CEDEFOP | European Centre for the Development of Vocational Training

2018 European Skills Index

Technical report

EUROPEAN SKILLS INDEX

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Note: This is not an official Cedefop publication. For any further information please contact Cedefop Expert Ilias Livanos

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Note

The technical report was drafted during the construction of the European Skills Index 2018. Following the literature, the scores were normalised as values between 0 and 1. In order to simplify the communication to the wider audience, the ESI final report [insert link] uses normalised scores with values between 0 and 100.

List of abbreviations

ESI	European Skills Index
ET2020	Education and Training 2020
EU	European Union
HCI	Human Capital Index
JRC	Joint Research Centre
NEET	Not in Education, Employment or Training
OECD	Organisation for Economic Co-operation and Development
PISA	Programme for International Student Assessment
VET	Vocational education and training
WEF	World Economic Forum
Cedefop	European Centre for the Development of Vocational Training
EU LFS	European Union Labour Force Survey
ISCED	International Standard Classification of Education
PCA	principal component analysis

Part One: Constructing the Index

1. Introduction

This technical report accompanies the release of the 2018 version of the European Skills Index (ESI) developed for Cedefop.

The methodological decisions made in constructing the Index have implications for the subsequent interpretation and understanding of the results. The first part of this report outlines the scope, structure and results of the Index. The second part of the report discusses the analysis motivating some of the methodological decisions made in constructing the Index.

The 2018 European Skills Index updates and refines the work undertaken for the Making Skills Work Index, published in 2016. The new Index builds on subsequent technical discussions with the European Commission Competence Centre on Composite Indicators and Scoreboards, experts in composite indices, and national stakeholders. As a result of those discussions and further statistical analysis, the Index underwent notable changes (see Part 2 of this report).

2. Theoretical framework

2.1. Developing a framework to conceptualise a country's skills system

The ESI is intended to measure the performance of EU Member States' skills formation and matching systems to enable a comparative assessment across EU Member States. The concept of a *skills system* is a multifaceted and complex one, and there is no single all-encompassing measure of the system's performance.

2.2. Defining a skills system

A country's skills system delivers enhanced skills to its population through compulsory education, and post-compulsory education and training. The skills system includes a variety of formal and informal training and education, secondary, further (continuing) and higher education, and both academic and vocational education and training (VET). It also includes lifelong learning, including on-the-job training and the acquisition of competences accrued through years working in a job. It also includes the activation of skills of different groups into the labour force to increase the skills base of the economy. The skills system's role is to ensure, as far as is feasible, that skills demand is met by skills supply in a way that optimises the use of the skills available in the labour force.

A country's skills system can be seen to fulfil several different roles, including:

(a) delivering the skills the country needs and/ or is anticipated to need in the future (including re-skilling and up-skilling);
(b) activating the skills in the labour market, by providing enough job opportunities to different groups in the population;
(a) matching, as far as possible, individuals' aspirations, interests, and abilities to the needs of the labour market.

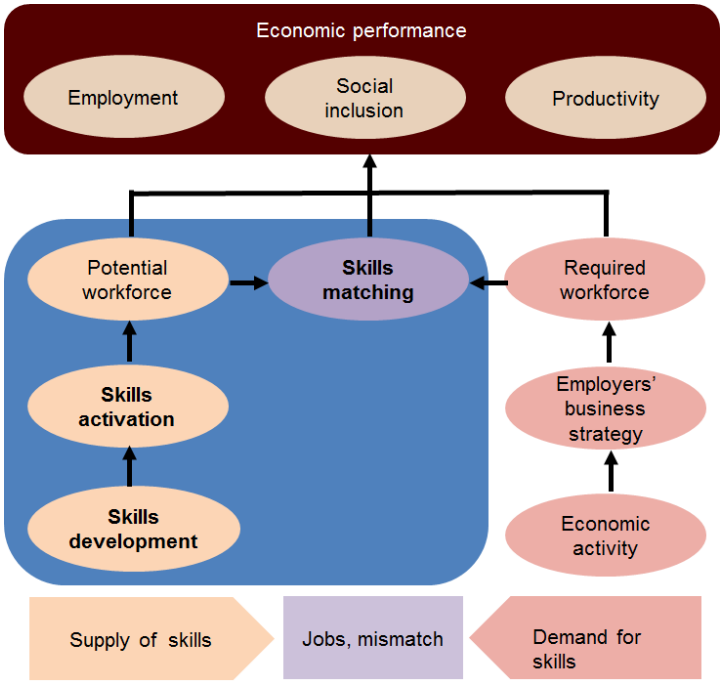
The capacity of a skills system to realise these ends has traditionally been measured with respect to individuals' propensity to avoid unemployment, obtain relatively high-wage work, and secure progression in the labour market. Accordingly, indicators have concentrated on measures of employment status and wages. The role that a skills system has in matching interests, aspirations, and abilities to labour market demand points to a wider range of outcomes that focus, more or less, on non-pecuniary measures relating to the quality of employment and working life.

These have driven the design of the ESI.

2.3. Our theoretical framework

In **Error! Reference source not found.** the theoretical framework to characterise a country's skills system is presented. The framework developed for ESI is based on a human capital approach in which both the individual and society derive economic benefits from investing in skills. The framework identifies the various dimensions of skills that can be acquired by an individual through both formal and informal learning. The starting point is that these skills drive economic performance through employment, social inclusion and productivity. Within the framework, social inclusion stands as a desired outcome because success in improving employment and productivity outcomes will depend on the latter being shared across the population as a whole. In other words, outcomes are socially as well as economically optimal.

Figure 2.1: Theoretical framework for the skills system



Source: European Skills Index (2018), Cedefop.

The role of the skills system is to bring together and match a suitably skilled **potential workforce** (supply) with the needs of employers (the **required workforce**, demand). The required workforce and the skills needed are determined by the nature and scale of **economic activity** and by **employers' business strategies**. The potential workforce is determined by **skills development** (education and training, and lifelong learning) and by the **activation** (or participation) of workers in the labour market. It is through the interplay between skills supply and demand that the degree of successful **matching** of skills is observed.

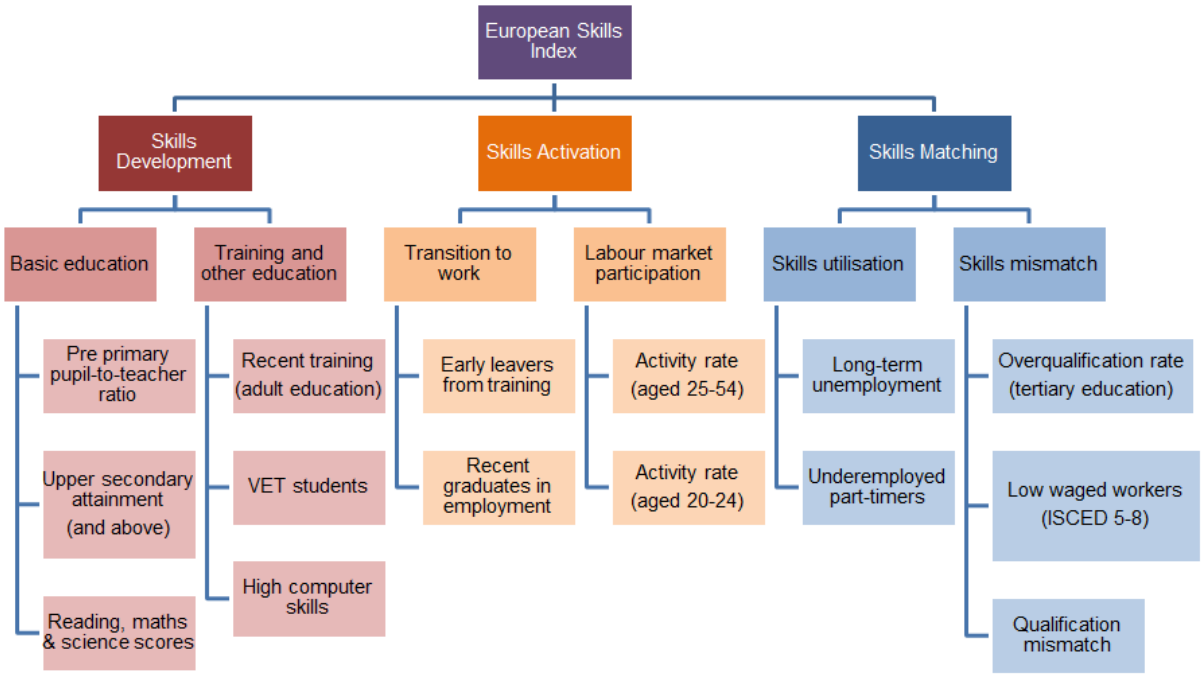
3. Scope of the European Skills Index (ESI)

3.1. Structure of the Index

In **Error! Reference source not found.** above, the area highlighted in the blue box indicates the aspects of the skills system that are included in the ESI. The ESI has three pillars (highlighted in bold in **Error! Reference source not found.** above) to assess how well the skills formation and matching systems of EU Member States are performing in relation to the degree to which they are **developing**, **activating** and **matching** skills reserves within their economies. The ESI focuses on these supply and matching aspects of the skills system. Within the ESI, the demand for skills is captured most clearly in the matching of skills, and in the extent to which it influences decisions to invest in training and to activate skills.

Each pillar is broken down further into sub-pillars, to further organise the indicators into related groups. In total, the ESI has three pillars, six sub-pillars, and 15 indicators. The rationale and definition of each indicator are outlined in **Table 3.2** below (Section 3.4). The structure of the Index is represented in **Figure 3.1**.

Figure 3.1 European Skills Index structure



Source: European Skills Index (2018), Cedefop.

3.1.1. Skills development

This pillar represents the training and education activities of the country and the immediate outputs of that system in terms of the skills developed and attained. This pillar has two sub-pillars:

- basic education; and
- training and other education.

3.1.2. Skills activation

The potential workforce of a country is determined not only by the development of skills in the population, but also by the activation (or participation) of skills in the labour market. This pillar includes indicators of the transition from education to employment, together with labour market activity rates for different groups of the population. This pillar has two sub-pillars:

- transition to work; and
- labour market participation.

3.1.3. Skills matching

Finally, the skills matching pillar represents the degree of successful utilisation of skills, the extent to which skills are effectively matched in the labour market. This can be observed in the form of jobs and mismatches which include unemployment, skills shortages, and skills surpluses or underutilisation of skills in the labour market. This pillar has two sub-pillars:

- skills utilisation; and
- skills mismatch.

3.1.4. Interpretation of the pillars

The pillars represent different aspects of the skills system and they organise our understanding of the system and the indicators that will be used to measure it. In reality, inter-relationships exist between the different pillars of the ESI. This is evident in all composite indices, for example, other composite indices (in a similar domain to ESI) also include pillars that are inter-related: the WEF's Human Capital Index (World Economic Forum, 2017) (pillars - education; health and wellness; workforce and employment; and enabling environment); and the European Commission's Social Scoreboard for the European Pillar of Social Rights (Joint Research Centre, 2018) (pillars - education, skills and lifelong learning; gender equality in the labour market; inequality and upward mobility; living conditions and poverty; and youth).

In our framework, the pillars can be interpreted as a process: the development of an individual's skills influences their activation in the labour market and consequently their matching to employment. However, as in other composite indices, there are also inter-relationships that run in the opposite direction: for example, an individual's decision to invest in training may be influenced by the likelihood of training improving their employment opportunities (matching).

3.2. Country coverage

The Index covers the 28 Member States of the EU, at the country level. The specific countries covered within the ESI are outlined in **Table 3.1** below.

Table 3.1 Country coverage

Countries (country code)			
Belgium (BE)	Greece (EL)	Lithuania (LT)	Portugal (PT)
Bulgaria (BG)	Spain (ES)	Luxembourg (LU)	Romania (RO)
Czech Republic (CZ)	France (FR)	Hungary (HU)	Slovenia (SI)
Denmark (DK)	Croatia (HR)	Malta (MT)	Slovakia (SK)
Germany (DE)	Italy (IT)	Netherlands (NL)	Finland (FI)
Estonia (EE)	Cyprus (CY)	Austria (AT)	Sweden (SE)
Ireland (IE)	Latvia (LV)	Poland (PL)	United Kingdom (UK)

Source: European Skills Index (2018), Cedefop.

