0
11	Chile	42.7	5.2	39	2	Serbia	57.6	6.7	45	0
12	Korea	34.6	4.3	9	1	Slovakia	54.4	6.4	47	1
13	Argentina*	33.3	4.2	30	-1	Denmark	53.6	6.3	23	0
14	Norway	33.0	4.2	25	1	Australia	51.9	6.2	10	3
15	Germany	28.3	3.6	4	0	Mexico	49.0	5.9	36	2
16	Russia	26.8	3.5	18	-3	Poland	48.8	5.8	19	0
17	Hong Kong SAR	26.1	3.4	27	0	Brazil	47.5	5.7	12	-1
18	Sweden	25.0	3.2	14	0	Portugal	46.0	5.6	26	0
19	Australia*	20.8	2.7	12	2	Turkey	43.7	5.3	17	1
20	Denmark	17.9	2.4	21	-2	Norway	43.2	5.3	31	0
21	Israel	17.2	2.3	28	-1	Singapore	42.5	5.2	34	-1
22	Austria	16.7	2.2	17	-1	Hong Kong SAR	40.1	4.9	28	1
23	India*	16.7	2.2	23	-2	Sweden	38.9	4.8	18	0
24	Belgium	16.6	2.2	19	-3	Bulgaria	38.3	4.7	49	1
25	France	16.3	2.2	6	1	Korea	35.9	4.5	11	-1
26	Canada	11.5	1.6	7	0	New Zealand	30.7	3.9	37	-2
27	Greece	9.4	1.3	33	-2	Argentina	30.0	3.8	39	-3
28	New Zealand	7.3	1.2	35	-1	Croatia	29.0	3.7	46	-1
29	United States	6.2	0.9	1	0	Czech Republic	26.9	3.5	29	-1
30	Ireland	5.4	0.8	32	-2	Finland	25.8	3.3	30	-3
31	Mexico	4.0	0.6	15	-5	Italy	24.1	3.1	8	0
32	Croatia	4.0	0.6	41	0	Ireland	23.4	3.0	35	-2
33	Netherlands	2.1	0.3	11	-1	Hungary	23.4	3.0	40	-3
34	Finland	2.1	0.3	26	-4	Spain	22.8	3.0	9	-2
35	United Kingdom	0.8	0.1	5	-1	United Kingdom	20.9	2.7	3	0
36	Japan	-1.1	-0.2	2	-1	Canada	19.7	2.6	6	1
37	Portugal	-2.0	-0.3	24	-4	Austria	18.8	2.5	24	-4
38	Spain	-11.3	-1.7	10	-3	Israel	18.7	2.5	25	-4
39	Italy	-11.4	-1.7	8	-1	Belgium	17.9	2.4	20	-2
40	Slovenia	-12.4	-1.9	43	0	Slovenia	16.6	2.2	48	-1
41	Serbia	-28.3	-4.6	38	-2	Netherlands	16.2	2.2	13	-1
42	Bulgaria	-33.1	-5.6	45	0	United States	15.3	2.1	1	0
43	Hungary	-35.8	-6.1	37	-2	Romania	14.2	1.9	32	-6
44	Romania	-44.0	-8.0	40	-2	Switzerland	8.9	1.2	16	-4
45	Ukraine	-48.4	-9.0	42	-2	Germany	7.9	1.1	4	0
46						Japan	3.7	0.5	5	-1
47						France	2.5	0.3	7	-3
48						Greece	1.6	0.2	27	-9
49						Taiwan-China	-2.5	-0.4	15	-6

*2008-15; **2009-15; ***2008-14

7.2 Selected Outcomes

Joint International Publications

Over the period 2010 to 2017 the median increase in the share of publications that are jointly authored with international researchers rose from 40.1 to 44.5 percent, a rise of 4.4 percentage points. Saudi Arabia has seen the largest increase of 18.9 percentage points to 74 per cent. A further nine countries have increased the international share by over ten percentage points. In alphabetical order these are Australia, Chile, Finland, Greece, the Netherlands, Singapore, South Africa, Taiwan-China and the United Kingdom. Saudi Arabia and Singapore were already ranked in the top ten for international publications in 2010, whereas Australia, Greece and the United Kingdom had the largest increase in rank over the period 2010-17. The increase has been only three percentage points for Germany and Korea. Joint publications fell in Russia and Ukraine.

Qualifications of the workforce

Our variable O7 is the percentage of the population aged 25-64 years who possess a tertiary qualification. We chose this measure as it is a more robust indicator of teaching output, albeit in the long term, than are rates of enrolment or completions. It is of

course much easier to raise the qualification ratio when it is low.

The second panel of the table of trends in outcomes contains a ranking of the absolute increases over the period 2010 to 2017 in workforce qualifications. Consistent data over the period are not available for seven countries: Argentina, China, India, Iran, New Zealand, Saudi Arabia and Ukraine. For a few included countries the latest data is for 2016 and/or is available for only six years. To facilitate comparisons we give annual average changes. The final columns of the table contain a ranking of the absolute values of the qualification shares in the base year, usually 2010, and the change in ranking.

The largest increases in qualification rates have occurred in Slovenia, Taiwan-China, Korea, Switzerland, Portugal and Singapore. There is limited relationship between change and levels. Korea and Singapore had high qualification rates in 2010 but a substantial increase. On the other hand, Russia, with very high initial rates, had a small increase. The smallest increases have been for Germany (middle rank for level) and South Africa (low rate for level).

