Informational Analysis of International University Rankings

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A thesis submitted for the degree of
Master in Innovation and Research in Informatics

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Barcelona, Spain

2017
Defended October 27th, 2017

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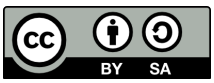

"The one exclusive sign of thorough knowledge is the power of teaching."

– Aristotle

ACKNOWLEDGEMENTS

I would like to thank Professor Joan Antoni Pastor Collado for his expert advice in supervising my final master thesis.

I would like to thank my family, especially to my parents, for all the advises and sweet support that they give to me.

ABSTRACT

This work on the informational analysis of international rankings is motivated by the fact that international university rankings are increasing their impact and importance. Given their diversity of origins, purposes and procedures, it makes sense to try to increase their knowledge and understanding by clearly defining and comparing them from an informational stance.

This research-orientated master thesis (master final project or TFM) addresses this purpose, by aiming at a clear and comparative definition of both the information managed by those rankings, as well as their respective processes for capturing, processing and publishing their results. These comparative definitions are carried using the *Method for informational analysis of university rankings* derived and designed from the experience of pursing the analysis work within this master thesis. At the same time, this method allows to assess transparency on rankings and helps to clarify the focus of the information used for rank universities.

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NOMENCLATURE

ARWU. The Academic Ranking of World Universities, also known as Shanghai Ranking.

BBVA. Banco Bilbao Vizcaya Argentaria.

BEST Global Universities. U.S. News Best Global Universities Rankings.

CWCU. Center for World-Class Universities.

CWTS. Centre for Science and Technology Studies.

EUA. European University Association.

HEEACT. Higher Education Evaluation and Accreditation Council of Taiwan.

HEI. Higher Education Institution.

HESA. Higher Education Statistics Agency.

I-UGR. University of Granada Rankings.

IHEP. Institute for Higher Education Policy.

IPEDS. Integrated Postsecondary Education Data System.

IREG. International Ranking Expert Group.

Ivie. Instituto Valenciano de Iinvestigaciones Económicas.

JCR. Journal Citation Reports.

MIAUR. Method for Informational Analysis of University Rankings.

NTU Ranking. National Taiwan University Ranking.

PATSTAT. Worldwide Patent Statistical Database.

QS. Quacquarelli Symonds.

SCI. Science Citation Index.

SSCI. Social Science Citation Index.

THE. Times Higher Education.

UNESCO. United Nations Educational, Scientific and Cultural Organisation.

UNESCO-CEPES. UNESCO European Centre for Higher Education.

University Ranking. A position or classification in a scale of achievement or status of the university performance..

URAP. First University Ranking by Academic Performance.

WoS. Web of Science.

Chapter 1

INTRODUCTION

International university rankings are increasing their social impact and importance, while they arise both critical opinions and media popularity. Given their diversity of origins, purposes and procedures, it makes sense to try to increase their knowledge and understanding by clearly defining and comparing them from an informational stance.

This research orientated master thesis (master final project or TFM) aims to expand the knowledge and understanding university rankings by proposing a method for doing informational analysis of international university rankings, that can be eventually adapted and applied to any kind of ranking. This method is designed to make easier ranking informational analysis by providing a set clear steps and assessment tools in order to extract and capture all the information, as well as to illustrate the orientation and transparency of rankings. An important aspect of the method is that this method is conceived to be adaptable in order to be used in any kind of ranking.

The research approach used to deploy this master thesis is defined in chapter 2. It presents the different research methodologies used and how these are applied to the research plan. The planning section details the timings, and the research plan changes explain the final research plan and why the first design has been modified. Following the research plan, first, a study of the state of the art presented in chapter 3, where the university rankings are introduced and their relevance pointed out. Moreover, some interesting aspects around university rankings are presented, such as the IREG Observatory, Berlin Principles, UNESCO and EUA reports, and social aspects voices about rankings. The *Method for Informational Analysis of University Rankings* in its final version is explained in chapter 4 and it is used in the following chapters do the informational analysis of U-Multirank, QS Ranking, Times Higher Education, U.S. News Best Global University Ranking, Academic Ranking of World Universities, National Taiwan University Ranking, and CWTS Leiden ranking. Results of the information analysis of university rankings are presented in chapter 12 as an informational global view that shows a global perspective of university rankings information. The conclusions and considerations of the informational analysis can be found in chapter 13. Additionally, following the conclusions, some proposals for improvements on social responsibility and transparency yo university rankings are presented in chapter 14. Finally, using all the knowledge obtained with this thesis, new research lines are presented in chapter 15. These new research lines define some tentative presentations of tools and services, and some strategic uses of the knowledge reached.