3.3. Time coverage

The 2018 European Skills Index draws on annual data, up to 2016. The Index is back-cast over 2014-2015 data to gauge, using the current methodology, how countries have performed over recent history (see Section 0 below).

3.4. Indicators in the Index

The details of each indicator in the Index are summarised in **Table 3.2** below.

Table 3.2 Details of the indicators

Indicator (unit of measurement)	Description	Relevance of indicator (direction of effect)	Source of data (and dataset code, if applicable)	Country coverage	Time coverage
Development					
Pre-primary pupil-to-teacher ratio (students per teacher)	Ratio of pupils and students to teachers and academic staff at the pre-primary education level (ISCED11 level 0, 3 years to the start of primary education.)	Proxy for the quality of teaching at pre-primary education level. (-)	Eurostat, Collected by the UNESCO, OECD, Eurostat joint data collection (Eurostat code educ_uoe_perp04)	EU 28 plus Iceland, Liechtenstein, Norway, Switzerland, Macedonia, Serbia, Turkey,	2013-2015, few data points for 2016
Upper secondary education (and above) (%)	Share of population aged 15-64 with at least upper secondary education (ISCED11 level 3-8)	Proxy for the education attainment level of the country (+)	Eurostat - Labour Force Survey (Eurostat code edat_lfse_03)	EU 28 plus Iceland, Norway, Switzerland, Macedonia, Turkey	1992 - 2016
Reading, maths & science scores (PISA score)	Average PISA scores (15-year olds) for reading, maths and science.	Proper levels of basic competences are key outcomes of initial education because they build the foundation for long-term economic growth of societies and social inclusion of individuals. Average across three separate indicators. (+)	OECD PISA programme	OECD plus other partner countries for a total of 72 countries	6 rounds, every three years, starting in 2000, last one being in 2015
Recent training (%)	Share of population aged 25-64 who stated that they received formal or non-formal education or training in the four weeks preceding the survey.	Continued learning after initial education is crucial for raising productivity levels of the working-age population and tackling skill mismatches and bottlenecks on the labour market. Matches EC E&T Monitor Target 6. (+)	Eurostat - Labour Force Survey, (Eurostat code edat_lfse_03)	EU 28 plus Iceland, Norway, Switzerland, Macedonia, Turkey	1992 - 2016
VET students (%)	Share of the population at ISCED11 level 3 attending vocational training	Evidence shows that within the group of graduates from upper secondary education, graduates from vocational education and training (VET) programmes have better employment prospects, particularly in countries where work-based learning is a strong component of VET programmes. EC E&T Monitor Target 13. (+)	Eurostat, Collected by the UNESCO, OECD, Eurostat joint data collection (Eurostat code educ_uoe_enra13)	EU 28 plus Iceland, Liechtenstein, Norway, Switzerland, Macedonia, Turkey, with a further breakdown at NUTS 2 level	2013 - 2016
High computer skills (%)	Share of 16-74-year olds able to carry out 5 or 6 out of the 6 tasks described in the survey	Digital competences are required for employability and active participation in society. (+)	Eurostat self-assessment survey (Eurostat code tsdsc460)	EU 28 plus Iceland, Norway, Switzerland, Montenegro, Macedonia, Serbia, Turkey,	2005-2007, 2009, 2011, 2012, 2014
Activation					
Early leavers from training (%)	Early leavers from education and training (work status 'not in employment') as a share of the population, aged 18-24 having attained ISCED11 level 0, 1, 2 or 3c short and not receiving any formal or non-formal education or training in the four weeks preceding the survey.	Early leavers experience reduced lifetime earnings and longer and more frequent unemployment spells; early leaving also brings large public and social costs.	Eurostat - Labour Force Survey (Eurostat code edat_lfse_14)	EU 28 plus Iceland, Norway, Switzerland, Macedonia, Turkey	1992-2016
Recent graduates in employment (%)	Share of employed people aged 20-34 having successfully completed upper secondary or tertiary education 1 to 3 years before the reference year of the survey and who are no longer in education or training.	Although education and training cannot compensate for the economic downturn, the quality and relevance of education can be strengthened to better meet the needs of the modern labour market. Matches EC E&T Monitor Target 5 (+)	Eurostat - Labour Force Survey (Eurostat code edat_lfse_24)	EU 28 plus Iceland, Norway, Switzerland, Macedonia, Turkey	2000-2016

Activity rate (aged 25-54) (%)	Employed/active persons as a share of same age total population	The supply of skills can be increased through higher activation. (+)	Eurostat - Labour Force Survey (Eurostat code lfsa_argaed)	EU 28 plus Iceland, Norway, Switzerland, Macedonia, Turkey	1983-2016
Activity rate (aged 20-24) (%)	Employed/active persons as a share of same age total population	Integrating under-represented groups into the labour force can increase the skills base in an economy. (+)	Eurostat - Labour Force Survey (Eurostat code lfsa_argaed)	EU 28 plus Iceland, Norway, Switzerland, Macedonia, Turkey	1983-2016
Matching					
Long-term unemployment (%)	Share of unemployed persons since 12 months or more in the total number of active persons in the labour market	Gives some indication of structural mismatch and of the effectiveness of a skills system in responding to skill obsolescence. (-)	Eurostat - Labour Force Survey (Eurostat code une_ltu_a)	EU 28 plus Iceland, Norway, Switzerland, Macedonia, Turkey	1996-2016
Underemployed part-timers (%)	Underemployed part-time workers aged 15-74 as share of active population. Persons working on an involuntary part-time basis are those who declare that they work part-time because they are unable to find full-time work	Ineffective use of skills - labour is underutilised among persons already employed and willing to work more hours. (-)	Eurostat - Labour Force Survey (Eurostat code lfsa_sup_age)	EU 28 plus Iceland, Norway, Switzerland, Macedonia, Turkey	2008-2016
Overqualification rate (tertiary education) (%)	Share of employed people aged 25-34 with ISCED11 level 5 and 6 that occupy jobs NOT corresponding to ISCO 1, 2 or 3	Gives an indication of ineffective use of skills – highly-educated employees working in lower skilled jobs (-)	Skills Panorama, from Eurostat – Labour Force Survey	EU 28	2011-2015
Low waged workers (ISCED 5-8) (%)	This is defined as the proportion of low wage earners out of all employees of ISCED11 level 5-8 qualification level, where low wage is defined as “those employees (excluding apprentices) earning two-thirds or less of the national median gross hourly earnings in that particular country”	Gives an indication of the ineffective use of skills - high-educated employees in low wage employment (-)	Eurostat - Structure of Earnings Survey (Eurostat code earn_ses_pub1i)	EU 28	2006, 2010, 2014
Qualification mismatch (%)	The measure is calculated by taking the modal education attainment level for each occupation in each industry and assessing whether each employee’s education attainment level matches it	Measures incidences of both underqualification and overqualification, which provides an indication of ineffective use of skills, or the need for upskilling. (-)	OECD WISE database	EU 28 plus Iceland, South Africa	2015

Source: European Skills Index (2018), Cedefop.

4. Treatment of indicators

4.1. Missing data and imputation methods

4.1.1. Method for data imputation in our dataset

For the ESI, a complete dataset for the latest year would mean 28 observations per indicator and 15 observations per country. Since the dataset is not complete, cold deck imputation is used, i.e. replacing missing values with values from a previous year. After that, by indicator, the lowest data availability is 93% for qualification mismatch indicator (Croatia and Malta have missing data).

For back-casting the Index, in addition to cold-deck imputation, linear interpolation is used to fill in missing data for which data are available in preceding and subsequent years in the same indicator.

4.1.2. Practical rules

In determining whether additional imputation methods are necessary, some practical rules are followed:

- a requirement for at least 60-65% indicator, pillar and sub-pillar coverage per country. This can be relaxed or made stricter depending on the degree of correlation between indicators within a dimension; for example, for each country, if there are more than 20% missing values in one dimension, then the country may be removed.
- there is a requirement for at least 75-80% data coverage per indicator.

Once cold deck imputation is applied, **no imputation** approach is adopted thereafter (see **Table 4.1** below). This is conceptually equivalent to imputing the missing value with the weighted mean of the values observed for that unit on the other indicators included in the same lower dimension (mean-row). This applies even if the indicators are assigned different weights.

Table 4.1: Data coverage (most recent year, 2016)

Indicator (unit)	Missing data after imputation	Year of data for the Index
Pre-primary pupil-to-teacher ratio (students per teacher)	IE	2015 except: AT, BG, CY, FI, HU, LT, MT, NL and RO - 2016; DK, EL, UK - 2014
Upper secondary education (and above) (%)	0.0	2016
Reading, maths & science scores (PISA score)	0.0	2015
Recent training (%)	0.0	2016
VET students (%)	0.0	13 countries with 2015 and 13 countries with 2016; EL - 2014; IE - 2013
High computer skills (%)	0.0	2014
Early leavers from training (%)	0.0	2016
Recent graduates in employment (%)	0.0	2016
Activity rate (aged 25-54) (%)	0.0	2016
Activity rate (aged 20-24) (%)	0.0	2016
Long-term unemployment (%)	0.0	2016
Underemployed part-timers (%)	0.0	2016
Over-qualification rate (tertiary education) (%)	0.0	2015
Low waged earners (ISCED 5-8) (%)	0.0	2014
Qualification mismatch (%)	HR, MT	2015

Source: European Skills Index (2018), Cedefop.

4.2. Outliers

Table 4.2 below presents the main summary statistics for the indicators for the latest year of data([1]).

Table 4.2: Summary statistics

Indicator (unit)	Range	Median	Mean	Standard deviation	Skewness	Kurtosis
Pre-primary pupil-to-teacher ratio (students per teacher)	[6.4, 21.5]	12.4	12.8	3.26	0.6	0.7
Upper secondary education (and above) (%)	[47.1, 87.6]	78.2	75.1	10.60	-1.4	1.5
Reading, maths & science scores (PISA score)	[437.7, 524.3]	491.8	486.9	23.87	-0.7	-0.1
Recent training (%)	[1.2, 29.6]	8.4	10.8	7.75	1.1	0.5
VET students (%)	[1.2, 73.2]	43.9	46.2	19.55	-0.4	-0.5
High computer skills (%)	[7.0, 46.0]	30.0	29.2	8.08	-0.4	1.2
Early leavers from training (%)	[2.1, 11.4]	4.6	5.2	2.44	1.3	0.9
Recent graduates in employment (%)	[49.2, 96.6]	79.9	78.4	10.32	-1.2	2.1
Activity rate (aged 25-54) (%)	[77.5, 90.9]	87.1	86.1	3.11	-1.0	0.8
Activity rate (aged 20-24) (%)	[39.7, 76.5]	58.5	59.7	10.59	-0.1	-1.1
Long-term unemployment (%)	[1.3, 17.0]	3.0	4.1	3.25	2.6(*)	8.7(*)
Underemployed part-timers (%)	[0.5, 7.8]	3.3	3.3	1.85	0.5	-0.3
Over-qualification rate (tertiary education) (%)	[4.2, 40.7]	22.7	24.6	8.49	0.2	0.4
Low waged earners (ISCED 5-8) (%)	[0.2, 13.8]	4.7	5.6	3.98	0.8	-0.5
Qualification mismatch (%)	[16.0, 44.1]	35.2	33.3	7.35	-0.6	-0.1

(*) Instances where skewness is greater than 2 or kurtosis greater than 3.5.
Source: European Skills Index (2018), Cedefop.

Outliers can polarise the scores and bias the rankings. All variables are checked for absolute skewness greater than 2, and kurtosis greater than 3.5. Winsorising is used for Greece for "Long-Term Unemployment" to stop this value from becoming an unintended benchmark and introducing bias in the aggregation with other indicators.