Overleaf:
Trends in Selected
Outcomes 2010-2017

Share of publications with international co-author					Qualifications of population 25-64			
Rank	Country	Percentage point increase	Base level rank	Change in rank	Country	Annual average percentage point increase	Base level rank	Change in rank
1	Saudi Arabia	18.9	2	1	Slovenia	1.51	24	3
2	Greece	12.0	32	12	Taiwan-China	1.29	13	5
3	Netherlands	12.0	14	4	Korea	1.25	7	1
4	United Kingdom	11.7	28	11	Switzerland	1.24	15	1
5	Australia	11.7	26	12	Portugal	1.23	35	5
6	Singapore	11.5	8	4	Singapore	1.20	5	0
6	Finland	10.6	12	3	Serbia	1.17	32	4
8	South Africa	10.4	31	9	Ireland	1.16	10	0
9	Taiwan-China	10.3	45	6	Sweden	1.15	16	1
10	Chile	10.1	10	2	Australia	1.11	11	0
11	Serbia	10.0	35	8	Poland	1.07	27	2
12	Ireland	9.9	23	7	United Kingdom	1.07	8	-1
13	Sweden	9.8	6	1	Hong Kong SAR	1.06	26	2
14	Canada	9.5	27	6	Czech Republic	1.01	34	3
15	Brazil	9.1	43	5	Turkey	0.99	38	2
16	Hong Kong SAR	8.9	38	5	Romania	0.98	40	3
17	Belgium	8.8	3	0	Thailand	0.97	39	0
18	Portugal	8.1	18	3	Japan	0.95	4	1
19	Austria	7.7	4	-2	Canada	0.91	2	1
20	Slovenia	7.4	20	1	Greece	0.90	23	0
21	Croatia	7.3	36	5	Chile	0.90	33	-1
22	Malaysia	7.3	37	5	France	0.89	20	0
23	Switzerland	6.8	1	-1	Finland	0.89	9	-3
24	Denmark	6.7	5	-2	Norway	0.84	12	-1
25	Norway	6.6	9	-2	Denmark	0.84	17	0
26	United States	6.1	40	3	Slovakia	0.83	31	-1
27	Spain	5.8	30	5	Spain	0.77	19	0
28	Italy	5.5	29	3	Israel	0.77	3	-1
29	Israel	5.5	21	-3	Belgium	0.76	14	-2
30	New Zealand	5.1	11	-2	Netherlands	0.68	18	0
31	Turkey	5.0	49	1	Austria	0.67	21	-1
32	Czech Republic	4.7	34	4	United States	0.67	6	-1
33	Iran	4.7	48	1	Bulgaria	0.63	25	-2
34	France	4.5	7	-5	Croatia	0.63	30	-3
35	China	4.3	47	1	Hungary	0.57	28	-1
36	Hungary	3.8	15	-3	Brazil	0.57	41	0
37	Japan	3.7	41	-1	Indonesia	0.56	42	0
38	Romania	3.6	44	-1	Italy	0.55	36	-2
39	Korea	3.0	42	-1	Malaysia	0.47	29	-6
40	Germany	2.5	16	-7	Russia	0.45	1	-1
41	Thailand	1.6	22	-6	Mexico	0.39	37	-3
42	Argentina	1.0	33	-2	South Africa	0.30	43	0
43	Poland	0.4	39	-2	Germany	0.29	22	-4
44	Bulgaria	-0.5	17	-12				
45	India	-1.5	46	-3				
46	Mexico	-2.0	25	-11				
47	Slovak Republic	-3.4	19	-15				
48	Russia	-13.8	24	-20				
49	Ukraine	-17.5	13	-27				

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. The results enable countries to measure their performance against both best practice and that of countries at similar levels of economic development. A step not taken would be to recognise that the various indicators vary in importance as income levels increase. This could be achieved by varying the weights. For example, frontier research is more important for high income countries whereas for low income countries applied research on issues facing the nation is more appropriate; developing countries need to balance expenditure on higher education against other pressing needs, such as health care and schooling.

Our data provide insights into how performance can be improved. The strongest result is the high correlation between research expenditure and performance. Links with the private sector are important, but they need to be multi-faceted, involving both research leading to joint publications and the more informal

links which facilitate knowledge transfer more broadly defined. The impact of research as measured by citations is enhanced by joint work with industry and with international authors. On the other hand, joint research conducted across domestic universities does not seem to improve impact.

There is no simple answer to what is the best policy environment. In the Nordic countries and Switzerland close links between tertiary institutions, government and industry produce good outcomes. Such links are easier to achieve in countries with a relatively small population. International links are of greatest benefit to small countries and developing countries. The mix between public and private funding of teaching and training is not an important determinant of outcomes, it is total funding that matters. However, government funding of research is important. There is an apparent trade-off between institutional autonomy and government funding, although naturally institutions strive for both. It is clear what does not work: strict government surveillance with limited government funding.

Appendix 1. Sources

- R1 and R2:** OECD, Education at a Glance, 2018, Table C2.2 and UNESCO, Institute for Statistics (www.uis.unesco.org)
- R3:** OECD, Education at a Glance, 2018, Table C1.2; 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 2018; 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 2018, Table C6.1; UNESCO
- C2:** InCites based on Web of Science databank (www.clarivate.com/products/incites)
- C4:** Webometrics (www.webometrics.info), July 2018 version.
- C5:** IMD World Competitiveness Report 2018, 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, October 2018 (www.clarivate.com/products/incites)
- O4 and O5:** Shanghai Jiao Tong University Rankings, 2018 (www.shanghairanking.com)
- O6:** UNESCO, Institute for Statistics
- O7:** OECD, Education at a Glance, 2018, Table A1.1; ILOSTAT (www.ilo.org); UNESCO, Institute for Statistics
- O8:** UNESCO, Institute for Statistics
- O9:** OECD (www.stats.oecd.org) and ILOSTAT (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 with a major update 2017. Other responses have been updated where 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).

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

de Rassenfosse, G. and Williams, R., 'Rules of Engagement: Measuring Connectivity in National Systems of Higher Education', *Higher Education*, Vol. 70, No. 6, 2015, pp. 941–956.

Salmi, J., 'Excellence Strategies and World-Class Universities'. In Ellen Hazelkorn (ed.), *Global Rankings and the Geopolitics of Higher Education*, London: Routledge, 2017a.

Salmi, J., *The Tertiary Education Imperative*, Sense Publishers, Rotterdam, 2017b.

Williams, R., de Rassenfosse, G., Jensen, P. and Marginson, S. 'The Determinants of Quality National Higher Education Systems', *Journal of Higher Education Policy and Management*, 35(6), 2013, pp. 599–611.

Williams, R. and de Rassenfosse, G., 'Pitfalls in Aggregating Performance Measures in Higher Education', *Studies in Higher Education*, Vol. 41, Nos. 1–2, 2016, pp. 51–62.

Williams, R., 'A Good National System of Higher Education: The Lessons of the U21 Rankings'. In G. Mihut, P. Altbach and H. de Wit (eds), *Understanding Global Higher Education: Insights from Key Global Publications*, Centre for International Higher Education in conjunction with University World News, Sense Publishers, Rotterdam, 2017.

Williams, R., 'Comparing and Benchmarking Higher Education Systems', in E. Hazelkorn, H. Coates and A. McCormick (eds), *Research Handbook on Quality, Performance and Accountability in Higher Education*, pp. 178–188, Edward Elgar, 2018.