Moreover, at the appendices the reader can find some algorithms used for ranking and a the sustainability report of this master thesis. The sustainability report covers and assesses the thesis from its conception until its product life, using environmental, economic and social factors.

It is crucial to point out and notice that the analysis of university rankings and the global view use UML diagrams to show the information found at university rankings systems, but these **UML diagrams are only used rather for visual than for detail definition purposes** because UML provides a powerful way of visualising concepts. The UML diagrams used do not aim to be any kind of formal UML diagrams (e.g. class diagrams). For that reason, the UML diagrams used do not follow usual UML's rules, they are only used to show concepts, data and information, and make it easy the visualisation for readers. Relations expressed do not follow any rule too, these are only used to express that one concept may have an interesting relationship with another concept.

Furthermore, the UML diagrams shown in this thesis use 5 different colours to distinguish different groups of indicators that are coloured and distributed in different places. The first group is represented by the white colour and it is placed in the middle. The white group represents basic, central concepts or definitions (e.g. an institution). The second group is represented by the blue colour and it is placed over the white group. The blue group represents concepts related to strategic factors, institutional relationships and international and regional projection. The third group is represented by the orange colour and it is placed below the white group. The orange groups represent concepts that can act as support or resource for HEIs (High Educational Institutes) activities, such as professors or facilities. The fourth group is represented by the purple colour and it is placed on the left side of the white group. The purple group represents the inputs that HEIs need to do their taks (e.g. students). The last group, the green group is placed on the right side of the white group. The green group represents the outputs or results of HEIs tasks (e.g. graduates, publications, grants).

This coloured representation of ranking concepts allows the reader to get a rapid sight about the main focus of each university ranking.

It is important to underline that we use the terms *university* and *Higher Education Instituiion* (HEI) as synonyms. However, university rankings sometimes understand these terms as similar but different concepts. In some cases, HEI is used to refer to a global concept that includes universities, hospital schools, autonomous business schools, or vocational higher-level studies, while the term *university* is used exclusively to refer to universities in the general sense. In this document, in order to avoid confusions, we use *university* as the principal term in the first chapters, up until the individual study of each university ranking. At the individual analysis of each ranking, we respect the term, either *university* or *HEI* preferred by the specific university ranking under consideration. And finally, in our last chapters (Conclusions, Informational Global View, and subsequent chapters) we have chosen to use as our preferred term that of *Higher Education Institution* (HEI), since we believe that the contents and results presented in those chapters are of use a applicability not just to regular *universities* but to the more general case of HEIs.

Chapter 2

RESEARCH METHODOLOGY

Chapter 2 defines the approach and methodologies used to carry out this Master Thesis. First, the methodologies used are introduced, and then the different stages handled to conduct the study are, established, detailed and justified.

2.1 Research Approach and Methodologies

The research approach of this thesis is the combination of the following basic research methodologies: (1) Start-of-the-Art, (2) Survey, and (3) Comparative Analysis. The research methods of (1) are used to gather the needed information for conducting this study. The processes of (2) are used to establish the method that is used to do the informational and comparative analysis of rankings based on (3).

2.2 Research Plan

This research master thesis project has three different stages defined at the research plan. The first stage is a state-of-the-art research about the current university rankings. In the second stage, using the U-Multirank [1], the process and method to analyse and evaluate rankings are established. The third stage applies the process and method defined in the second stage to the other different international rankings.

2.2.1 First Stage

The first stage studies the context of university rankings, where a first sight of the most important and known rankings is done, in order to understand them and find the most significant differences between them. Also, in the context scope, other aspects of university rankings are exposed to help to understand the rankings' environment and their critics. – The first stage is explained in the chapter 3 of this document.

