A QUANTITATIVE APPROACH TO WORLD UNIVERSITY RANKINGS

METHODOLOGY

Research Output: For this indicator, a list of journals (available from http://cfwur.org/journals) are mapped into 23 broad fields BF_i: agricultural sciences, arts & humanities, biology & biochemistry, chemistry, clinical medicine, computer science, economics & business, engineering, environment/ecology, geosciences, immunology, materials science, mathematics, microbiology, molecular biology & genetics, multidisciplinary, neuroscience & behavior, pharmacology & toxicology, physics, plant & animal science, psychiatry/psychology, general social sciences, and space sciences. For each broad field BF_i, the journals are used to sort universities according to their total number of articles between years $Y-2$ and $Y-11$, where Y is the current year. Universities are then sorted according to the combined number of their articles in the 23 broad fields.

High-Quality Publications: For this indicator, journals are ranked as follows. After excluding self-citations, the PageRank algorithm is used to assign weighted citations to the journals over a 5-year period. A score can be assigned to each journal as the ratio of its weighted citations to its 5-year article count. For a given broad field BF_i, journals are sorted according to their scores, from largest to smallest, and a sorted list L_i of journals can then be obtained. If N_i is the total number of articles between years $Y-2$ and $Y-11$ in BF_i, the ones chosen for this indicator, n_i, are those that make up $0.25N_i$ and found at the top of L_i (Up to and including the cutoff journal, where the overall number of articles a_i is closest to $0.25N_i$, a multiplicative factor λ_i is introduced such that $\lambda_i\, a_i$ equals $0.25N_i$). Universities are then sorted according to the combined number of their articles in the 23 n_i.

Influence: Here, an Influential Journal is defined as one that belongs to the list of journals where $0.25N_i$ in the above indicator is replaced by $0.05N_i$. Using this criterion, universities are sorted according to the number of articles between years $Y-2$ and $Y-11$ in these influential journals.

Citations: If Y is the current year, then for each of the 23 broad fields, the most cited articles are counted between years $Y - 2$ and $Y - 11$. The cutoff for the number of highly-cited papers in a given broad field is 1% of the total number of articles in that field (for tie-breaking purposes at the cutoff, articles are sorted by newest first). By considering all 23 broad fields, universities are sorted according to the total number of the highly-cited publications.

Faculty: This indicator measures the weighted number of faculty members of an institution who have received the following top academic distinctions covering the 23 broad fields listed earlier: Wolf Prize in Agriculture, Praemium Imperiale, Kluge Prize, Louisa Gross Horwitz Prize, Nobel Prize in Chemistry, Nobel Prize in Physiology or Medicine, Turing Award, Nobel Memorial Prize in Economic Sciences, Herbert Simon Award, Charles Stark Draper Prize, Queen Elizabeth Prize for Engineering, Tyler Prize for Environmental Achievement, Crafoord Prize in Biosciences, Crafoord Prize in Geosciences, Vetlesen Prize, Novartis Prizes for Immunology, German Immunology Award, Kyoto Prize in Materials Science and Engineering, Von Hippel Award, Abel Prize, Fields Medal, Microbiology Society Prize Medal, Mendel Medal of the Leopoldina, Gruber Prize in Genetics, Albert Einstein World Award of Science, Kavli Prize in Neuroscience, NAS Award in the Neurosciences, Robert R. Ruffolo Career Achievement Award, Leading Edge in Basic Science Award, Nobel Prize in Physics, Linnean Medal, Jean Delay Prize, Grawemeyer Award in Psychology, Holberg International Memorial Prize, Crafoord Prize in Astronomy, and Kavli Prize in Astrophysics (this list could be modified in the future if necessary). Faculty members are defined here as those who were employed at the institution in question at the time of being awarded the academic distinction. Faculty members are assigned r_F points according to the following formula $r_F = C\ 0.99^{((Y - 2) - x)}$, where Y is the current year and x is the year when the academic distinction was awarded to the faculty member. The constant C is set to 1 except in rare cases where a faculty member holds more than one full-time position (in which case, C is equal to the reciprocal of the number of institutions) or additional adjunct/part-time position(s) (in which case, $C = 1/(1 + (N - 1)/3)$ for the main affiliation and $(1/3)/(1 + (N - 1)/3)$ for the adjunct/part-time affiliation(s), where $N > 1$ is the number of affiliations of the faculty member). For each award/medal/prize(s) associated with a given broad field, let R_F be the sum of all r_F and P be the ratio of article publications between years $Y - 2$ and $Y - 11$ in this given broad field to the total 23 broad fields

combined. For each faculty member, $(100/R_F) \cdot P \cdot r_F$ points are assigned to his/her university. Adding up these points for each institution for all 23 broad fields, and calling the sum p_F, universities can be sorted based on the total points p_F.

Employability: This indicator measures the weighted average number (per year) of a university's alumni who have held top positions since 2011 at the world's largest 2000 public companies relative to the university's size. The companies are sorted according to the sum of their assets, market value, profits, and sales ranks. An alumnus/alumna is defined as a student who graduated with a Bachelor, Master, or Doctorate degree (or their equivalents). If more than one degree was obtained from a given institution, the institution is considered only once (and in the rare case of co-CEOs, each CEO's educational institution(s) when counted will be assigned a weight of 0.5). The multiplicative factor used in this indicator is similar to the quantity $(1/C) \cdot r_F$ above, with x being the year when the companies' list is compiled (starting from 2011). If an institution has a yearly weighted average of q alumni in top positions, it will be assigned points according to the formula $p_E = (q^2)/n$, where n is the current number of students enrolled at the institution, which can be obtained from national agencies. The above formula increasingly rewards institutions that have produced, relative to their size, a high number of alumni in top positions. The ratio p_E measures employability based on the professional success of a university's alumni.

Education: This indicator measures the weighted number of a university's alumni who have received top academic distinctions relative to the university's size. Here, alumni are defined as students who obtained Bachelor, Master, or Doctoral degrees (or their equivalents) and received the academic distinctions listed under the "Faculty" section. For each alumnus/alumna, r_A points are assigned to him/her according to the following formula $r_A = 0.99^{((Y - 2) - x)}$, where Y is the current year and x is the year when the academic distinction was awarded to the alumnus/alumna. If he/she obtains more than one degree from an institution, the institution will be considered only once. For each award/medal/prize(s) associated with a given broad field, let R_A be the sum of all r_A and P as defined above. Let s_A be the sum of $(100/R_A) \cdot P \cdot r_A$ points of an institution for all the 23 broad fields. As in the previous indicator, each university is assigned points according to $p_A =$

(s_A^2)/n. This ratio measures the quality of education of a university based on the academic success of its alumni.

Aggregation and Scoring: Each indicator is assigned a weighting factor equals to 0.1 (10%) except for the education and employability indicators which have a weighting factor of 0.25 (25%) each. An institution's pre-final score S_{pf} is given by the expression

$$S_{pf} = \prod_{k=1} (1 + (100 t_k / t_{Top}))^{w_k} - 1$$

where t_k is the university's score on indicator k, t_{Top} is the score of the top performing institution on that indicator, and w_k is the weighting factor for the corresponding indicator. Universities are then ranked based on their pre-final scores and assigned final scores based on a scaled 0-100 Gaussian bell curve.