Country Summaries

March 2019

Argentina

Argentina ranks equal 38th overall, which combines ranks of 37 in Resources, 32 in Environment, 41 in Connectivity and 39 in Output. In the Resources category, the level of government expenditure on higher education as a share of GDP is ranked at 15 but total expenditure per student is ranked much lower at 44. The difference is explained by the high enrolment rate, ranked at 7. In links with the private sector, Argentina is ranked 35th for knowledge transfer and 47th for articles written jointly with researchers from industry. Both published articles per head and their average impact are ranked 45th. Argentina is ranked highly at 5 for employment of graduates compared with school leavers. When the rankings are adjusted for differences in GDP per capita Argentina is ranked at 38; its overall score is below that expected for its level of income.

Australia

Australia ranks eighth overall, which combines ranks of 12 for Resources, 2 for Environment, 13 for Connectivity and 4 for Output. The ranking for Resources is pulled down by the low ranking (37th) 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 fifth. Expenditure per student, which includes research expenditure, is ranked ninth. In the Connectivity measures, Australia ranks fifth on the share of international students, but first on master's degree enrolments. Links with the private sector are at average levels: 27th for joint publications with industry and 21st for knowledge transfer. Australia is ranked seventh on total publications and 12th on their average impact. On a per capita basis, it ranks fourth on research publications compared with tenth on research expenditure. In the share of publications with an international co-author Australia ranks 14th and the increase over the last seven years is the fifth highest. Australia ranks 12th for the (tertiary) educational qualifications of the labour force, but enrolment rates are ranked much higher. On a per capita basis, the national stock of

researchers is ranked 17th. The unemployment rate for graduates compared with school leavers has fallen to 35th position. Australia is ranked tenth when levels of GDP per capita are taken into account and the score is above that expected at its income level.

Austria

Austria ranks 12th overall, which combines ranks of 9 for Resources, 24 for the Environment, 2 for Connectivity and 20 for Output. In Connectivity it ranks in the top six for three measures: 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 11th for total expenditure as a share of GDP. Within Output, the highest ranks are 12th for both the number of national researchers per head of population and the depth of its universities, and 13th for tertiary enrolment rates. Austria ranks 15th on published articles per head of population, which compares unfavourably with research expenditure per head which is ranked fourth. Publications rank 13th on their average impact. When the rankings are adjusted for levels of GDP per capita, Austria's ranking falls to 15th overall, but its score is above what is expected at its income level.

Belgium

Belgium ranks 13th overall, which combines ranks of 15 for Resources, 10 for Environment, 10 for Connectivity and 14 for Output. Total expenditure as a share of GDP is ranked 22nd but government expenditure is ranked ninth and expenditure per student is ranked 15th. 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 sixth for joint publications and 14th for knowledge transfer. In Output, Belgium is ranked 14th for publications per head and fourth for their average impact. It is ranked 16th on the quality of its top three universities. 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 40th overall, which combines ranks of 25 for Resources, 42 for Environment, 47 for Connectivity and 41 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 25th. Links with industry are limited: ranked 45th by business and 43rd for joint publications. International research links are rated 38th. In the Output module, Brazil is 13th on total publications but only 43rd on publications per head and 46th for their average impact. The country ranks 26th 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. When the country standings are adjusted for levels of GDP per capita, Brazil rises to 25th 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 42 for Output. It ranks 43rd for government expenditure on higher education as a share of GDP and 42nd for total expenditure. Bulgaria is ranked 16th for employment of those with a tertiary qualification relative to school leavers – a fall of nine places from last year. Enrolment rates and the educational attainments of its workforce are around median levels. Publications per head are ranked at 36. Joint publications with international authors rank 29th and joint publications with industry 21st, but business ranks knowledge transfer with tertiary institutions at a low 46th. Taken together, these results imply that Connectivity is limited to specialised groups. When account is taken of the level of GDP per capita in each country, Bulgaria is ranked 40th and its score is below the expected level.

Canada

Canada is ranked sixth overall, which combines ranks of 5 for Resources, 13 for Environment, 9 for Connectivity and 6 for Output. In Resources, Canada ranks fourth for total expenditure as a share of GDP and seventh for expenditure per student. In the Output category, Canada is ranked fifth for total publications and 11th for publications deflated by population. The average impact of publications is ranked 14th. Its best three universities are ranked fifth. Canada is ranked first for the formal educational qualifications of its workforce. In Connectivity, Canada ranks third for web impact and 21st for the share of publications that joint with international authors. Engagement with industry is above average: ranked seventh for knowledge transfer and 15th for joint publications. When levels of GDP per capita are taken into account, Canada ranks sixth overall and the score is well above that expected at its income level.

Chile

Chile ranks 32th overall, which combines ranks of 25 for Resources, 20 for Environment, 33 for Connectivity and 35 for Output. In the Resources category, Chile is ranked highly on total expenditure as a share of GDP (second) but much lower on expenditure per student (40th). However, public expenditure varies markedly across years. In the current ranking, both government expenditure as a share of GDP (data relate to 2016) and research expenditure rank 36th. In the Connectivity category, Chile ranks eighth in the share of articles co-authored with international collaborators but 41st in joint articles with industry. The score by business on the extent of knowledge transfer has fallen back to 37th. In Output, Chile does best on the tertiary enrolment rate (sixth) but the (tertiary) educational qualifications of its workforce remains low (ranked 37th). Chile ranks 37th for published articles per head of population. When levels of GDP per capita are allowed for, Chile ranks 32nd and is a little below that expected at its income level.

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China

China ranks 27th overall, a rise of 12 places over the last seven years. The overall rank combines ranks of 42 for Resources, 16 for Environment, 40 for Connectivity and 22 for Output. In the Resources category, total expenditure on higher education as a share of GDP is ranked 30th. Within the Connectivity category, knowledge transfer with business is ranked 20th and the share of articles co-authored with industry is ranked 36th. Along with other countries with a large domestic research base, articles with international collaborators represent a low share of publications (ranked 46th), but domestic collaboration across universities is above median values (ranked 18th). In Output, China is ranked second on total publications but 44th when population is allowed for. Publications have doubled over the period 2010–17 and research expenditure has risen by 86 per cent over a similar period. China ranks in the top ten for the quality of its best three universities. 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 43rd overall, which combines ranks of 41 for Resources, 47 for Environment, 38 for Connectivity and 40 for Output. As shares of GDP, public expenditure on higher education is ranked 23rd, total expenditure 44th and research expenditure 32nd. External joint publications are the highest ranked components in Connectivity: international co-authored papers are ranked at 31 and those co-authored with industry are ranked at 20. However, knowledge transfer with business is ranked at 47, suggesting that external links are with specialised groups. The Output category includes a rank of 27 for publications per head and their average impact is ranked at 36. Enrolment rates are at median levels. Croatia scores at median values for employment of those with a tertiary qualification compared with school leavers. Croatia's overall rank improves to 35 when allowance is made for income differences across countries, but its overall score is less than expected at its level of income.