2.2.2 Second Stage

The second stage takes as a reference the U-Multirank to establish a method to analyse and evaluate rankings (the justification for using U-Multirank as a reference can be found below at *Justification of U-Multirank as a reference case*). U-Multirank is used as the reference case to help defining and testing the model, producing, as a result, the *Method for informational analysis of university rankings* (see chapter 4).

Justification of U-Multirank as the reference case

The main arguments to choose U-Multirank as the reference case to define and test the method to do the informational analysis are:

1. U-Multirank is one of the newest rankings and has innovative approaches such as being presented as a tool to compare universities and play with different indicators. These aspects are interesting for making the method more general and flexible.

2. U-Multirank is a general ranking that covers many different aspects of universities, that is used to include and consider the different possible situations into the method.

3. U-Multirank has a high level of transparency and information available, that helps to test each aspect of the method.

4. U-Multirank is a project supported by the European Commission, a public institution. For that reason, it is not considered as a project from a private corporation or institution that could be perceptible of third-party influences, and the usage of that ranking as the reference can help to avoid that our method is perceptible of external influences.

5. U-Multirank follows Berlin Principles.

2.2.3 Third Stage

The thirds stage applies the Method for informational analysis of university rankings to other international university rankings. The goal of this stage is to assess and compare different rankings, and show how other university rankings work.

2.3 Planning

The submitted master thesis for the *Master in Innovation and Research in Informatics* of the Barcelona School of Informatics at the Technical University of Catalonia - BarcelonaTech has an approximate workload of 900 hours (30 ECTS credits[1] according to the European Higher Education Area[2]), it concludes with the oral defence, and the thesis is done from the first of February 2017 to the last of October 2017. The 900 hours of workload includes all research, supervisor meetings, project development, writing stage, defence preparation, and oral defence – as it is explained below.

According to the workload explained above, a full time job dedication is estimated to accomplish the thesis:

$$\textit{Hours per week: } 5day/week \times 5hour/day = 25hour/week$$

$$\textit{Hours per month: } 25hour/week \times 4weeks = 100hour/month$$

$$\textit{Total workload: } 100hour/month \times 9months = 900hours$$

[1] ECTS Users' Guide. (n.d.). Retrieved from https://ec.europa.eu/education/sites/education/files/ects-users-guide_en.pdf

[2] Home - European Higher Education Area and Bologna Process. (n.d.). Retrieved April 17, 2017, from http://www.ehea.info/

2.4 Research Plan Changes

Finally, the research plan that was initially presented at the research methodology section has been slightly updated in order to adapt the *Method for Informational Analysis of University Rankings* to all different circumstances found while doing the different university ranking analysis. These circumstances force to make changes to the design of the method, to provide better accuracy. Along the process, the transparency assessment of the method changes the scale from 20 points to 30 points and from 3 levels to 4 levels to get better precision, and the different categories of ranking profiling were detailed more in deph to be more clear.

These changes were done after the second stage of the research plan (apply the *Method for Informational Analysis to University Rankings* to U-Multirank), when the method was refined by introducing some clarifications at the ranking profiling categories. And also the changes were produced in the middle of the third stage of the research plan (apply the *Method for Informational Analysis to University Rankings* to other university rankings) after the third university ranking, when the method was refined by introducing more clarifications at the profiling categories and by changing the transparency scales.

In each change of the method, all previous informational analysis were done again, as it can be shown in the following process.