4.3. Normalisation – Distance to frontier

The distance to frontier normalisation method is a special case of min-max normalisation method with bounds, where a country's performance in a variable is compared with the value of a logical "best case" as well as that of a logical "worst case". As a result, the country's relative position can be captured by the generated distance-to-frontier scores. If the upper and lower bounds are time-invariant, then this approach enables easier comparison of Index scores over time. A country's distance-to-frontier score for each indicator is calculated using the formula:

$$\frac{I_{ij} - lower\ bound}{Upper\ bound - lower\ bound}$$

([1]) The latest year of data in this instance refers to figures for 2016, including imputed values.

where I_{ij} is the raw value of country i in indicator j.

The normalised scores for every indicator calculated using the formula above range from zero to one.

4.4. Bounds for the indicators

The fixed bounds, i.e. best case and worse case, adopted for each indicator are derived from statistical considerations. Some bounds could have been aligned with targets identified in policy papers at the EU level, in instances where they exist and can provide a target that countries can aspire to. However, it was decided not to use policy targets because of difficulties in interpretation and statistical coherence issues. Regarding the first problem, many policy bounds are expressed as "at least" and they are average targets for the EU as a whole (e.g. at least 40% of people aged 30-34 should have completed some form of higher education). If such as target is used as a maximum bound, countries score full marks as soon as they achieve that bound, but no more if they exceed it – we do not reward the country performing better than the (EU-wide) target. If such a target is used as a minimum bound, countries score no points until they achieve that bound – we do not reward the country for making progress towards that (EU-wide) target. Regarding the second point, using policy bounds as described above causes a lack of variation in the scores of some indicators and this might be an issue for the index calculation. Statistical bounds are close to the maximum and minimum values observed at indicator level, across EU countries, and observed over 2010-2016, in instances where data are available.

Table 4.3 below presents the bounds used for each Indicator in the Index and the rationale behind the choice of bounds, which are statistically computed bounds.

Table 4.3: Upper and lower bounds

Indicator (unit)	Rationale for bounds	Lower bound	Upper bound
Pre-primary pupil-to-teacher ratio (students per teacher)	There is no clear evidence on worst nor optimal student-to-teacher ratios. Bounds are the minimum and maximum across the years as the worst and best-case frontiers.	22	6
Upper secondary education (and above) (%)	Best outcome bound close to the maximum across the years. The Education and Training 2020 target is 40% attainment for tertiary education (of 30-34-year-olds), so in the long-term we would expect that the share of population with at least upper secondary education should be at least higher than this target. It was rounded up to the nearest 10%, based on the 5th percentile of the last seven years.	50	90
Reading, maths & science scores (PISA score)	Bounds close to the (EU) minimum and maximum, in particular, and the 5th and 95th percentile scores rounded to the nearest 10.	440	550
Recent training (%)	This indicator corresponds to the Education and Training target 6. Bounds as the seven-year minimum for worst outcome, and a number close to the seven-year maximum for the frontier.	1	30
VET students (%)	This indicator is monitored in the Strategic framework – Education and Training 2020. Bounds close to the minimum and maximum across the seven years.	10	75

Indicator (unit)	Rationale for bounds	Lower bound	Upper bound
High computer skills (%)	Bounds close to the minimum and maximum across the seven years.	7	46
Early leavers from training (%)	This indicator corresponds to the Education and Training target 1. It was decided for a number close to the maximum as the worst frontier across the years, and for the best frontier a figure close to the minimum scored across the years.	10	2
Recent graduates in employment (%)	This indicator corresponds to the Education and Training target 5. The best and worst frontiers are figures close to the minimum and maximum across the years.	55	95
Activity rate (aged 25-54) (%)	Bounds close to the minimum and maximum across the seven years.	80	90
Activity rate (aged 20-24) (%)	Bounds close to the minimum and maximum across the seven years.	40	78
Long-term unemployment (%)	Bounds close to the minimum and maximum across the seven years.	10	1
Underemployed part-timers (%)	Bounds close to the minimum and maximum across the seven years.	7	1
Over-qualification rate (tertiary graduates) (%)	Bounds close to the minimum and maximum across the seven years.	40	10
Low waged earners (ISCED 5-8) (%)	Bounds close to the minimum and maximum across the seven years.	14	0
Qualification mismatch (%)	Bounds close to the minimum and maximum across the seven years.	44	16

Source: European Skills Index (2018), Cedefop.

4.5. Transformation

No transformations are applied to the normalised scores. Although some of the normalised indicators present left or right skewness, it is considered that a sample of 28 countries is prone to such type of distributions. Some of the indicators exhibit a median greater than or equal to 0.7 (after normalisation) and lower than or equal to 0.3 (after normalisation). However, since the mean was above 0.3 or below 0.7, it was decided to not proceed with transformation which would make the interpretation of individual indicator scores more difficult for policy makers.

5. Aggregation

5.1. Aggregation method

A mixture of weighted arithmetic and geometric means is used at different levels of the Index.

The Index score is computed as the weighted geometric average of three pillar scores. Pillar scores are derived from calculating the weighted arithmetic average of the sub-pillar scores. Sub-pillar scores are calculated as the weighted arithmetic average of the Indicator scores.

The weighted arithmetic average method is easy to interpret, but makes a key assumption of perfect compensability between indicators as it assumes that the score in one indicator/sub-pillar can fully offset the score in another. At the indicator and the sub-pillar level, the interpretation of perfect compensability of scores is considered reasonable and adequate. The use of weighted arithmetic average also has precedence in the creation of other composite indices in which a distance-to-frontier normalisation approach is chosen ([2]).

The choice to use the weighted geometric average to combine the three pillar scores into an Index score stems from the consideration that perfect compensability at this level is more problematic. By using weighted geometric average, unbalanced profiles are penalised - that is, with pillar scores of two and eight, the weighted geometric average would be four, whereas pillar scores of five and five would score higher (five). Moreover, the geometric average gives more incentive for policymakers to improve those pillars with low values.

5.2. Weighting method

In practice, the (normalised) indicators within any given pillar in a composite index are often given equal weights. This approach makes the assumption that each indicator is equally informative with respect to the theme covered by the pillar.

However, there are several cases where the weights would be expected to deviate from equal weights:

- Theoretical basis – there may be a basis for considering certain indicators as being more important according to theory or relatable studies. As such, one may decide to increase the weight of these indicators/pillars relative to the other indicators/pillars.
- Statistical basis – correlation analysis and loadings from principal components analysis (PCA) can indicate similarity of one or more indicators. The information (the factor loadings) from PCA can be used to adjust the weights so that they act as “scaling coefficients” aiming to assign less weight to more correlated indicators, so that all indicators contribute in the same way to the index variance. An additional consideration is that being multidimensional phenomena, Index, pillar and sub-pillar scores should not be driven by a single pillar, sub-pillar or indicator.

([2]) See for instance Doing Business from World Bank (World Bank, 2016) and the Legatum Prosperity Index 2016 (Legatum Institute, 2016). The Human Development Index (United Nations, 2016) uses simple arithmetic average at sub-pillar level and then simple geometric average at pillar level.

As a starting point, equal weights were assigned at all levels ([3]). The weights of each indicator were then adjusted (informed by PCA factor loadings calculated at sub-pillar level) as follows: the higher the PCA factor loading of an indicator, the lower the weights used and the opposite (see Section 8.4.4). Then the correlation between the sub-pillar index and each indicator in the sub-pillar was checked so that no indicator is "driving" the sub-pillar and that each indicator is significantly correlated ([4]) with its sub-pillar. The weights were then adjusted upwards/ downwards to achieve these objectives. This check was repeated for the upper dimensions, i.e. sub-pillar, pillar and Index, to ensure that both sub-pillar correlation with its corresponding pillar, the individual indicators' correlation with their pillar and finally with the Index. Again, the weights were adjusted so that no indicator or sub-pillar would "drive" the score of the pillar or the Index. The whole purpose of this exercise was to ensure that indicator, sub-pillar and pillar scores contribute as equally as possible to sub-pillar, pillar and Index scores.

The ESI has also been back-cast (see Section 6.2). The variation of each indicator over time has been reviewed; any indicators that are particularly volatile might cause low correlations and so warrant an adjustment to the corresponding weight. No such adjustments to weights were made because none of the indicators were judged to show problematic volatility.

The final weights for each indicator and pillar are given in **Table 5.1** below.

Table 5.1 Pillar, sub-pillar and indicator weights

Pillar/ *sub-pillar*/ indicator	Weights
Skills Development	**0.3**
Basic education	*0.5*
Pre-primary pupil-to-teacher ratio	0.4
Upper secondary education (and above)	0.3
Reading, maths & science scores (aged 15)	0.3
Training and other education	*0.5*
Recent training	0.3
VET students	0.35
High computer skills	0.35
Skills Activation	**0.3**
Transition to work	*0.5*
Early leavers from training	0.7
Recent graduates in employment	0.3
Labour market participation	*0.5*
Activity rate (aged 25-54)	0.5
Activity rate (aged 15-24)	0.5
Skills Matching	**0.4**
Skills utilisation	*0.4*
Long-term unemployment	0.4
Underemployed part-timers	0.6
Skills mismatch	*0.6*
Over-qualification rate	0.4
Low waged earners (ISCED 5-8)	0.1
Qualification mismatch	0.5

Source: European Skills Index (2018), Cedefop.

All ESI sub-pillars correlate strongly with their respective pillars (correlation coefficients close to 0.85 or greater) and all three ESI pillars correlate strongly and in a balanced way with the

([3]) In previous versions of the index, engagement with thematic experts on possible weights concluded that no strong case could be made to assign greater or lesser weighting to any pillar, sub-pillar or indicator.
([4]) i.e. significant Pearson's correlation at 1% level.

ESI (correlations ranging between 0.71 and 0.77) – see Figure 8.2 in Section 8.3. The correlation analysis confirms the choice to use uneven weights for the three pillars (0.3, 0.3 and 0.4) in order to ensure that all three pillars are placed on equal footing when it comes to calculating a summary measure for the performance of a country's skills system.

Sensitivity analysis was undertaken to test the potential change in ranks and scores of countries given alternative aggregation and weighting procedures than the one used above (see Sections 9.2 and 9.3 below).

6. Results

6.1. The 2018 Index

The rankings of the Index for 2018 are presented in **Figure 6.1** below. At the Index level, Czech Republic is ranked highest, and Spain is ranked lowest. At the pillar level, Finland is ranked highest and Malta lowest in terms of Skills Development, Sweden is ranked highest and Italy lowest in Skills Activation, and Czech Republic highest and Greece lowest in Skills Matching.

The dispersion of ranks at the pillar level indicate that there is not one single country far outperforming other countries. For example, Netherlands is ranked second in Skills Activation, but ranks 15th at the Index level. Similarly, Malta ranks second in Skills Matching, but ranks 16th at the Index level.

Figure 6.1 Index, pillar and sub-pillar rankings (*)

Rankings		Index	Skills Development	Skills Activation	Skills Matching	Basic education	Training and other education	Transition to work	Labour market participation	Skills utilisation	Skills mismatch
CZ	Czech Republic	1	8	9	1	10	8	8	15	1	1
FI	Finland	2	1	11	6	2	1	17	10	13	5
SE	Sweden	3	2	1	13	4	4	3	1	10	15
LU	Luxembourg	4	6	13	3	13	2	2	21	8	3
SI	Slovenia	5	3	6	9	3	7	10	11	12	8
EE	Estonia	6	4	7	11	1	10	14	6	3	18
DK	Denmark	7	5	4	17	8	3	9	4	19	11
PL	Poland	8	17	15	5	11	21	7	20	5	9
DE	Germany	9	9	10	15	5	17	15	7	11	16
AT	Austria	10	7	3	19	12	5	6	2	17	21
LT	Lithuania	11	13	5	18	9	20	5	9	6	23
HR	Croatia	12	14	18	7	14	16	4	24	14	4
SK	Slovakia	13	12	19	8	15	13	19	17	15	6
LV	Latvia	14	11	14	16	7	19	20	8	16	13
NL	Netherlands	15	10	2	21	18	6	1	3	23	19
MT	Malta	16	28	16	2	27	25	11	18	4	2
HU	Hungary	17	22	23	4	16	24	23	19	2	7
BE	Belgium	18	16	22	14	17	15	18	23	18	10
UK	United Kingdom	19	15	8	24	19	11	16	5	20	24
FR	France	20	18	17	22	25	9	22	13	25	17
PT	Portugal	21	24	20	23	28	12	24	12	24	20
IE	Ireland	22	19	21	25	6	28	13	22	22	28
BG	Bulgaria	23	25	27	10	21	23	25	27	7	14
CY	Cyprus	24	26	12	26	24	27	12	14	26	25
RO	Romania	25	27	26	12	26	26	26	26	9	12
IT	Italy	26	20	28	20	22	14	28	28	21	22
EL	Greece	27	23	24	28	20	22	21	25	27	27
ES	Spain	28	21	25	27	23	18	27	16	28	26

(*) Sorted from highest Index score to lowest.
Source: European Skills Index (2018), Cedefop.