Czech Republic

The Czech Republic ranks 26th overall, which combines ranks of 32 for Resources, 34 for Environment, 21 for Connectivity and 30 for Output. As a share of GDP public expenditure is ranked 26th, total expenditure 40th and research expenditure 25th. The highest ranking in Connectivity is for the international student share (ninth). Joint publications with international authors rank 30th. The Czech Republic is ranked 18th for joint publications with industry but business views on knowledge transfer give a lower rank of 28. 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 13th). Publications adjusted for population are ranked equal 20th and their impact 26th. The Output rank has remained remarkably stable over eight years of ranking. When levels of GDP per capita are taken into account the Czech Republic is ranked 20th and its score is about that expected at its level of income.

Denmark

Denmark is ranked fifth overall, which combines ranks of 4 for Resources, 22 for Environment, 5 for Connectivity and 5 for Output. Within the Resources category, it is ranked fifth 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. In the Connectivity module, Denmark is ranked fourth by business for knowledge transfer, fifth for joint publications with industry, and seventh for joint publications with international authors. In Output it is ranked first for publications per head of population and third for their average impact. Denmark is ranked third for the overall quality of its universities. Denmark maintains its overall ranking of fifth 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 ninth overall, which combines ranks of 10 for Resources, 5 for Environment, 8 for Connectivity and 10 for Output. Small declines in the ranking for Resources and Output have led to a fall of three in the overall rank. Finland ranks third in government expenditure on higher education as a share of GDP and 13th on total expenditure (public plus private) per student. Allowing for population, Finland ranks sixth on publications which roughly matches its rank on research expenditure of eighth. The average impact of papers is ranked 11th. It ranks sixth in the number of national researchers per head of population. Enrolment rates are ranked tenth which compares with a rank of 13 for the tertiary qualifications of the workforce. In Connectivity, Finland is ranked fourth for web impact and 13th by business for knowledge transfer. In joint publications it is ranked ninth for those with international authors and tenth for those with industry. When levels of GDP per capita are taken into account Finland is ranked second and its score is well above what is expected given its level of income.

France

France ranks 17th overall, which combines ranks of 16 in Resources, 24 in Environment, 17 in Connectivity, and 16 in Output. Within the Resources category it is ranked 16th for government expenditure as a share of GDP, 18th for total expenditure per student and 15th for research expenditure. In Connectivity, France ranks 12th for joint publications with industry, 12th for joint publications with international authors and 13th for international students. In the Output module, France is ranked sixth for the standing of its best three universities. The total number of publications by the country's universities is ranked tenth but this falls to 28th when adjusted for population. Publications have increased by only 2.5 per cent over the period 2010–17, the third lowest increase. The average impact of publications is ranked 18th. France is ranked 20th for researchers per head. The enrolment rate is ranked 30th and the tertiary education qualifications of the workforce 22nd. When levels of GDP per capita are taken into account, France's overall rank is 21 and its score is around the level expected at its level of income.

Germany

Germany is ranked 16th overall, which combines ranks of 18 for Resources, 28 for Environment, 14 for Connectivity and 13 for Output. In the Resources category it ranks 37th on total expenditure (public plus private) as a share of GDP but 16th on expenditure per student. The difference is explained by the lower rank (26th) for the participation rate in higher education. In tertiary qualifications of the work force, Germany is ranked at 27 and has shown the smallest increase over the period 2010–17. In Connectivity, Germany performs well on links with industry: ranked eighth for joint publications and ninth for knowledge transfer. It ranks 23rd for the share of publications that have international co-authors. In Output, German universities are ranked fourth for total publications, 22nd for publications deflated by population and 15th for average impact even though research expenditure is ranked 11th. Germany ranks seventh for the standing of its best three universities. 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 around the level expected given its level of income.

Greece

Greece is ranked equal 37th overall, which combines ranks of 43 for Resources, 50 for Environment, 26 for Connectivity and 27 for Output. The Resources rank has fallen largely owing to better data. Greece ranks 31st for government expenditure on higher education as a share of GDP but 47th for expenditure per student. This difference is explained by the high recorded participation rate in tertiary education (ranked equal first). The low Environment rank occurs because of an excessively centralised system and a low grade from business. In Connectivity, Greece is ranked 22nd for joint publications with industry but the tertiary system is rated lower by business for knowledge transfer (41st). The share of publications with an international co-author is ranked 20th and has shown the second largest increase of the 50 countries over the period 2010–17. Other than for the highly-ranked participation rate, the rankings for all the Output measures lie around median values: ranging

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from a rank of 22 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 (25th) roughly matches that for research expenditure (28th), but publications have only increased by 1.6 per cent over the period 2010–17. When account is taken of levels of per capita GDP, Greece's overall ranking improves to 28th and is around the level expected at its level of income.

Hong Kong SAR

Hong Kong SAR is ranked 15th overall, which combines ranks of 14 for Resources, 4 for Environment, 19 for Connectivity and 18 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 24th, a fall of eight places in two years. Total expenditure per student is ranked sixth. In Connectivity, the higher education sector is ranked 17th for business satisfaction with the extent of knowledge transfer but is ranked lower at 32nd for articles written with industry. Web-based connectivity is ranked 12th. In the Output category, Hong Kong SAR is ranked 12th on publications per head and sixth on the average impact of articles. When account is taken of levels of GDP per capita Hong Kong's ranking falls to 30th and its score is around the level expected at its relatively high income level.

Hungary

Hungary is ranked equal 35th overall, which combines ranks of 47 for Resources, 46 for Environment, 18 for Connectivity and 33 for Output. Government expenditure on higher education as a share of GDP ranks 47th and total expenditure ranks 48th. Research expenditure has declined by 36 per cent over the period 2009–16 and as a share of GDP is now ranked 39th. Total expenditure per student ranks 36th. The Connectivity ranking includes third in joint publications with industry but business ranks knowledge transfer lower at 30th. Joint publications with international authors rank 18th. Within the Output category, Hungary is ranked third for tertiary qualifications of the workforce compared with those who left after completing their final year of schooling. It is ranked 32nd on publications per head and 27th for their impact. When account is

taken of relative levels of GDP per capita, Hungary's ranking is 33rd and its score is below that expected at its income level.