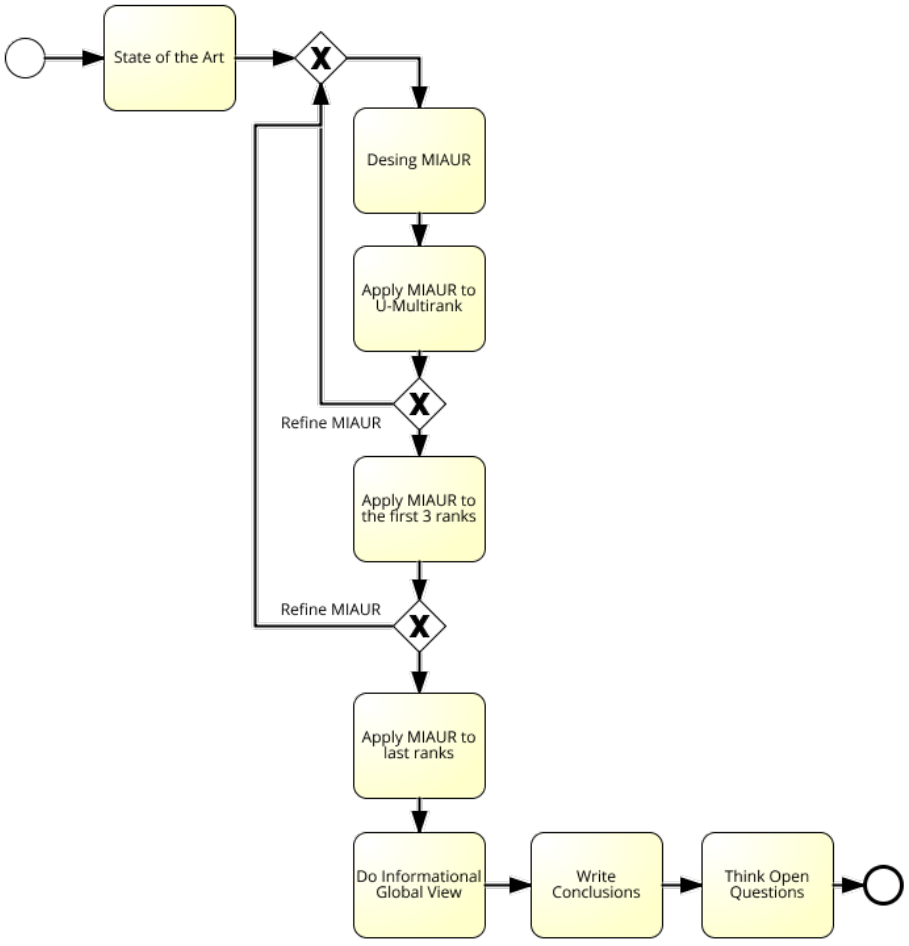


Figure 2.1: Final research process followed

Chapter 3

STATE OF THE ART

Chapter 3 shows the importance of studying and understanding university rankings for making them more useful to educational and social improvement. The first section introduces rankings and briefly explains the most relevant international and national rankings. The second section classifies the previous rankings into different categories based on ranking characteristics. The third section talks about how universities invest resources to monitor their presence in rankings. The fourth section describes how and why UNESCO pays special attention to university rankings. The fifth section presents a work about social development at university and its relationships to university rankings.

3.1 University Rankings

University rankings are arising both in popularity and influence in a world-class university systems. It spawned the development and publication of more and more ranking tables from numerous countries and organisations around the world [2]. Rankings are keeping the attention from governments, universities, companies, and students, influencing them in their actions and policies. The most important ranks are briefly introduced below.

3.1.1 Shanghai Ranking

The Academic Ranking of World Universities (ARWU) [3] was first published in 2003 by the Center for World-Class Universities (CWCU), Graduate School of Education of Shanghai Jiao Tong University (China). Since 2009 the ARWU has been published and copyrighted by ShanghaiRanking Consultancy, that is a fully independent organisation and not legally subordinated to any universities or government agencies.

Figure 3.1: ARWU Logo

ARWU is a research-focused ranking, that ranks universities by their research performance. ARWU uses 6 different performance indicators:

- The number of alumni and staff winning Nobel Prizes and Fields Medals.
- Number of highly cited researchers selected by Thomson Reuters.
- Number of articles published in journals of Nature and Science.
- Number of articles indexed in Science Citation Index - Expanded.
- Number of articles indexed in Social Sciences Citation Index.
- Per capita performance of a university.