Table 6.1 and **Figure 6.3** displays the distribution of Index, pillar and sub-pillar scores. Figure 6.2 shows the index ranking and scores.

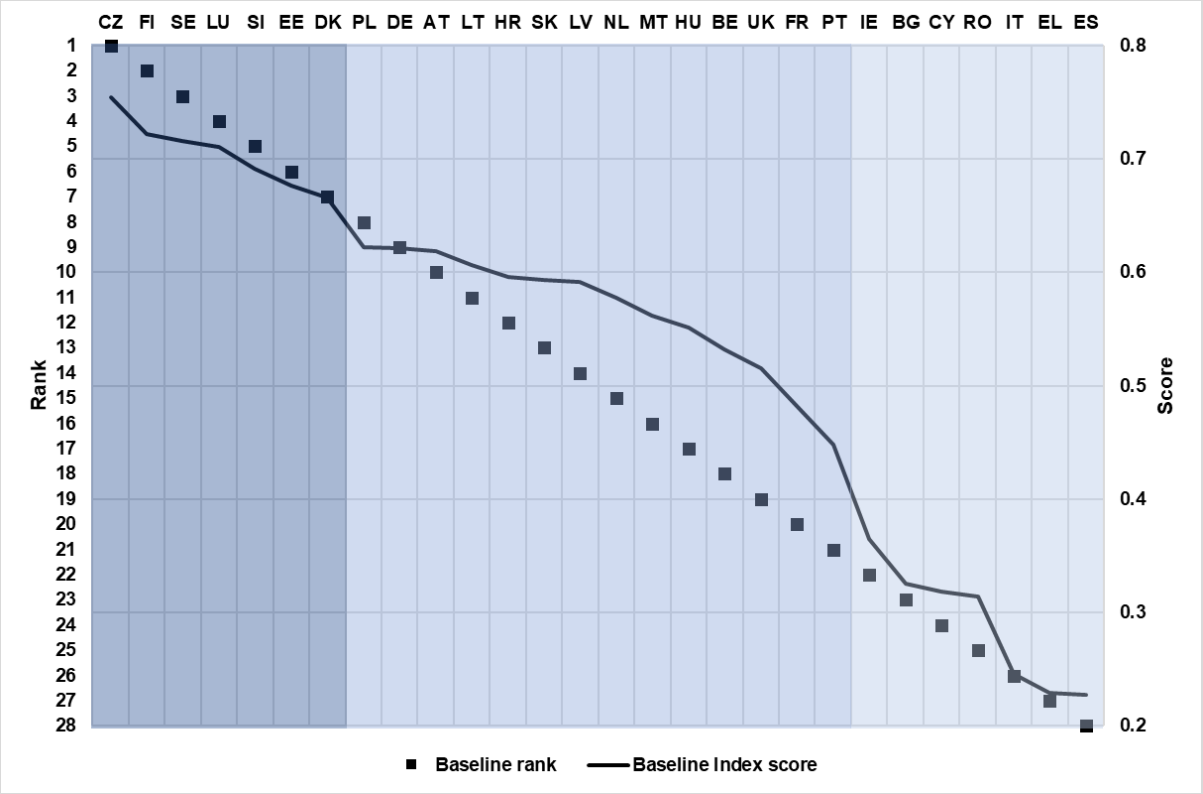
Table 6.1 Index, pillar and sub-pillar scores, 2016(*)

	Index	Skills Development	Skills Activation	Skills Matching	Basic education	Training and other education	Transition to work	Labour market participation	Skills utilisation	Skills mismatch
Czech Republic	0.75	0.64	0.69	0.91	0.67	0.60	0.77	0.61	0.97	0.88
Finland	0.72	0.89	0.66	0.66	0.83	0.94	0.62	0.71	0.66	0.66
Sweden	0.72	0.76	0.87	0.59	0.80	0.72	0.82	0.93	0.75	0.48
Luxembourg	0.71	0.68	0.66	0.78	0.60	0.75	0.86	0.46	0.84	0.74
Slovenia	0.69	0.72	0.73	0.64	0.81	0.64	0.76	0.69	0.67	0.63
Estonia	0.68	0.72	0.71	0.62	0.88	0.56	0.68	0.74	0.93	0.41
Denmark	0.67	0.72	0.78	0.56	0.71	0.73	0.76	0.80	0.62	0.52
Poland	0.62	0.52	0.63	0.71	0.66	0.37	0.78	0.48	0.89	0.58
Germany	0.62	0.63	0.69	0.57	0.77	0.48	0.65	0.73	0.73	0.46
Austria	0.62	0.67	0.83	0.47	0.63	0.70	0.80	0.86	0.64	0.36
Lithuania	0.61	0.54	0.76	0.55	0.70	0.39	0.81	0.72	0.88	0.34
Croatia	0.60	0.54	0.58	0.66	0.60	0.48	0.82	0.33	0.66	0.66
Slovakia	0.59	0.54	0.57	0.65	0.59	0.50	0.59	0.55	0.66	0.65
Latvia	0.59	0.58	0.65	0.56	0.72	0.43	0.58	0.72	0.65	0.50
Netherlands	0.58	0.61	0.83	0.42	0.54	0.68	0.86	0.81	0.46	0.39
Malta	0.56	0.29	0.62	0.86	0.32	0.25	0.72	0.52	0.89	0.85
Hungary	0.55	0.42	0.48	0.75	0.57	0.27	0.47	0.48	0.94	0.63
Belgium	0.53	0.52	0.49	0.58	0.56	0.48	0.62	0.36	0.64	0.54
United Kingdom	0.52	0.54	0.71	0.39	0.54	0.53	0.63	0.79	0.60	0.26
France	0.48	0.49	0.58	0.41	0.39	0.59	0.49	0.67	0.38	0.44
Portugal	0.45	0.41	0.56	0.40	0.32	0.50	0.45	0.68	0.43	0.39
Ireland	0.36	0.47	0.54	0.22	0.72	0.23	0.68	0.40	0.50	0.04
Bulgaria	0.33	0.38	0.11	0.64	0.45	0.31	0.13	0.10	0.84	0.50
Cyprus	0.32	0.32	0.66	0.18	0.40	0.24	0.70	0.63	0.19	0.18
Romania	0.31	0.29	0.14	0.62	0.33	0.25	0.12	0.15	0.77	0.51
Italy	0.25	0.47	0.06	0.43	0.44	0.49	0.05	0.07	0.56	0.34
Greece	0.23	0.41	0.43	0.09	0.47	0.35	0.53	0.33	0.16	0.04
Spain	0.23	0.43	0.33	0.11	0.41	0.45	0.10	0.57	0.10	0.11

(*) Sorted from highest Index score to lowest.
Source: European Skills Index (2018), Cedefop.

It is possible to distinguish three groups of countries: around seven top performers with scores above 0.67; a large group of middle performers with scores 0.45-0.62; and seven low performers, with scores below 0.36.

Figure 6.2 Index ranking and scores, 2016 (*)

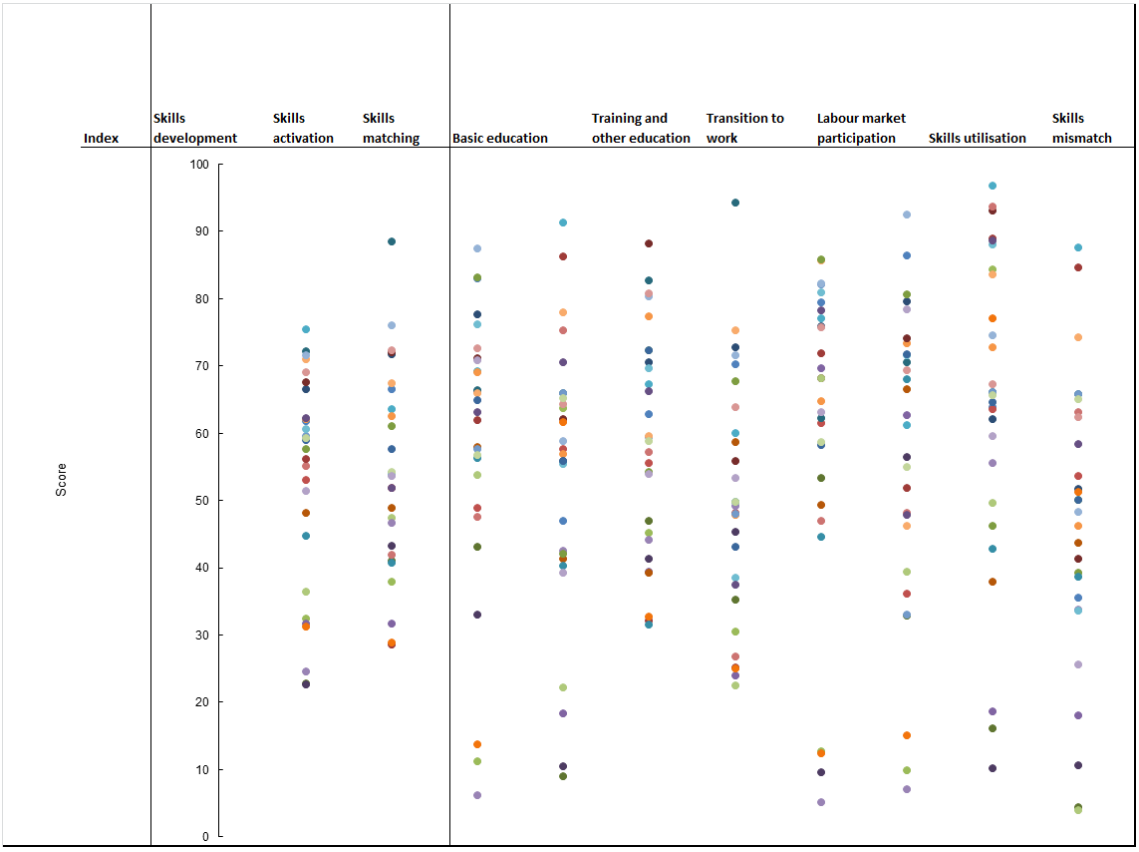


(*) Sorted from highest Index score to lowest.
Source: European Skills Index (2018), Cedefop.

There is a wider distribution of scores across EU countries in the second and third pillars (Skills Activation and Matching), than in the first pillar (Skills Development).

At the sub-pillar level, for each sub-pillar there are some “lagging” countries which cluster close to zero.

Figure 6.3 Distribution of index, pillars and sub-pillars scores, 2016



Source: European Skills Index (2018), Cedefop.

6.2. Back-casting the Index

Table 6.2 shows the changes in the ESI score, the ESI ranking and the ranking by pillar over the period 2014-2016. As can be observed in the first four columns below, not all increases in the ESI score translate to an increase in the position in the ranking. Czech Republic (1), France (20), Netherlands (15), Portugal (21) and United Kingdom (19) are not changing their position in the ranking during this period although their scores change over time. In the pillar rankings, Italy maintains the same position in all three years.