India

India is ranked 49th overall, which combines ranks of 40 for Resources, 38 for Environment, 49 for Connectivity and 47 for Output. It is ranked 19th for government expenditure on higher education as a share of GDP. In common with other large countries with a sizeable domestic research base, India ranks well down for joint publications with international authors (49th) but much higher on domestic research links across institutions (ranked 16th). Joint publications with industry are ranked 45th, but India is scored higher by business on knowledge transfer (ranked 33rd). India rates lowly for web connectivity. Within the Output category, India ranks 9th on total publications but 49th on publications per head, which roughly matches the research expenditure rank of 47. Publications have doubled over the period 2010–17, the sixth largest increase among the 50 countries. The average impact of articles is ranked 43rd. When account is taken of relative levels of GDP per capita, India's overall ranking rises to 19th owing mainly to a large increase in the ranking for Resources (now 12th). 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, 30 for Environment, 46 for Connectivity and 50 for Output. It is ranked 49th for government expenditure on higher education as a share of GDP. In Connectivity, Indonesia ranks in the bottom decile for publications with international authors and 32th for knowledge transfer with business. Indonesian publications increased sharply in 2017, apparently owing to a widening in journal coverage. Publications now rank 37th, as does the employment rate of the tertiary educated compared with school leavers. In all other Output measures, Indonesia is ranked in the lowest decile. It loses points for not having a university in the Shanghai top 1000. 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, 41 for Environment, 50 for Connectivity and 43 for Output. Government expenditure on higher education as a share of GDP is ranked 35th. 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. Over the period 2010–17 the number of publications doubled, the fifth largest increase of any of the 50 countries and Iran is now ranked 17th. However, when population is allowed for, the rank falls to 40th. The average impact of articles is ranked 42nd. Iran ranks 25th for enrolment rates and 40th for the (tertiary) educational qualifications of its workforce. When account is taken of levels of GDP per capita, the rank for Output improves to 26th and is about the level expected at Iran's level of income. However, the improvement in the overall rank is only marginal (to 44th) and this score is below that expected at Iran's level of income.

Ireland

Ireland is ranked 19th overall, which combines ranks of 35 for Resources, 18 for Environment, 14 for Connectivity and 15 for Output. Government expenditure as a share of GDP is ranked 45th, a fall of 25 places since the 2017 ranking. Expenditure per student is ranked 23rd. In Connectivity, the business rating of knowledge transfer is ranked highly at sixth. Joint publications with industry are ranked 23rd and with international authors 16th. The latter have increased by seven ranks over the period 2010–17. Under Output, Ireland is ranked ninth on publications per head of population and 20th on their average impact. It ranks 11th for the educational levels of its workforce and tenth for employment of those with a tertiary qualification compared with school leavers. When account is taken of relative levels of GDP per capita the overall ranking is 41st, but because of the importance of foreign firms in Ireland the rank would be much higher if Gross National Income was used as a measure of income.

Israel

Israel is ranked 18th overall, which combines ranks of 21 for Resources, 18 for Environment, 20 for Connectivity and 11 for Output. Israel ranks 34th for government expenditure on higher education as a share of GDP, which improves to 24th when private expenditure is added. Expenditure per student is ranked 28th. Expenditure by tertiary institutions on R&D as a percentage of GDP is ranked 14th. Israel is ranked first for the number of researchers in the country per head of population and fourth for the tertiary qualifications of the workforce. It is ranked tenth 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 24th for joint articles with industry. It is ranked 24th for international co-authorship of publications. Web impact is ranked 18th. When account is taken of relative levels of GDP per capita, the overall ranking improves to 11th and the score is above that expected at Israel's income level.

Italy

Italy is ranked 30th overall, which combines ranks of 39 for Resources, 37 for Environment, 27 for Connectivity and 25 for Output. Government expenditure on higher education as a share of GDP has fallen and is now ranked 46th; total expenditure per student (including research and private expenditure) is ranked 27th. In Connectivity, joint publications of academics with industry are ranked 19th and joint publications with international authors 26th. Knowledge transfer with firms is ranked 27th. In the Output category, Italian tertiary institutions publish the eighth largest number of journal articles but this rank falls to 23 when deflated by population size, matching the rank of 24 for research expenditure per head. The average impact of articles is ranked 16th. The three best performing universities are ranked 22nd. Italy ranks 43rd on the education qualifications of its workforce and 35th on number of researchers per head of population. When account is taken of relative levels of GDP per capita, Italy's ranking falls to 34th and its score is below the average at its income level.

Country Summaries

(continued)

Japan

Japan is ranked 20th overall, which combines ranks of 24 for Resources, 21 for Environment, 25 for Connectivity and 21 for Output, little changed from last year. Japan is ranked last for government expenditure as a share of GDP but total expenditure (of which two-thirds is private) is ranked 29th. Because the participation rate is below median levels, expenditure per student is ranked 11th. Connectivity is predominantly internal: Japan ranks seventh for the percentage of articles written jointly with industry collaborators and the business rank for knowledge transfer is 24th. Domestic research links across universities are ranked eighth. In contrast, the percentage of articles co-authored with international researchers is ranked a lowly 42nd and the international student share is ranked 32nd. In Output, Japan ranks sixth on total articles published but 33rd when population size is allowed for, lower than the rank for research expenditure of 20. Both the number of publications and research expenditure have remained relatively static over the past seven years. The average impact of articles is ranked 38th. Japan ranks fourth on the quality of its best three universities. It ranks third on the educational qualifications of its workforce and 11th for the number of researchers in the country. When account is taken of relative levels of GDP per capita, Japan's rank falls to 39 and is below the level expected at its income level.

Korea

Korea is ranked 23rd overall, which combines ranks of 27 for Resources, 44 for Environment, 30 for Connectivity and 17 for Output. Government expenditure on higher education as a share of GDP has fallen markedly to 36 per cent of total expenditure and is now ranked 42nd. Total expenditure as a share of GDP ranks eighth but expenditure per student ranks much lower at 33rd because Korea has the fourth 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 23rd for knowledge transfer. Joint publications

with international authors are ranked 43rd but domestic research links across universities are ranked seventh. In the Output category, Korea ranks 12th on total publications but 24th when adjusted for population size, a similar rank as for research expenditure. The average impact of publications is ranked at 32. Korea ranks seventh on the education qualifications of its workforce and fourth on total researchers in the nation (adjusted for population). When account is taken of relative levels of GDP per capita, Korea's overall rank falls to 36 and is below that expected at its income level.