3.1.2 Times Higher Education (World University Rankings)

Times Higher Education (THE) World University Rankings [4] was founded in 2004 to provide a list of the world's best universities. THE use indicators to evaluate universities across teaching, research, international outlook and reputation and more. THE presents their ranks as a "vital resource for students, helping them choose where to study".

Figure 3.2: THE Logo

THE uses 13 different performance indicators [5] that are grouped into five areas:

- Teaching (the learning environment)
- Research (volume, income and reputation)
- Citations (research influence)
- International outlook (staff, students and research)
- Industry income (knowledge transfer)

The last THE World University Rankings 2016-2017 has been independently audited [6] by PricewaterhouseCoopers (PWC) firm [7].

3.1.3 QS World University Rankings

QS World University Rankings [8][9] were first developed in 2004 by Quacquarelli Symonds [10], a medium-sized company. QS presents their QS World University Rankings as "rankings designed to help prospective students make informed comparisons of leading universities around the world".

Figure 3.3: QS Logo

QS World University Rankings ranks universities based on 6 performance indicators [11], that can be grouped into four areas: research, teaching, employability and internationalisation:

- Academic reputation.
- Employer reputation.
- Student-to-faculty ratio.
- Citations per faculty.
- International faculty ratio.
- International student ratio.

3.1.4 U-Multirank

The first U-Multirank [1] ranking was the 2014 edition by the European Commission. U-Multirank is an independent ranking, founded from the European Commission's Erasmus+ programme. This ranking has a clearly defined and transparent methodology [12] and it is based on Berlin Principles [13].

Figure 3.4: U-Multirank Logo

U-Multirank compares institutions with similar institutional profiles ('like-with-like') and allows users to develop their own personalised rankings by selecting indicators in terms of their own preferences. It compares the performances of universities in the five broad dimensions of activity:

- Teaching and learning.
- Research.
- Knowledge transfer.
- International orientation.
- Regional engagement.

3.1.5 Best Global Universities

The first U.S. News Best Global Universities ranking (BEST Global Universities) [14] was the 2013 edition, although U.S. News [15] has been ranking separately for more than 30 years the U.S.A Universities.

Figure 3.5: Best Global Universities logo

Best Global Universities rankings are focused specifically on schools' academic research and reputation overall and not on their separate undergraduate or graduate programs. Rankings are produced by the private company U.S. News & World Report LP. and powered by the data from Clarivate Analytics InCites [16][17].

3.1.6 National Taiwan University Ranking

National Taiwan University Ranking (NTU Ranking) [18] was first published in 2007 by Higher Education Evaluation and Accreditation Council of Taiwan (HEEACT) [19].[1] Taiwan Ranking system is designed to evaluate universities' achievements in scientific research, based on the scientific paper publications.

Indicators can be grouped into three main groups [20]:

- Research productivity.
- Research impact.
- Research excellence.

[1]The name of the ranking system was changed from "HEEACT" to "Taiwan Ranking". Since 2012, the Performance Ranking of Scientific Papers for World Universities has been individually and officially executed and released by National Taiwan University.

3.1.7 CWTS Leiden Ranking

The CWTS Leiden Ranking [21] was first published in 2011 by CWTS Group[2] [22]. CWTS Leiden Ranking is based exclusively on bibliographic data from the Web of Science database [23] produced by Thomson Reuters [24].

Leiden Ranking offers two new perspectives for rankings, the Chart View and the Map View. The Chart View presents universities in a scatter plot, and the Map View presents universities in an interactive geographical map. Both views are based on global publication impact and the collaborations with others universities.

3.1.8 University Ranking by Academic Performance (URAP)

First University Ranking by Academic Performance (URAP) [25] was published in 2010. URAP is a non-profit organisation, based in the URAP Research Laboratory at the Informatics Institute of Middle East Technical University (METU).

According to the URAP methodology: the main objective of URAP is to develop a ranking system based on academic performances to help universities identify potential areas of progress with respect to specific academic performance indicators. The main performance indicators are:

- Number of Articles.
- Citation.
- Total Document.
- Journal Impact Total.
- Journal Citation Impact Total.
- International Collaboration.