Table 6.2Back-cast Index, 2014-2016

	ESI				Skills development	Skills activation	Skills matching
	2014 score	2015 score	2016 score	2014-2016 rank change	2014-2016 rank change	2014-2016 rank change	2014-2016 rank change
Belgium	0.53	0.51	0.53				
Bulgaria	0.34	0.36	0.33				
Czech Republic	0.75	0.74	0.75				
Denmark	0.70	0.70	0.67				
Germany	0.61	0.62	0.62				
Estonia	0.63	0.65	0.68				
Ireland	0.28	0.32	0.36				
Greece	0.23	0.23	0.23				
Spain	0.19	0.20	0.23				
France	0.48	0.47	0.48				
Croatia	0.58	0.56	0.60				
Italy	0.21	0.19	0.25				
Cyprus	0.30	0.31	0.32				
Latvia	0.60	0.59	0.61				
Lithuania	0.59	0.61	0.59				
Luxembourg	0.72	0.71	0.71				
Hungary	0.51	0.54	0.55				
Malta	0.52	0.53	0.56				
Netherlands	0.54	0.56	0.58				
Austria	0.62	0.62	0.62				
Poland	0.59	0.60	0.62				
Portugal	0.40	0.44	0.45				
Romania	0.34	0.33	0.31				
Slovenia	0.69	0.67	0.69				
Slovakia	0.58	0.58	0.59				
Finland	0.72	0.71	0.72				
Sweden	0.69	0.70	0.72				
United Kingdom	0.49	0.51	0.52				

Source: European Skills Index (2018), Cedefop.

Czech Republic kept the lead position throughout the three-year period. Finland was third in 2014 and became second in 2014 and 2015, at the expense of Luxembourg (now 4th), thanks to improvements in pillars 1 and 2. Sweden ranks 3rd in 2016, gaining two positions from 5th in 2014 and 2015 because of improvements in skills matching.

The bottom of the ranking is occupied by Spain, Greece and Italy. Spain was the bottom ranked country in 2014 and 2016, exchanging place with Italy in 2015, mainly because of very low scores in the skills matching pillar. Greece faces a similar situation, passing from rank 26 to 28 because of low skills matching performance. Instead, Italy is characterised by a very poor skills activation score, while has higher scores in the other two pillars compared to Greece and Spain.

The highest-ranking member states in skills matching are: Czech Republic (1); Malta (2) and Luxembourg (3). Sweden (1), Netherlands (2) and Austria (3) hold the top positions in skills

activation, while Finland (1), Sweden (2) and Slovenia (3) hold the top three in skills development.

The low achievers remain the same in the first two pillars in each of the three years. In skills activation, Romania (26), Bulgaria (27) and Italy (28) are at the bottom. In skills development, the low achievers are Cyprus (26), Romania (27) and Malta (28). In 2016, Cyprus (26), Greece (27) and Spain (28) occupy the bottom positions in skills matching, with Ireland becoming 25th in 2015 at the expenses of Cyprus.

Despite being one of the low achievers (i.e. in the last three positions) in skills development and activation, Romania manages to stay in the first half ranked member states in skills matching and thus ranking 25/28 at ESI level. Malta holds the last positions in all three years in skills development and middle to low range position in skills activation but is a top achiever in skills matching.

Part Two: Statistical coherence analysis

7. Considerations since the last Index update

The ESI builds on the work undertaken for the Making Skills Work Index, published by Cedefop in 2016. While the theoretical framework remains unchanged, numerous changes have been made to the structure of the Index. Figure 7.1 below presents the initial refinements made to move from the MSWI to the starting point of the 2018 ESI.

Figure 7.1: Moving from MSWI to the initial structure of the ESI

Making Skills Work Index

Pillar	Sub-pillar	Indicator group	Indicator
Skills Development			
	Basic education		
		Participation in compulsory education	
			Pre-primary participation
			Upper secondary participation (aged 15-17)
		Attainment from compulsory education	
			Upper secondary attainment (aged 15-64)
			Reading, maths & science scores (aged 15)
	Post-compulsory education and training		
		training	
			Recent training
			Lifelong learning (employees)
			Lifelong learning (aged 25-64)
			VET students
			Training deficit
		training	
			Tertiary attainment (aged 30-34)
			High computer skills
Skills Activation			
	Transition from education to work		
			Early leavers from training
			NEETs
			Recent graduates in employment
	Activity rates		
			Activity rate (aged 15-24)
			Activity rate (aged 25-54)
			Activity rate (aged 55-64)
Skills Matching			
	Unemployment and vacancies		
		Unemployment	
			Long-term unemployment
		Vacancies	
			Structural vacancies
		Under-employment	
			Underemployed part-time workers
	Skills mismatch		
			Skills obsolescence
			Higher education mismatch

Full list of considered indicators, European Skills Index (2018

Pillar	Sub-pillar	Indicator
Skills Development		
	Basic education	
		Pre primary pupil-to-teacher ratio
		~~*Pre-primary participation*~~
		Upper secondary attainment (aged 15-64)
		Reading, maths & science scores (aged 15)
	Training and other education	
		Recent training
		Lifelong learning (employees)
		~~*Lifelong learning (aged 25-64)*~~
		VET students
		Training deficit
		Tertiary attainment (aged 30-34)
		High computer skills
Skills Activation		
	Transition to work	
		Early leavers from training
		NEETs
		Recent graduates in employment
	Labour market participation	
		Activity rate (aged 15-24)
		Activity rate (aged 25-54)
		Activity rate (aged 55-64)
Skills Matching		
	Skills utilisation	
		Long-term unemployment
		Structural vacancies
		Underemployed part-timers
	Skills mismatch	
		Skills obsolescence
		Low waged earners (ISCED 5-8)
		Qualification mismatch
		Higher education mismatch (renamed as Over-qualification rate)
		Communication skills gap
		Problem solving skills gap
		ICT skills gap

Source: European Skills Index (2018), Cedefop.

New indicators were added to the structure. For the first pillar, three indicators were removed, and two indicators were added for consideration:

- *Pre-primary participation* was removed from Pillar 1 (Skills Development) because of the low variance of the indicator and the negative correlation identified between itself and other indicators in the sub-pillar. Since pre-primary education participation is set as one of the quantitative benchmarks in Education and Training 2020, this indicator is replaced by another indicator relating to early childhood education.
- *Upper secondary participation (aged 15-17)* was dropped from Pillar 1 (Skills Development) because there is limited variation between the Member States. Only one

country has a value below 90% in 2016 ([5]), so there is not much room for improvement for this indicator.

- *Lifelong learning (aged 25-64)* was dropped from Pillar 1 (Skills Development) because it measures a similar concept as *Lifelong learning (employees)*, the difference being the data source and the respondents to the survey (one is asking the employers and one is asking the employees). The rationale for removing it from the current structure is to reduce the number of indicators in this sub-pillar in order to balance the number of indicators among pillars. This indicator was subsequently removed due to low correlation at the sub-pillar and pillar level following normalisation (see section 8.3).
- *Pupil-to-teacher ratio for pre-primary education* was added for consideration to Pillar 1 (Skills Development). Given that early childhood education and care plays an essential role in tackling inequalities and raising proficiency in basic competences, pupil-to-teacher ratio at pre-primary education age proxies for the quality of teaching at pre-primary education level. Although this indicator could be perceived as an "input" variable (and thus the type of indicator that was avoided in previous explorations of indicators), the interpretation is that it can be interpreted as a measure of education quality as well.
- *Share of population aged 15-64 with at least upper secondary education* was added for consideration to Pillar 1 (Skills Development). This indicator is considered as related to but distinct from a similar indicator that was already in the Index – Upper Secondary Attainment (aged 15-64), which measures the share of individuals who have *at most* upper secondary education. Inclusion of the new indicator is based on the rationale that a higher value of this indicator can be interpreted as a higher level of educational attainment of the population.

New indicators were also considered in the third pillar (Skills Matching), and in particular, to the sub-pillar Skills Mismatch, because of the sparsity of that sub-pillar and because of the importance of this particular theme in the context of skills systems.

- *ISCED 5-8 proportion of low wage earners* indicator was added for consideration to Pillar 3 (Skills Matching) as an additional indicator to represent skills mismatches. This is defined as the proportion of low wage earners out of all employees of ISCED 5-8 qualification level, where low wage is defined as "those employees (excluding apprentices) earning two-thirds or less of the national median gross hourly earnings in that particular country" ([6]).
- *Qualification mismatch* was added for consideration to Pillar 3 (Skills Matching). This indicator is obtained from the OECD WISE database, and is calculated using the EU Labour Force Survey. It measures incidences of both underqualification and overqualification. The measure is calculated through taking the modal education attainment level for each occupation in each industry and assessing whether each employee's education attainment level matches it ([7]).
- In addition to this, further stakeholder engagement brought to light that metrics measuring soft-skills mismatches are important to consider within a skills system. Mismatches of a range of skills were drawn from the European Skills and Jobs Survey (ESJS) ([8]). Out of the full list of skills considered, three in particular were considered most important for the Index – *communication skills gap, problem-solving skills gap, and ICT skills gap*. These indicators were considered most important to include given their

([5]) Data accessed October 2017, Eurostat code edat_lfse_19
([6]) http://ec.europa.eu/eurostat/cache/metadata/en/earn_ses_main_esms.htm.
([7]) http://www.keepeek.com/Digital-Asset-Management/oecd/employment/getting-skills-right-skills-for-jobs-indicators_9789264277878-en#.WYyA6uyGNuU#page7.
([8]) At the outset, the skills gap considered were: communication skills gap; customer handling skills gap; learning skills gap; planning and organisation skills gap; problem solving skills gap; team working skills gap; foreign language skills gap; ICT skills gap; literacy skills gap; and numeracy skills gap.

anticipated importance as skill requirements in the economy ([9]) and were added for consideration. These indicators were later removed due to low correlation at the sub-pillar and pillar level following normalisation (see section 8.3).

- Some stakeholders have expressed their concerns about using indicators "Activity rate (%) 15-24" and "Activity rate (%) 25-54" from a policy point of view. From a theoretical point of view, there is value in considering an "Activity Rate" measure that omits the age range 15-17 as this age group would still be in education, and an "Activity rate" measure that includes the age range 55-64 since the retirement age in most countries is 65. Therefore, the indicators "Activity rate (%) 20-24" ([10]) and "Activity rate (%) 25-64" were introduced into the Index as "in-consideration" indicators.

([9]) According to WEF (World Economic Forum, 2016), social skills, content skills and process skills will grow in importance, and these skills map broadly in concept to the three skills chosen from the ESJS.
([10]) The data for "Activity Rate (%) aged 18-24" are not available from Eurostat (lfsa_argaed).

8. Descriptive statistics

8.1. Summary statistics

Summary statistics on the unprocessed data for the considered indicators can be found in **Table 8.1** below.

Table 8.1 Summary statistics

	Range	Mean	Median	Observations (2010-2016)	Skewness and kurtosis check (*)
Pre-primary pupil-to-teacher ratio	[5.8, 21.8]	13.11	13.10	86	-
Upper secondary attainment (aged 15-64)	[18.8, 71.1]	47.43	45.35	196	-
Upper secondary attainment (and above)	[32.7, 87.6]	73.01	75.60	196	-
Reading, maths & science scores (aged 15)	[437.49, 529.4]	490.24	493.02	54	-
Recent training	[1.2, 32.6]	10.43	7.9	196	-
Lifelong learning (employees)	[51.9, 81.0]	66.83	67.2	28	-
VET students	[1.2, 88.1]	47.91	47.4	91	-
Training deficit	[4.8, 55.1]	12.62	10.6	46	2011
Tertiary attainment (aged 30-34)	[18.3, 58.7]	37.88	40.1	196	-
High computer skills	[7.0, 46.0]	28.51	29	84	-
Early leavers from training	[2.1, 15.5]	5.85	5.3	196	-
NEETs	[5.7, 29.1]	15.77	15.2	196	-
Recent graduates in employment	[40.0, 96.6]	75.80	76.9	196	-
Activity rate (aged 25-54)	[72.9, 90.9]	85.80	87.1	196	-
Activity rate (aged 20-24)	[39.7, 78.1]	59.73	60.1	196	
Activity rate (aged 15-24)	[23.9, 69.2]	40.16	37.2	196	-
Activity rate (aged 25-64)	[62.7, 88.4]	78.18	78.8	196	
Activity rate (aged 55-64)	[33.3, 79.7]	53.09	53.45	196	-
Long-term unemployment	[1.2, 19.5]	4.77	4	196	2015, 2016
Underemployed part-timers	[0.5, 7.8]	3.23	2.9	196	-
Structural Vacancies	[2.3, 60.6]	13.65	11.17	136	-
Skills obsolescence	[16.5, 73.2]	48.29	47.38	28	-
Over-qualification rate	[3.3, 40.7]	23.28	21.22	140	-
Low wage earners (ISCED 5-8)	[0.2, 13.8]	5.04	3.58	56	-
Qualification mismatch	[16.0, 44.1]	33.33	35.21	26	-
Communication skills gap	[14.7, 38.6]	25.22	25.3	28	-

	Range	Mean	Median	Observations (2010-2016)	Skewness and kurtosis check (*)
Problem solving skills gap	[12.4, 39.0]	23.66	23.28	28	-
ICT skills gap	[16.8, 35.1]	25.0	24.27	28	-

(*) Skewness and kurtosis checks relates to years where the absolute skewness is greater than 2 and absolute kurtosis is greater than 3.5.
Source: European Skills Index (2018), Cedefop.