Malaysia

Malaysia is ranked 28th overall, which combines ranks of 17 for Resources, 9 for Environment, 31 for Connectivity and 44 for Output. Government expenditure on higher education has fallen from previous high levels and Malaysia's rank on this measure has fallen from eighth to 18th. Expenditure on R&D in tertiary institutions as a share of GDP is ranked 22nd. In Connectivity, Malaysia is ranked 18th for knowledge transfer with business, but 49th for joint publications with industry. Joint publications with international authors are ranked 32nd. Malaysian institutions are ranked 24th for total publications and 34th for publications per head of population and 33rd for the average impact of articles. Over the period 2008–15 research expenditure by tertiary institutions increased over threefold, the highest increase for any country. This increase is reflected in a more than doubling of research publications over the period 2010–17, ranked second. The country is ranked 38th for the educational attainment of the workforce and 31st for the number of researchers in the nation (adjusted for population). When account is taken of relative levels of GDP per capita, Malaysia's overall ranking improves to 27th and the estimated overall score is at the level expected at its income level.

Mexico

Mexico is ranked 47th overall, which combines ranks of 36 for Resources, 24 for Environment, 45 for Connectivity and 49 for Output. As a share of GDP, government expenditure is ranked 21st and total expenditure 28th, but research expenditure is ranked lower at 40th. Expenditure per student is ranked 38th. In Connectivity, Mexico ranks 46th for joint publications with industry and 38th for knowledge transfer. Joint publications with international authors are ranked 36th. Domestic research links between universities are around median levels. Web connectivity is well below average. In Output, Mexico is ranked 34th for total publications but 48th when adjusted for population. Over the period 2010–17 the increase in publications has been above average (ranked 15th). Tertiary enrolment rates are ranked 47nd. 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.

Netherlands

The Netherlands is ranked tenth overall, which combines ranks of 11 for Resources, 8 for Environment, 4 for Connectivity and 8 for Output. It is ranked 12th for total expenditure on higher education (which is 70 per cent government funded) as a share of GDP. Expenditure per student is ranked 12th. The Netherlands ranks highly for Connectivity with business: second for joint publications and sixth for knowledge transfer. Joint publications with international authors are ranked 10th 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 second. The participation rate is ranked 19th, and the education qualifications of the workforce 20th. The standing of its universities is high: ranked seventh for depth (the Netherlands has the most even spread of publications across institutions) and 12th for its best three universities. The Netherlands ranks 14th for the national stock of researchers 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 level.

New Zealand

New Zealand is ranked 14th overall, which combines ranks of 19 for Resources, 3 for Environment, 12 for Connectivity and 18 for Output. For expenditure as a share of GDP, New Zealand is ranked 28th for government expenditure and tenth for total expenditure. In Connectivity, New Zealand's is ranked score is for the percentage of students who are international, where it is ranked second. It is ranked 13th for publications with international researchers and 25th for publications with industry. Joint publications across domestic institutions are ranked in the bottom quintile. The rank for business views on knowledge transfer continues to fall and is now ranked 25th. On a per capita basis, New Zealand is ranked 13th for publications per head but 22nd for research expenditure: the difference is indicative of high productivity. It ranks 17th on the average impact of publications. New Zealand's tertiary enrolment rate is ranked 16th 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 eighth and its score is above the level expected at its income level.

Norway

Norway is ranked 11th overall, which combines ranks of 6 for Resources, 17 for Environment, 16 for Connectivity and 9 for Output. In expenditure as a share of GDP, Norway is ranked second for public expenditure (95 per cent of total expenditure) and 12th for total expenditure. Expenditure per student is ranked eighth. In Connectivity, co-authorship with international collaborators is ranked 11th and with industry 14th. Web connectivity is ranked eighth. There is a matching of research expenditure as a share of GDP with research publications per head: both are ranked fifth. Norway ranks ninth for the average impact of publications. It is ranked 18th for participation rates in higher education, 14th for the tertiary educational qualifications of the workforce and eighth for the number of national researchers per head. Norway's overall rank falls to 22nd when account is taken of levels of GDP per head and the overall score is around that expected at its high income level.

Country Summaries

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Poland

Poland is ranked 31st overall, which combines ranks of 29 for Resources, 15 for Environment, 39 for Connectivity and 31 for Output. In expenditure as a share of GDP, Poland is ranked 17th for public expenditure, 32nd for total expenditure and 30th for research expenditure. Connectivity with industry is below average: Poland ranks 39th for both joint articles with industry and knowledge transfer with business. In joint articles with international collaborators Poland is ranked 41st. Web connectivity is around the median. In Output, Poland is ranked 19th on published articles but this falls to 30th when adjusted for population. The average impact of articles is ranked 30th. Participation rates are ranked 29th and the tertiary educational qualifications of the workforce 26th. Poland performs well (fourth) 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 24th 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 25th overall, which combines ranks of 22 for Resources, 35 for Environment, 23 for Connectivity and 29 for Output. In expenditure as a share of GDP, Portugal is ranked 30th for public expenditure and 35th for total expenditure. Under the heading of Connectivity, Portugal is ranked 15th for joint publications with international researchers and 34th for publications with industry. Knowledge transfer with business is ranked 24th. Publications per head are ranked 18th matching research expenditure at 19th, but research expenditure has been stagnant over the period 2009–16. Portugal ranks 32nd in the tertiary educational qualifications of the workforce but the increase over the period 2010–17 has been the fifth largest. After allowing for population, Portugal ranks 23rd for the number of researchers in the country. When account is taken of relative levels of GDP per capita, Portugal's ranking improves to 12th (fifth on Output) and its score is above that expected at its level of income.

Romania

Romania is ranked 45th overall, which combines ranks of 45 for Resources, 31 for Environment, 42 for Connectivity and 46 for Output. Total expenditure as a share of GDP is ranked 39th; research expenditure is ranked 43rd. The level of research expenditure has fallen by the second largest percentage over the last seven years, reflected in a fall of six places in publications. 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 45th and those with co-authors from industry are ranked 38th. Transfer of knowledge with business is ranked 43rd. Romania is ranked 35th on research articles per head and 41st on their average impact. When account is taken of relative levels of GDP per capita Romania is ranked 42nd and its score is below that expected at its level of income.

Russia

Russia is ranked equal 35th overall, which combines ranks of 44 for Resources, 28 for Environment, 44 for Connectivity and 26 for Output. In expenditure as a share of GDP, Russia is ranked 39th for public expenditure, 41st for total expenditure and 42nd for research expenditure. In the Connectivity module, Russia universities are relatively weak on interactions with industry: ranked 44th for joint publications with industry and 42nd for knowledge transfer with firms. Russia ranks 44th 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. Total research publications rank 15th, publications per head 42nd and their average impact 34th. Over the period 2010–17 the increase in the number of publications is ranked third. When account is taken of relative levels of GDP per capita the rank is 46 and the GDP adjusted score for Russia is well below that expected at its income level.