3.1.9 Rankings I-UGR

Rankings I-UGR [26] was first published in 2010 by research team members of EC3-EC3metrics spin-off [27] and SCI2S [28] from the University of Granada. I-UGR is a national ranking of Spanish Universities and it is based on research production on international journals with high impact and visibility.

Figure 3.6: I-UGR Logo

3.1.10 U-Ranking

U-Ranking [29] was first published in 2013 by a joint initiative of the BBVA Foundation [30] and the Ivie [31]. U-Ranking evaluates and ranks the Spanish University System with transparency and rigour as principles.

U-Ranking ranks universities using indicators that are grouped in three main groups: teaching, research, and innovation and technological development.

Figure 3.7: U-Ranking Logo

[2]CWTS B.V. (Centre for Science and Technology Studies) is an independent contract research organisation that provides high-quality research performance and evaluation studies. Leiden University's Centre for Science and Technology Studies forms the core of the company.

3.2 University Ranking Classification

Due to the high variability and quantity of different university rankings, their classification is important to help the users to take the right reference for their objectives. Rankings often can be classified by their geographical scope or with the performance indicators that are used. However, there are other kinds of classification based on subjects, studies fields, emerging economies and university age, among others.

3.2.1 Classification by Geographical Scope

By geographical, the scope distinguishes two kinds of university rankings: national rankings and international rankings. National rankings are those that only evaluate the universities of a specific region, for example, Catalonia or Spain. International rankings are those that evaluate universities over the world.

The rankings at section 3.1 can be classified as:

Classification by Geographical Scope	
National	International
I-UGR U-Ranking	Shanghai Ranking THE QS World University Ranking U-Multirank Best Global Universities NTU Ranking Leiden Ranking URAP

Table 3.1: University ranking classification by geographical Scope

3.2.2 Classification by Performance Indicators

Classification by performance indicators means that rankings are classified taking into account which indicators are used to rank universities. The most common classifications are research focus rankings and general bias rankings. Research focus rankings only use and evaluate scientific impact of universities, using scientific citation, collaboration, production and relevance indicators of the scientific and research university environment. General bias rankings measure not only scientific performance, but also measures educational, employment, recognition indicators, among other indicators.

The rankings at section 3.1 can be classified as:

Classification by Performance indicators	
Research	General bias
Shanghai Ranking Best Global Universities NTU Ranking Leiden Ranking URAP I-UGR	THE QS World University Ranking U-Multirank U-Ranking

Table 3.2: University ranking classification by performance indicators

3.3 University Ranking Observatories

Considering the large diversity and influence of university rankings, many universities and organisations have started tracking and publishing their results, and also investing resources to understand and improve ranking positions. The groups in charge of these activities are known as Ranking Observatories, as found in different universities such as Technical University of Catalonia [32], Caltech [33], or Georgia Tech [34].

3.4 IREG Observatory

Not only universities have ranking observatories. Other ranking observatories exist handled by organisations such as the International Ranking Expert Group (IREG) [35]. IREG is an international and institutional non-profit association of ranking organisations, universities and other bodies interested in university rankings and academic excellence. IREG was founded in 2004 by the UNESCO European Centre for Higher Education (UNESCO-CEPES) [36] and the Institute for Higher Education Policy (IHEP) [37] with the aim of strengthening the public awareness and understanding a range of issues related to university rankings and academic excellence.

Members of the IREG Observatories come from the university environment, such as different universities along worldwide, ranking organisations, qualification agencies, and consultancy companies. Among IREG's members [38] appear some ranking organisations as QS Intelligence Unit, Shanghai Ranking Consultancy, US News & World Report, Centre for Higher Education, RAEX Group, and Perspektywy Education Foundation. Some of those ranking institutions are members of the IREG's executive committee [39] too.

IREG conducts two relevant activities: IREG Ranking Audit [40], and Berlin Principles.

3.4.1 IREG Ranking Audit

The objective of IREG Ranking Audit is to verify and corroborate that rankings are done professionally, with a transparent methodology, and good practices. To audit rankings, IREG uses its *IREG Ranking Audit Manual* [41]. IREG Observatory provides an IREG Approved certificate and a public audit executive summary to those rankings that pass successfully the IREG Ranking Audit.