8.2. Correlation analysis

Correlation analysis is used to assess to what extent the selected indicators support the ESI framework. From the analysis of the correlation matrix within an Index, indicators should be more correlated to:

- indicators from its own dimension than to indicators from other dimensions;
- its own dimension than to other dimensions.

Figure 8.1 below displays the correlation matrix of the preliminary list of indicators that was considered for the ESI. Directional adjustments were accounted for in the matrix figure below That is, it controls for differences in direction of impact, in instances where a lower value indicates a more positive outcome, by ensuring that the correlation calculation treats both indicators as if they are moving in the same direction for positive outcomes.

Figure 8.1 Correlation matrix of considered list of indicators (*)

	Pre-primary pupil-to-teacher ratio	Upper secondary attainment	Share of population aged 15-	Reading, maths & science scores	Recent training	Lifelong learning (employees)	VET students	Training deficit	Tertiary attainment (aged 30-34)	High computer skills	Early leavers from training	NEETs	Recent graduates in employment	Activity rate (aged 25-54)	Activity rate (aged 20-24)	Activity rate (aged 15-24)	Activity rate (aged 25-64)	Activity rate (aged 55-64)	Long-term unemployment	Underemployed part-time workers	Structural Vacancies	Skills obsolescence	Over-qualification rate	ISCED 5-8 proportion of low	Qualification mismatch	Communication skills gap	Problem solving skills gap	ICT skills gap
Pre-primary pupil-to-teacher rat	1.00																											
Upper secondary attainment (ag	0.25	1.00																										
Share of population aged 15-64 v	0.33	0.79	1.00																									
Reading, maths & science scores	0.11	-0.13	0.13	1.00																								
Recent training	0.22	-0.30	0.03	0.58	1.00																							
Lifelong learning (employees)	0.10	0.03	0.15	0.50	0.24	1.00																						
VET students	-0.03	0.43	0.28	0.17	0.12	0.11	1.00																					
Training deficit	0.28	0.47	0.37	0.11	0.09	-0.01	0.50	1.00																				
Tertiary attainment (aged 30-34)	0.18	-0.29	0.30	0.33	0.45	0.09	-0.29	-0.13	1.00																			
High computer skills	0.32	-0.35	0.02	0.64	0.77	0.32	0.02	0.09	0.54	1.00																		
Early leavers from training	0.29	0.17	0.43	0.34	0.31	0.36	0.09	0.00	0.53	0.39	1.00																	
NEETs	0.26	-0.01	0.18	0.57	0.56	0.44	0.12	0.37	0.34	0.52	0.54	1.00																
Recent graduates in employmen	0.15	0.09	0.24	0.30	0.31	0.45	0.00	0.23	0.21	0.20	0.40	0.84	1.00															
Activity rate (aged 25-54)	0.21	0.07	0.34	0.33	0.45	0.10	0.12	0.39	0.46	0.56	0.41	0.60	0.39	1.00														
Activity rate (aged 20-24)	0.09	-0.19	0.10	0.53	0.61	0.49	-0.18	-0.10	0.35	0.49	0.45	0.60	0.62	0.34	1.00													
Activity rate (aged 15-24)	0.12	-0.17	0.06	0.47	0.70	0.38	0.00	0.05	0.28	0.45	0.39	0.64	0.60	0.28	0.93	1.00												
Activity rate (aged 25-64)	0.29	-0.04	0.33	0.41	0.59	0.13	-0.08	0.25	0.53	0.60	0.26	0.54	0.40	0.82	0.53	0.48	1.00											
Activity rate (aged 55-64)	0.29	-0.06	0.24	0.39	0.52	0.11	-0.22	0.10	0.37	0.41	0.05	0.32	0.30	0.38	0.58	0.55	0.83	1.00										
Long-term unemployment	0.22	0.26	0.39	0.34	0.44	0.29	0.09	0.18	0.21	0.19	0.36	0.72	0.80	0.23	0.53	0.57	0.34	0.36	1.00									
Underemployed part-time work	0.37	0.59	0.30	-0.07	-0.28	0.01	0.24	0.41	-0.35	-0.22	-0.01	0.15	0.24	-0.14	-0.32	-0.30	-0.21	-0.16	0.38	1.00								
Structural Vacancies	-0.07	0.16	0.11	0.07	-0.04	0.02	-0.01	-0.09	-0.07	-0.07	-0.22	0.20	0.43	0.06	0.14	0.07	0.18	0.22	0.41	0.31	1.00							
Skills obsolescence	0.05	-0.35	-0.32	-0.07	0.26	0.18	-0.16	-0.03	0.00	0.12	-0.09	0.22	0.36	-0.23	0.27	0.35	-0.12	0.01	0.29	-0.06	0.12	1.00						
Over-qualification rate	0.23	0.07	-0.01	0.34	0.37	0.13	0.34	0.23	-0.09	0.32	0.30	0.63	0.57	0.19	0.17	0.25	0.09	0.00	0.60	0.49	0.19	0.22	1.00					
ISCED 5-8 proportion of low wag	-0.01	-0.10	-0.33	-0.10	0.20	0.04	0.37	0.17	-0.35	0.08	-0.15	0.00	-0.04	0.02	-0.30	-0.18	-0.20	-0.34	-0.06	0.11	-0.21	0.30	0.34	1.00				
Qualification mismatch	0.16	0.76	0.59	-0.17	-0.16	0.19	0.57	0.45	-0.28	-0.25	0.05	0.16	0.28	0.12	-0.30	-0.24	-0.12	-0.25	0.34	0.66	0.34	-0.10	0.32	0.29	1.00			
Communication skills gap	-0.04	0.13	-0.07	-0.45	-0.46	0.03	-0.07	-0.20	-0.22	-0.42	0.13	-0.30	-0.11	-0.43	-0.11	-0.13	-0.56	-0.50	-0.20	-0.08	-0.32	0.03	-0.14	-0.01	-0.01	1.00		
Problem solving skills gap	-0.09	0.16	-0.05	-0.31	-0.38	0.14	0.02	-0.12	-0.31	-0.46	0.02	-0.34	-0.13	-0.47	-0.10	-0.10	-0.54	-0.39	-0.22	-0.11	-0.41	0.03	-0.18	0.09	0.00	0.91	1.00	
ICT skills gap	-0.35	-0.02	-0.08	-0.24	-0.32	-0.20	0.04	-0.17	-0.09	-0.40	-0.20	-0.40	-0.39	-0.23	-0.30	-0.27	-0.30	-0.29	-0.39	-0.47	-0.31	-0.09	-0.36	-0.05	-0.17	0.51	0.58	1.00

(*) The full names of each indicator are available in Figure 7.1 and Figure 3.1 above. Blue figures denote significant Pearson's correlation at 1% level.
Source: European Skills Index (2018), Cedefop.

From the correlation analysis, it is evident that there are no indicators that are highly correlated with each other (i.e. correlation coefficient greater than 0.92), and that there are no indicators that are negatively and significantly correlated with each other. In addition:

- supported by the correlation analysis, NEETs (young people not in education, employment or training) is considered to mirror the same information captured by other variables. Conceptually, it relates very closely to activity rates, recent graduates in employment, and long-term unemployment. Therefore, high correlations with long-term unemployment, activity rates and recent training are interpreted as this information already being included in other indicators within the Index. Therefore, it was dropped.
- the indicators relating to soft skill mismatches are, although correlated significantly with each other, weakly (and often negatively) correlated with other indicators in the Index. These indicators are therefore considered as less suitable for inclusion.
- a few random correlations exist (significant correlations between indicators outside of its own sub-pillar and pillar). Of those indicators, Upper secondary attainment is considered as one that could feasibly be removed, as a similar indicator that represents a similar concept (Share of population who have at least upper secondary attainment) is added. The theoretical framework indicates that there are close relationships between the three pillars, and so random correlations are not considered entirely unusual given the theoretical underpinnings.

8.3. Correlation analysis following normalisation

Correlation and principal component analysis followed the normalisation of the indicators. Together with the correlation analysis in Section 0 above and after checking which indicators are significant at the Index level, the original list of indicators and structure was refined slightly following an iterative process. In particular, other indicators are also removed, because of their limited or negative contribution at the sub-pillar and pillar level. These are:

- Upper secondary attainment (aged 15-64);
- Training deficit;
- Tertiary attainment (aged 30-34);
- Lifelong learning (employees);
- NEETs;
- Activity rate (aged 55-64);
- Activity rate (aged 15-24);
- Activity rate (aged 25-64);
- Structural vacancies;
- Skills obsolescence;
- Communications skills gap;
- Problem solving skills gap;
- ICT skills gap.

As a result, the number of indicators is reduced to 15. They are outlined in **Figure 3.1**.

Figure 8.2 below outlines the correlation results of the Index, based on the indicators, normalisation, weights and aggregation procedure outlined in Part 1 of the technical report. Given the lack of highly collinear (i.e. Pearson correlation coefficient greater than 0.92) pairs of indicators within the same sub-pillar, the correlation analysis of normalised indicators suggests that there is no redundancy of information in the ESI framework.

Figure 8.2: Correlation analysis of normalised scores (*)

	Index	Skills Development	Skills Activation	Skills Matching	Basic education	Training and other education	Transition to work	Labour market participation	Skills utilisation	Skills mismatch
Index	1.00									
Skills Development	0.77	1.00								
Skills Activation	0.76	0.62	1.00							
Skills Matching	0.71	0.28	0.16	1.00						
Basic education	0.70	0.84	0.57	0.29	1.00					
Training and other education	0.62	0.88	0.50	0.20	0.48	1.00				
Transition to work	0.76	0.53	0.90	0.29	0.55	0.37	1.00			
Labour market participation	0.61	0.59	0.89	-0.01	0.47	0.54	0.62	1.00		
Skills utilisation	0.64	0.26	0.14	0.90	0.41	0.06	0.27	-0.02	1.00	
Skills mismatch	0.68	0.26	0.16	0.95	0.16	0.28	0.28	0.00	0.73	1.00
Pre-primary pupil-to-teacher ratio	0.43	0.51	0.26	0.32	0.71	0.22	0.30	0.17	0.39	0.22
Share of population aged 15-64 with at least upper secondary education	0.52	0.50	0.39	0.30	0.70	0.19	0.43	0.27	0.41	0.18
Reading, maths & science scores (aged 15)	0.52	0.73	0.51	0.04	0.64	0.62	0.38	0.55	0.08	0.01
Recent training	0.49	0.72	0.56	0.03	0.41	0.81	0.36	0.66	-0.03	0.07
VET students	0.38	0.48	0.03	0.37	0.20	0.61	0.08	-0.03	0.19	0.46
High computer skills	0.48	0.72	0.60	-0.06	0.48	0.75	0.41	0.67	-0.09	-0.02
Early leavers from training	0.65	0.51	0.83	0.16	0.53	0.36	0.96	0.53	0.13	0.16
Recent graduates in employment	0.72	0.34	0.70	0.53	0.36	0.23	0.66	0.60	0.52	0.48
Activity rate (aged 25-54)	0.54	0.53	0.69	0.03	0.40	0.51	0.45	0.81	-0.02	0.06
Activity rate (aged 20-24)	0.46	0.43	0.76	-0.04	0.37	0.37	0.56	0.81	-0.01	-0.06
Long-term unemployment	0.72	0.45	0.54	0.63	0.47	0.32	0.51	0.45	0.72	0.49
Underemployed part-time workers	0.42	0.08	-0.13	0.84	0.28	-0.11	0.05	-0.29	0.91	0.68
Over-qualification rate	0.74	0.42	0.36	0.78	0.26	0.46	0.39	0.25	0.64	0.78
ISCED 5-8 proportion of low wage earners	0.12	0.06	-0.17	0.34	-0.23	0.32	-0.15	-0.16	0.05	0.50
Qualification mismatch	0.48	0.21	0.00	0.81	0.23	0.13	0.11	-0.12	0.63	0.84

(*) Figures in blue denote significant Pearson's correlation at 1% level.
Source: European Skills Index (2018), Cedefop.