Saudi Arabia

Saudi Arabia is ranked equal 22nd overall, which combines ranks of 7 for Resources, 45 for Environment, 28 for Connectivity and 32 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 decile. The highest score in the Output module is for the quality of its best three universities which are ranked 14th. Saudi Arabia is ranked 39th for publications per head and 21st for their average impact. Publications have increased nearly fourfold over the period 2010–17, the largest percentage increase for any country. 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 41st overall, which combines ranks of 31 for Resources, 49 for Environment, 37 for Connectivity and 44 for Output. Government expenditure on higher education as a share of GDP is ranked 13th and expenditure by institutions on R&D is ranked 29th. Over the last seven years, research expenditure has fallen by the fifth largest percentage but the number of publications has increased by the 11th largest percentage. Serbia ranks 42nd on joint publications with industry and 27th on joint publications with international authors. In the Output module, Serbia ranks 31st in publications per head and 44th in their average impact. It is ranked 30th for the tertiary education qualifications of the work force and 37th for the tertiary enrolment rate. In per capita terms, Serbia ranks 34th for the national stock of researchers. 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 seventh overall, which combines ranks of

3 for Resources, 7 for Environment, 6 for Connectivity and 12 for Output. It ranks 22nd 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 eighth for publications per head and fifth for their average impact. In the Connectivity category, it ranks first for the relative importance of international students and fourth for joint publications with international authors (ranked sixth for the increase over 2010–17). Domestic research links across institutions are strong (ranked third). In engagement with the private sector, Singapore ranks eighth for knowledge transfer with firms but 33rd for joint scientific publications with industry. The (tertiary) educational qualifications of the workforce and the number of national researchers per head are both ranked sixth. When allowance is made for national levels of GDP per head Singapore's ranking falls to 23rd but the score is around what is expected at its high income level.

Slovakia

Slovakia is ranked 33rd overall, which combines ranks of 20 for Resources, 40 for Environment, 36 for Connectivity and 34 for Output. The OECD expenditure data has been extended to cover all the tertiary sector with a consequent increase in the rank for Resources of 11 places. Total expenditure as a share of GDP is ranked 20th; government expenditure tenth; research expenditure 34th. However, total research expenditure has more than doubled over the period 2009–16, the third largest increase. Slovakia is ranked 29th for publications per head and 25th for their average impact. Research links across domestic institutions are ranked 43rd. Within the Connectivity module, Slovakia is ranked 34th for joint publications with international researchers, 31st for joint scientific publications with industry and 48th for knowledge transfer with firms. On a per capita basis, the national stock of researchers ranks 30th. Slovakia ranks seventh 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 is ranked 37th and its score is below that expected at its income level.

Country Summaries

(continued)

Slovenia

Slovenia is ranked 29th overall, which combines ranks of 38 for Resources, 36 for Environment, 24 for Connectivity and 28 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 29th but because private expenditure is low (15 per cent) total expenditure is ranked 43rd. On a per capita basis, publications per head rank 19th, a creditable performance given that R&D expenditure by tertiary institutions ranks only 35th. In the Connectivity module, joint scientific papers with industry are ranked 17th and business ranks knowledge transfer 29th. The share of publications that are joint with international authors is ranked 19th but domestic research links across universities rank only 48th. The participation rate in higher education is ranked 20th; the tertiary qualification rate of the labour force is ranked 23rd but shows the largest improvement of all 50 countries over the last seven years. On a per capita basis Slovenia is ranked 22nd for the number of researchers in the nation. When allowance is made for levels of GDP per capita, Slovenia is ranked 26th and the score is around that expected at its income level.

South Africa

South Africa is ranked 34th overall, which combines ranks of 34 for resources, 22 for Environment, 32 for Connectivity and 36 for Output. Government expenditure on higher education as a share of GDP is ranked 38th and research expenditure 33rd. In Connectivity, South Africa is 22nd for the percentage of joint publications with international researchers; 28th for joint publications with industry (which show the eighth largest increase over the last seven years); and 34th for knowledge transfer with firms. But web-based connectivity is in the bottom decile. The tertiary education sector is ranked equal 25th for total publications, 41st for publications per head and 23rd for their average impact. Over the last seven years the increases in research expenditure and publications are ranked sixth and seventh, respectively. Both enrolment rates and the educational qualifications of the workforce are in the bottom decile. 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 fourth and the score is well above that expected at its level of income.

Spain

Spain is ranked 24th overall, which combines ranks of 30 for Resources, 33 for Environment, 29 for Connectivity and 23 for Output. As a share of GDP, Spain is ranked 32nd for government expenditure on higher education (about 70 per cent of total expenditure), 36th for total expenditure and 27th for research expenditure. Total research expenditure has fallen over the last seven years but notwithstanding the increase in publications is ranked 34th. In engagement with the private sector, Spain ranks 26th for joint scientific publications with industry and 36th for knowledge transfer. Joint publications with international collaborators are ranked 25th. Spain's tertiary institutions are ranked 21st for web connectivity. In Output, Spain is ranked 11th for total publications and 21st on a per capita basis. The average impact of published articles is ranked 24th. In the educational qualifications of the workforce Spain is ranked 21st but it is ranked fifth on enrolments. On a per capita basis, the national stock of researchers is ranked 27th. When allowance is made for differences in GDP per head, Spain's rank is 31 and its score is around that expected at its level of income.

Sweden

Sweden is ranked fourth overall, which combines ranks of 2 for Resources, 14 for Environment, 7 for Connectivity and 7 for Output. In Resources as a share of GDP, Sweden is ranked seventh for government expenditure (about 90 per cent of total expenditure), 18th 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 to institutional autonomy being only around median values. Sweden performs well in engagement with industry: it ranks fourth for joint publications and 11th for knowledge transfer. It ranks fifth for joint publications with international researchers and 11th for research links across domestic universities. It is in the

top ten for web connectivity. In Output, Sweden is ranked third for publications per head and eighth for their average impact. Over the last seven years the percentage increases in the level of research expenditure and publications have been around median levels. Sweden's university sector is ranked second for average quality. The country is ranked 16th for the (tertiary) educational qualifications of its workforce. On a per capita basis, Sweden ranks third for the number of researchers in the nation. When allowance is made for levels of GDP per capita, Sweden is ranked seventh 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, 12 for Environment, 1 for Connectivity and 3 for Output. Government expenditure on higher education as a share of GDP ranks eighth and expenditure per student third. Connectivity within the nation and externally is high. It is rated first for knowledge transfer with firms, ninth for joint publications with industry, and second for joint publications with international researchers. It is fourth for the proportion of students who 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 the increase over the last seven years is ranked fourth. It is ranked 10th 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 ninth 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 28 for Resources, 11 for Environment, 22 for Connectivity and 24 for Output. Expenditure on higher education as a share of GDP is ranked 23rd, of which 55 per cent is private. In Connectivity, knowledge transfer with firms is ranked 16th but joint scientific publications with industry are ranked lower at 30th. Joint publications with international researchers are ranked 39th but domestic research links across universities are ranked fifth. Taiwan-China ranks 15th for Web connectivity. In Output, it is ranked 21st for total publications (although stagnant over the last seven years) and 39th for their average impact. It is ranked ninth for the educational qualifications of its workforce (second largest increase over the last seven years) 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 43rd in the ranking and is below the level expected at its income level.