Figure 3.8: IREG Approved certificate

The ranking organisations that passed the IREG Ranking Audit so far are some members of IREG Observatory: Perspektywy University Ranking, CHE University Ranking, Russian University Ranking, QS World University Rankings.

3.4.2 Berlin Principles

IREG together with the IHEP has convened to consider a set of principles of quality and good practice in university rankings - the Berlin Principles on Ranking of Higher Education Institutions [13].

Berlin Principles' aim is to provide good ranking practices to be useful for the improvement and evaluation of ranking. The set of principles are grouped into four groups:

- *Purposes and Goals of Rankings*: Be one and clear the purpose and approach of the ranking, recognise the diversity of organisations and missions, provide clarity about the range of information and generated sources, and specify the linguistic, cultural, economic, and historical contexts of the educational systems being ranked.
- *Design and Weighting of Indicators*: Provide a transparent methodology, choose indicators according to their relevance and validity, make the weights assigned to indicators prominent and limit changes to them, and measure outcomes in preference to inputs whenever possible.
- *Collection and Processing of Data*: Use audited and verifiable data, include data that are collected with proper procedures for scientific data collection, apply measures of quality assurance to ranking processes, and apply organisational measures that enhance the credibility of rankings.
- *Presentation of Ranking Results*: Provide a clear understanding of all of the factors used to develop a ranking, offer to costumers a choice in how rankings are displayed, be compiled in a way that eliminates or reduces errors in original data, and be organise d and published in a way that errors and faults can be corrected.

3.5 UNESCO Report

Nowadays, universities and governments are increasingly using rankings into an intense competition to assess and measure their performance and quality in university education and research. This university performance classification effects to public policy and the choices of students and their families. Due to that importance, UNESCO [36] has opened a debate about pros and cons of university rankings and their relevance.

In the article *Rankings and Accountability in Higher Education: Uses and Misuses*, UNESCO reports that the top 200 ranked schools tend to be older than 200 years, focusing mostly on scientific research, and large institutions (around 25,000 students and 2,500 faculties, and annual budgets higher than 2 billion of USD). In addition, the article suggests that rankings should evolve to give information that is more pertinent to the needs of universities, students and policy-makers, and matches local contexts and contributes to the growth of world-class higher education systems, rather than a limited number of world-class institutions. Accordingly, authors reveal many of the drawbacks of the prevailing ranking systems, one being an excessive focus on increasing research output at the expense of social impact in local communities; second being on Spanish-language and non-English languages research are clearly ignored in favour of English.

In addition, the UNESCO article considers if benchmarking performance in achieving educational outcomes would be more useful and effective than what ranking institutions are currently doing. To support that, The World Bank is exploring this possibility through the design of a new assessment system that privileges relevant factors to developing regions and thus allowing for more reliable comparisons to be made among them.

3.6 EUA Reports

The European University Association (EUA) is the representative organisation of European universities and their presidents, and it regularly organises the rectors' conferences and meetings in 47 European countries. One of the main activities of the EUA is the study and analysis of higher education in Europe. Along this line of activity, the EUA published in 2013 their last report about university rankings, the EUA Report on Rankings 2013, entitled *Global University Rankings and their Impact - Report II* [42].

The EUA Report on Rankings 2013 analysed what they considered the most relevant university rankings and in general underscored the consolidation of the overall phenomenon of rankings, their use, abuse, and policy implications, as well as how universities respond to rankings. At the same time, the report highlighted some awareness and weaknesses to consider about rankings, such as the continued focus on elite universities, the relative but persistent neglection of the arts, humanities and the social sciences, the lack of transparency of many rankings and the exclusiveness of English-language publications used on rankings.

3.7 Social Aspects in University Rankings

According to UNESCO concerning the lack of social aspects and social impact of universities in rankings, the book *Universidad y Desarrollo Social* [43] suggest new approaches, improvements and indicators to evaluate the universities' social behaviour. These indicators can be grouped into three groups:

- Equity and equality: the relation with graduates and their access to university research and teaching positions, women percentage at university and research and professor positions, and student' studies progression respect their parents.
- University involvement in social development projects and activities.
- Degree program competencies directly related to social development.