Figure 8.2 indicates that the Index is not overly dominated by specific pillars, sub-pillars, or indicators. Moreover, Figure 8.2 confirms the expectation that the indicators are more associated with their own sub-pillar than to any of the other sub-pillars. Similarly, the sub-pillars are more associated within their respective pillar than across the three pillars. Therefore, the correlation analysis suggests that the allocation of ESI indicators to the specific sub-pillar, and allocation of sub-pillars to pillars, is consistent both from conceptual and statistical perspectives.

Ten out of 15 indicators are also positively and significantly correlated with the overall Index (see values in blue in Figure 8.2). Some indicators have low correlation at the Index level (e.g. ISCED 5-8 proportion of low wage earners), but some remain significantly correlated at both sub-pillar level and pillar level (e.g. Underemployment part-time workers and Activity rate (aged 20-24)).

8.4. Principal Component Analysis (PCA)

The correlation analysis was followed by a statistical procedure called principal component factor analysis (PCA) that was used to investigate to what extent the elements that comprise the composite index measure different factors of the index/pillar and thereby minimise issues of overlap/overrepresentation within the index. Therefore, PCA is used in general in the development of a composite index to find natural groupings (factors or components) based on the internal relationship of the variables and to verify the structure (internal consistency) of each pillar and sub-pillar.

First, the initial list of indicators is adjusted also based on the results of PCA; the entire 7 years of imputed and normalised data is used. The findings of the PCA together with the correlation analysis led to the removal of some indicators (out of the ones mentioned in Section 8.3).

Then, PCA is used to assess to what extent the conceptual framework is confirmed by statistical approaches. For each sub-pillar and pillar, loadings with eigenvalues greater than one were considered for the factor matrix, which is rotated using varimax rotation. Ideally, this rotation should result in one single latent component that captures more than 60% of the total variance and all the loadings in the same component have the same sign. In addition,

the restriction is added that each individual component with eigenvalue greater than one and that it has to explain more than 10% of the variance (see OECD (2008)).

In addition, one of the most common uses of PCA is to extract the principal components that meet the criteria mentioned above and to consider them as factors, neglecting those remaining. This way the factor loading can be used to construct weights representing the information content of individual indicators (see OECD (2008)) that can be used to inform decisions about the weights used as scaling coefficients.

The final PCA analysis shows the presence of a single statistical dimension between the three pillars that explains 60% of the total variance, thus justifying the three-pillar structure and the aggregation of these three pillars into one number:

European Skills Index			
Factor	Eigenvalue	Proportion	Cumulative
Factor1	1.79	0.60	0.60
Factor2	0.84	0.28	0.88
Factor3	0.37	0.12	1.00

The factor loadings suggest that the third pillar should have the greatest weight among the three pillars if we want to increase its influence on the Index:

Index	Factor 1
Pillar 1 Score	0.88
Pillar 2 Score	0.84
Pillar 3 Score	0.56

The sections below look at the unidimensionality at pillar and sub-pillar level.

8.4.1. Pillar 1 – Skills Development

For the two sub-pillars in Skills Development, the results of the PCA show one latent component in both sub-pillars using eigenvalues greater than 1 as a criterion:

Basic education			
Factor	Eigenvalue	Proportion	Cumulative
Factor1	1.44	0.48	0.48
Factor2	0.89	0.30	0.78
Factor3	0.66	0.22	1.00
Training and other education			
Factor	Eigenvalue	Proportion	Cumulative
Factor1	1.77	0.59	0.59
Factor2	0.99	0.33	0.92
Factor3	0.25	0.08	1.00

The factor loadings are presented in the table below:

Basic education		
Indicators	Variable	Factor1
Pre-primary pupil-to-teacher ratio	Ind01	0.72
Upper secondary attainment (and above)	Ind02	0.78
Reading, maths & science scores	Ind03	0.56
Training and other education		
Indicators	Variable	Factor1
Recent training	Ind04	0.93
VET students	Ind05	0.23
High computer skills	Ind06	0.92

While the PCA factor loadings suggest a weak relationship between "VET students" and the other two indicators in this pillar, this indicator will not be removed as it fits into the overall structure of the index.

PCA at the pillar level confirms unidimensionality of the first pillar: the single latent dimension captures 74% in Pillar 1 Skills Development of the total variance of the underlying sub-pillars:

Skills Development			
Factor	Eigenvalue	Proportion	Cumulative
Factor1	1.47	0.74	0.74
Factor2	0.53	0.26	1.00

Thus, the structure of the pillar is justified. Moreover, the loadings of the two sub-pillars would suggest that the use of equal weights for the two sub-pillars is appropriate:

Skills Development	Factor 1
Basic education Score	0.86
Training and other education Score	0.86

8.4.2. Pillar 2 – Skills Activation

The PCA confirms the unidimentionality in each of the sub-pillars: single latent dimension captures more than 60% of the variance of the underlying indicators:

Transition to work			
Factor	Eigenvalue	Proportion	Cumulative
Factor1	1.44	0.72	0.72
Factor2	0.56	0.28	1.00
Labour market participation			
Factor	Eigenvalue	Proportion	Cumulative
Factor1	1.50	0.75	0.75
Factor2	0.50	0.25	1.00

As expected, the loadings of each indicators of the two sub-pillars indicate equal weighting:

Transition to work	
Indicators	Factor1
Early leavers from training	0.85
Recent graduates in employment	0.85
Labour market participation	

Indicators	Factor1
Activity rate (aged 25-54)	0.77
Activity rate (aged 15-24)	0.77

The conceptual framework for this pillar is confirmed by the fact that almost 80% of the variance of the underlying sub-pillars is captured by a single latent component:

Skills Activation			
Factor	Eigenvalue	Proportion	Cumulative
Factor1	1.57	0.79	0.79
Factor2	0.43	0.21	1.00

And the loadings suggest equal weighting when the two sub-pillars are to be aggregated at pillar level:

Skills Activation	Factor 1
Transition to work Score	0.89
Labour market participation Score	0.89

8.4.3. Pillar 3 – Skills Matching

The PCA analysis confirms the unidimensionality in both sub-pillars capturing almost 60% of the variation of the underlying indicators:

Skills Utilisation			
Factor	Eigenvalue	Proportion	Cumulative
Factor1	1.18	0.59	0.59
Factor2	0.82	0.41	1.00
Skills mismatch			
Factor	Eigenvalue	Proportion	Cumulative
Factor1	1.66	0.55	0.55
Factor2	0.73	0.24	0.80
Factor3	0.61	0.20	1.00

The factor loadings suggest that equal weights could be a used:

Skills Utilisation	
Indicators	Factor1
Long-term unemployment	0.77
Underemployed part-timers	0.77
Skills mismatch	
Indicators	Factor1
Over-qualification rate	0.79
Low waged earners (ISCED 5-8)	0.72
Qualification mismatch	0.72

PCA analysis confirms the unidimensionality at the pillar level: the single latent dimension captures 86% in Pillar 3 Skills Matching of the total variance of the underlying sub-pillars:

Skills Matching

Factor	Eigenvalue	Proportion	Cumulative
Factor1	1.68	0.84	0.84
Factor2	0.32	0.16	1.00

The loadings of the two sub-pillars would suggest the use of equal weights:

Skill Matching	Factor 1
Skills utilisation Score	0.92
Skills mismatch Score	0.92

8.4.4. How PCA is used

The PCA analysis served two purposes:

1. Using factor loadings to inform the decision on weights in the first instance;
2. To assess to what extent the conceptual framework is confirmed by statistical approaches.

In the construction of the ESI, weights are used as scaling coefficients to obtain higher correlations between each indicator/ sub-pillar/ pillar and its upper level, i.e. sub-pillar/ pillar/ index, so that scores are balanced among in their underlying dimension. For this purpose, PCA factor loadings were used in a first step to inform on which indicator/ sub-pillar/ pillar required a higher relative weight because their information was not yet captured by other components within the dimension. However, the final decision on the weights was not based solely on the PCA factor loadings (see Section 5.2).

Using PCA, the theoretical framework receives statistical confirmation of the way the three pillars have been calculated.

9. Sensitivity analysis

The robustness of rankings and the manner in which a composite index is interpreted are greatly influenced by the many methodological choices that are made during its development, for example, the selection of pillars and indicators, the selection of weights and the method of aggregation. These choices require assumptions to be made that introduce uncertainty into the final results. As in any modelling exercise, it is good practice to assess the uncertainties associated with the modelling process and the methodological choices made.

The robustness of the composite index calculation is checked using different scenarios in which one step in the calculation is varied with respect to the original version. Our analysis focussed on varying the:

1. bounds used in normalisation;
2. aggregation method;
3. weights.

Each of these scenarios are explained in the sections below and the results are discussed in Section 9.4.

9.1. Bounds used in normalisation

There is a lot of flexibility on how to choose the “frontier”, i.e. the best and worst cases, and different ways of defining the frontier can be applied to different indicators.

As described in Section 4.4 above, the method used for the ESI is to use statistical-defined bounds, i.e. close to the maximum and minimum values over 7 years.

In this scenario, the impact of using as bounds the actual (rather than close to) minimum and the maximum value over a 7 years period, instead of percentiles close to them, is tested.

9.2. Aggregation method

The Index is calculated using weighted arithmetic mean to calculate the score of the sub-pillar and then using weighted arithmetic mean of sub-pillar scores to obtain the score for each pillar. The pillar scores are then aggregated using weighted geometric mean to obtain the overall ESI score.

In this scenario, the impact on the composite index results of varying the method of aggregation only from pillar to index is tested; weighted arithmetic mean (rather than weighted geometric mean in the baseline) is used. In other words, the only change made is to allow full compensability between pillars.

9.3. Equal weights

Equal weights are applied when there is no clear reference in the literature about the importance of elements the composite indicator. Under the equal weighting scheme all indicators should be equally important in classifying countries with respect to the sub-dimension; sub-dimensions should be equally important in classifying countries with respect to the dimension etc.

In this scenario, the impact on the composite index of using equal weights at sub-pillar, pillar and index level is tested.

9.4. Findings

In this sensitivity analysis, different scenarios are considered to test the robustness of countries' ranking by varying different steps in the calculation of the composite index. In this section, the original composite index presented in Part 1 is referred to as the "baseline" index. Five other variations of this index were calculated with the changes to the calculation as explained in sections 9.1 - 9.4 above and summarised in the table below:

Table 9.1 Description of scenarios

Scenario	Short description
Baseline	Composite index calculated as presented in Part 1.
Scenario 1 (Section 9.1)	Baseline with normalisation bounds changed to the actual (rather than close to) minimum and maximum over 7 years.
Scenario 2 (Section 9.1 combined with 9.2)	Scenario 1 with weighted arithmetic mean at the index level.
Scenario 3 (Section 9.2)	Baseline plus weighted arithmetic mean at the index level.
Scenario 4 (Section 9.3)	Baseline with simple means (equal weights) at all levels of aggregation.
Scenario 5 (Section 9.3 combined with 9.2)	Scenario 4 with weighted arithmetic mean at the index level.

Source: European Skills Index (2018), Cedefop.

Table 9.2 shows the results of the sensitivity analysis. The "ranks" columns show the ranking of the index and the pillars in the baseline scenario, while the "range" columns display the best and worst rankings obtained by the country among the scenarios considered in the sensitivity analysis. This table shows to what degree a country's rank depends on the modelling choices.