Thailand

Thailand is ranked 46th overall, which combines ranks of 49 for Resources, 27 for Environment, 35 for Connectivity and 47 for Output. Government expenditure on higher education as a share of GDP is ranked 44th and expenditure on R&D is ranked 41st. In Connectivity, knowledge transfer with industry is ranked 26th and joint publications with industry 29th. Joint articles with international researchers are ranked 28th. Publications per head are ranked 46th and their average impact 37th. Over the most recent seven years for which data are available, the level of research expenditure has doubled (ranked second) and publications have increased by 63 per cent (ranked 10th). The (tertiary) educational qualifications of the workforce 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.

Country Summaries

(continued)

Turkey

Turkey is ranked equal 42nd overall, which combines ranks of 22 for Resources, 48 for Environment, 48 for Connectivity and 37 for Output. Calculated as shares of GDP, government expenditure on higher education ranks 11th, total expenditure ranks 17th, and research expenditure by tertiary institutions ranks 24th. The level of research expenditure shows the fifth largest percentage increase over the most recent seven years for which data are available. Connectivity is weak for the included indicators: the highest rank is 41 for Web impact. Knowledge transfer as viewed by business is ranked 40th; joint articles with international authors and with industry are each ranked 48th. However, domestic research links across institutions are relatively strong (ranked sixth). In Output, Turkish institutions of higher education rank 16th for total publications but 38th for publications per head. Citations per article are ranked 47th. Participation rates are ranked third 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 38th. When levels of GDP per capita are taken into account, Turkey's rank is 47th and its score is well below that expected at its level of income.

Ukraine

Ukraine is ranked equal 38th overall, which combines ranks of 33 for Resources, 39 for Environment, 43 for Connectivity and 38 for Output. Ukraine is ranked sixth for government expenditure on higher education as a share of GDP. However, because of the relatively high participation rate (ranked 14th) total expenditure per student is in the lower decile. R&D expenditure by tertiary institutions as a 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 35th for joint publications with international authors and 44th for knowledge transfer with business. In Output, Ukraine loses points for not having a flagship university in the Shanghai top 1000. Ukraine ranks 45th for total publications, 47th for publications per head of population, and 50th for their average impact. Over

the last seven years the level of research expenditure has shown the largest percentage decrease of any of the 50 countries but publications have increased by the ninth highest percentage. The level of (tertiary) educational qualifications of its workforce is ranked sixth. Using per capita figures, the number of national researchers is ranked 40th. When levels of GDP per capita are taken into account, Ukraine's overall ranking improves to 16th and its score is above that expected at its income level.

United Kingdom

The United Kingdom is ranked third overall, which combines ranks of 13 for Resources, 6 for Environment, 3 for Connectivity and 2 for Output. Total expenditure on higher education as a share of GDP is ranked seventh. 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 38th). Connectivity with industry is relatively strong: the United Kingdom ranks second for knowledge transfer with business and 11th for joint scientific publications. In the share of publications with an international author, the United Kingdom ranks 17th and the increase over the last seven years is the fourth highest. It 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 seventh for the average impact of articles. On a per capita basis, research publications rank tenth compared with a rank of 18 for research expenditure, which implies an above-average level of efficiency. The level of research expenditure has been stagnant over the last seven years. The United Kingdom ranks second for the quality of its best three universities. It is ranked 10th for the (tertiary) educational qualifications of the workforce. In per capita terms, the United Kingdom ranks 18th for the national stock of researchers. When levels of GDP per capita are taken into account, the United Kingdom is ranked first 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 8 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 third 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 37, but domestic research links across institutions are strong (ranked fourth). Although the United States has the largest absolute number of international students, as a share of its total students it ranks only 24th. 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, but over the period 2010–17 the percentage increase was ranked in the lowest quintile. On a per capita basis it ranks 19th for publications, similar to the rank for research expenditure of 16. It ranks in the top ten for average impact of publications. The United States ranks eighth for both participation rates and 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. When levels of GDP per capita are taken into account, the overall rank for the United States falls to 17th but its score is above the level expected at its income level.

Overleaf:
Summary of Country
Rankings 2019

Country	Overall	Resources	Environment	Connectivity	Output
Argentina	#38	38	32	41	39
Australia	8	12	2	13	4
Austria	12	9	#24	2	20
Belgium	13	15	10	10	14
Brazil	40	#25	42	47	41
Bulgaria	44	48	43	34	42
Canada	6	5	13	9	6
Chile	32	#25	20	33	35
China	27	42	16	40	22
Croatia	43	41	47	38	40
Czech Republic	26	32	34	21	30
Denmark	5	4	#22	5	5
Finland	9	10	5	8	10
France	17	16	#24	17	16
Germany	16	18	#28	#14	13
Greece	37	43	50	26	27
Hong Kong SAR	15	14	4	19	#18
Hungary	#35	47	46	18	33
India	49	40	38	49	#47
Indonesia	50	50	30	46	50
Iran	48	46	41	50	43
Ireland	19	35	#18	#14	15
Israel	18	21	#18	20	11
Italy	30	39	37	27	25
Japan	20	24	21	25	21
Korea	23	27	44	30	17
Malaysia	28	17	9	31	#44
Mexico	47	36	#24	45	49
Netherlands	10	11	8	4	8
New Zealand	14	19	3	12	#18
Norway	11	6	17	16	9
Poland	31	29	15	39	31
Portugal	25	#22	35	23	29
Romania	45	45	31	42	46
Russia	#35	44	#28	44	26
Saudi Arabia	22	7	45	28	32
Serbia	41	31	49	37	#44
Singapore	7	3	7	6	12
Slovakia	33	20	40	36	34
Slovenia	29	38	36	24	28
South Africa	34	34	#22	32	36
Spain	24	30	33	29	23
Sweden	4	2	14	7	7
Switzerland	2	1	12	1	3
Taiwan-China	21	28	11	22	24
Thailand	46	49	27	35	#47
Turkey	42	#22	48	48	37
Ukraine	#38	33	39	43	38
United Kingdom	3	13	6	3	2
United States	1	8	1	11	1