In the baseline index, Czech Republic is the top performer, followed by a group of countries with a similar overall score until the 6^{th}-7^{th} position. The last position in the baseline is occupied by Spain, preceded closely by Greece. Scenario 1 produces higher scores than the baseline for almost all the countries, while the Scenario 5 produces the largest changes of rank positions compared to the baseline.

Table 9.2: Distribution of ranks and scores, sensitivity analysis (*)

	Composite index			Pillar 1			Pillar 2			Pillar 3		
Country	Rank	Range	Score	Rank	Range	Score	Rank	Range	Score	Rank	Range	Score
Czech Republic	1	[1,3]	0.75	8	[8,9]	0.64	9	[9,14]	0.69	1	[1,1]	0.91
Finland	2	[2,2]	0.72	1	[1,1]	0.89	11	[10,13]	0.66	6	[6,10]	0.66
Sweden	3	[1,4]	0.72	2	[2,2]	0.76	1	[1,1]	0.87	13	[7,14]	0.59
Luxembourg	4	[3,5]	0.71	6	[6,7]	0.68	13	[13,16]	0.66	3	[3,3]	0.78
Slovenia	5	[5,6]	0.69	3	[3,5]	0.72	6	[6,9]	0.73	9	[8,9]	0.64

Estonia	6	[6,8]	0.68	4	[3,4]	0.72	7	[7,10]	0.71	11	[11,16]	0.62
Denmark	7	[4,7]	0.67	5	[3,5]	0.72	4	[4,4]	0.78	17	[13,17]	0.56
Poland	8	[8,12]	0.62	17	[16,17]	0.52	15	[15,16]	0.63	5	[5,5]	0.71
Germany	9	[9,11]	0.62	9	[8,9]	0.63	10	[6,10]	0.69	15	[14,17]	0.57
Austria	10	[7,10]	0.62	7	[6,7]	0.67	3	[3,3]	0.83	19	[18,19]	0.47
Lithuania	11	[10,15]	0.61	13	[12,13]	0.54	5	[5,6]	0.76	18	[17,18]	0.55
Croatia	12	[12,18]	0.60	14	[14,15]	0.54	18	[18,21]	0.58	7	[7,10]	0.66
Slovakia	13	[11,15]	0.59	12	[12,14]	0.54	19	[18,21]	0.57	8	[6,15]	0.65
Latvia	14	[13,16]	0.59	11	[11,11]	0.58	14	[11,14]	0.65	16	[15,19]	0.56
Netherlands	15	[10,17]	0.58	10	[10,10]	0.61	2	[2,2]	0.83	21	[21,24]	0.42
Malta	16	[9,19]	0.56	28	[27,28]	0.29	16	[11,16]	0.62	2	[2,2]	0.86
Hungary	17	[16,17]	0.55	22	[22,22]	0.42	23	[22,23]	0.48	4	[4,4]	0.75
Belgium	18	[18,19]	0.53	16	[16,17]	0.52	22	[22,23]	0.49	14	[12,14]	0.58
United Kingdom	19	[15,19]	0.52	15	[12,15]	0.54	8	[5,8]	0.71	24	[23,24]	0.39
France	20	[20,20]	0.48	18	[18,19]	0.49	17	[17,17]	0.58	22	[21,22]	0.41
Portugal	21	[21,21]	0.45	24	[23,24]	0.41	20	[19,20]	0.56	23	[21,23]	0.40
Ireland	22	[22,24]	0.36	19	[18,19]	0.47	21	[18,21]	0.54	25	[25,25]	0.22
Bulgaria	23	[22,24]	0.33	25	[25,25]	0.38	27	[27,27]	0.11	10	[7,10]	0.64
Cyprus	24	[23,26]	0.32	26	[26,26]	0.32	12	[12,15]	0.66	26	[26,26]	0.18
Romania	25	[23,25]	0.31	27	[27,28]	0.29	26	[26,26]	0.14	12	[11,12]	0.62
Italy	26	[25,28]	0.25	20	[20,20]	0.47	28	[28,28]	0.06	20	[20,20]	0.43
Greece	27	[27,28]	0.23	23	[23,24]	0.41	24	[24,25]	0.43	28	[28,28]	0.09
Spain	28	[26,28]	0.23	21	[21,21]	0.43	25	[24,25]	0.33	27	[27,27]	0.11

(*) Sorted from highest Index score to lowest.
Source: European Skills Index (2018), Cedefop.

Scenario 1 (using the actual minimum and maximum values across seven years for the bounds) produces a change in the top three compared to the baseline, with Luxembourg becoming 3rd at the expense of Sweden. Lithuania loses the most in terms of ranking (three positions), followed by Netherlands and Cyprus, while Greece exchanges place with Spain as bottom rank country, and Italy gains one position with Cyprus taking its place.

Scenario 2 (Scenario 1 with weighted arithmetic mean at the index level) looks like Scenario 1 ranking results at the top and the bottom of the ranking, but sees slightly more variability in the middle of the ranking, with Malta jumping seven positions from 16th to 9th and Lithuania losing four positions from 11th to 15th.

Scenario 3 (baseline with aggregation at the index level using the weighted arithmetic mean) does not show any changes at the top or at the bottom of the ranking, with the only sizeable movement being Malta gaining five positions.

Scenario 4 (baseline with equal weights at all levels of aggregation) sees Sweden exchanging place with Czech Republic at the top, with the latter becoming 3rd, while Finland remains 2nd. Similarly, Italy loses two positions reaching the bottom while Spain takes its pace at rank 26. Croatia loses four positions (12 to 16), UK gains four positions (19 to 15).

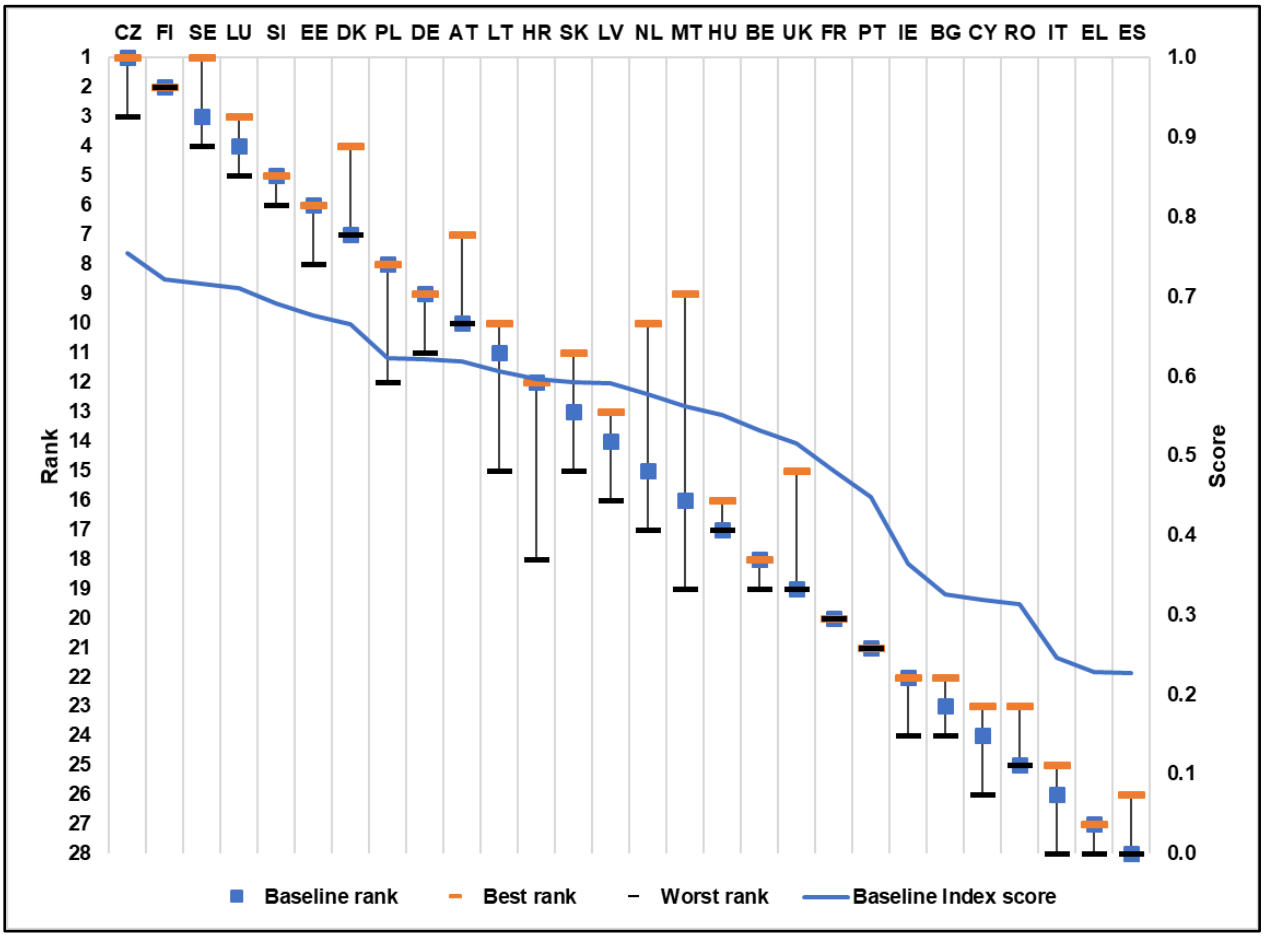
Scenario 5 (equal weights at all levels of aggregation and arithmetic mean at the index level) has again Sweden as first and Czech Republic as third the ranking. At the bottom of the ranking, Greece and Spain exchange positions. Netherlands gains five positions (from 15th to 10th) while Croatia loses six positions (from 12th to 18th).

Table 9.3 Changes in ranking relative to baseline (negative is an improvement in ranking)

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Belgium	0	0	0	0	1
Bulgaria	-1	-1	-1	1	0
Czech Republic	0	0	0	2	2
Denmark	0	-1	0	-3	-3
Germany	0	2	1	0	0
Estonia	0	1	0	1	2
Ireland	2	1	1	0	0
Greece	1	1	0	0	1
Spain	-1	-1	0	-2	-1
France	0	0	0	0	0
Croatia	0	1	2	4	6
Italy	-1	-1	0	2	0
Cyprus	2	2	1	-1	0
Lithuania	3	4	1	-1	0
Latvia	-1	0	2	-1	0
Luxembourg	-1	0	0	1	1
Hungary	-1	0	0	0	0
Malta	-1	-7	-5	3	-3
Netherlands	2	1	-2	-3	-5
Austria	0	-2	-2	-2	-3
Poland	0	2	1	3	4
Portugal	0	0	0	0	0
Romania	-2	-1	-1	0	0
Slovenia	0	0	0	1	1
Slovakia	-2	-1	2	1	2
Finland	0	0	0	0	0
Sweden	1	0	0	-2	-2
United Kingdom	0	0	0	-4	-3

Figure 9.1 shows the ranking's variation of the composite index across different scenarios. The country experiencing the highest variation is Malta, ranging from the 9th to the 19th position, followed by Netherlands, Croatia and Lithuania changing respectively 7, 6 and 5 positions. The average rank change is of 2.8 positions.

Figure 9.1: Index range (*)



(*) Sorted from highest Index score to lowest.
Source: European Skills Index (2018), Cedefop.

From this sensitivity analysis of ranks, it can be acknowledged that in some cases there are large variations in Member State (maximum being 7 positions) performance particularly in the middle of the distribution. This is due to Member States having particularly strong or weak performance in an individual indicator or pillar. This emphasises the need to look into the detail of the index to see which indicators are driving a Member State's performance. The rankings are most sensitive for those mid-ranking Member States that are clustered around a very similar baseline score so that *small changes in the score can have an exaggerated impact on the rankings*.

Notwithstanding some sizable variations, it is possible to distinguish five groups of countries: top performers varying within the top 7 positions (with scores above 0.67); a small group of three upper-middle countries follows; a big group of middle performers varying approximately between the 11th and the 21st positions (with scores 0.45-0.61); a group of lower-middle performers varying between the 22nd and the 25th position (with scores 0.31-0.36); and finally a small group of lower performing countries (with scores 0.23-0.25).

In conclusion, the sensitivity analysis shows that the ESI ranks are reliable for the vast majority of EU Member States.

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