Chapter 4

METHOD FOR INFORMATIONAL ANALYSIS OF UNIVERSITY RANKINGS

The informational analysis of university rankings process is split into four phases, the three first phases are related each one with the different informational components of rankings – ranking process, ranking data, and indicators and calculus –, and the last one is the evaluation of the ranking information.

One of the most important aspects of this method is the way how the information for the informational analysis is gathered. **All the information has to be referenced from the ranking's official public and universal access sources**, either from ranking web sites, ranking's linked sources, or ranking publications. This aspect is needed to assess transparency in rankings.

4.1 Ranking Process

The first phase is the analysis of the **ranking process**, focused on how is the process for ranking universities. The objective of this phase is to explain and find how rankings do the process to assess each university from university contact until the results presentation, using both textual and visual explanations[1]. The process should include the detailed information produced and used in each step, which participants are involved, the expected timing or schedule for each task, and the possible errors and solutions. The expected detailed tasks are:

- **University contact process**: how rankings ask to universities for their participation into the ranking process, or how universities are noticed they are included into the ranking process, and which protocols are used to contact and solve incidents, such as when universities do not answer.
- **Data collection process**: which data sources are used, who provides data and how it is provided, which protocols are used to gather, schedule, check the data and solve incidents.
- **Data cleaning process**: which are the mechanisms or processes to verify reliability and correctness and which are the protocols when a data error or incident is detected.
- **Data assessment process**: which are the processes and techniques used to rank and compute the ranking of universities, and over which data are applied.
- **Results publication**: how data is published and which kind of tables are used.

[1]The suggested tool for visual representation of processes is BPMN.

4.2 Ranking Conceptual Model

The second phase is the **ranking conceptual model**, focused on the data used for ranking universities. The objective of this phase is to model and understand all concepts used for ranking universities[2]. Concepts used for ranking universities should include all variables, attributes, and indicators used and their definition, and the sources used to collect the data and who provides those data. Furthermore, this phase should include how data is validated and cleaned. The expected results of this phase are:

- **Description/definition of ranking data**: the description and definition of data and indicators used in ranking.
- **Conceptual model of ranking data**: conceptual model, and which data is used to produce each indicator and how.
- **Description of validation and cleaning mechanisms**: description of techniques and protocols used to verify the correctness and reliability, the methods used to clean the data or deal with errors.

4.3 Ranking Calculus Method

The third phase is the **ranking calculus method**, that is focused on how rankings are computed. The objective of this phase is to identify the weights of each indicator, variable, attribute or concept used for ranking universities and how rankings are computed. The identification should include all weights used for each indicator and all the algorithms used to rank universities.

Some rankings, instead of using weights, use different algorithms to compute each indicator and rank the universities. In that case, the objective of that phase should be to find the description of indicators and algorithms.

The expected results of this phase are:

- Weights or algorithms for each concept or indicator
- Algorithms for ranking universities

4.4 Ranking Evaluation

The last phase is the **ranking evaluation**, where the previous three phases converge into a ranking transparency evaluation and ranking profiling. The objective of this phase is to assess the level of transparency in university rankings and show which aspects are more represented.

4.4.1 Ranking Transparency Evaluation

Transparency is evaluated using 30 points in a range of [0:30], where 0 means no transparency and 30 means full transparency. To assess transparency each expected result of the phases one, two and three have to be graded using the following rules, and then the global sum will show the total transparency grade of the university ranking.

[2]The suggested tool for model the data is UML, due to its powerful visual representation.

Transparency Grades	
0	No information available.
1	Some concepts are not explained or some missed information.
2	All concepts are explained, but without enough precise information to satisfy the expected results.
3	Full information available to satisfy the expected results.

Table 4.1: Transparency assessment grades

4.4.2 Ranking Profiling

To identify which aspects of university rankings are more represented, each indicators and concept has to be classified into one and only one of these following seven categories:

- **Scientific and research**: research and scientific production activities, outcome or reputation, such as research output, publications, citations, scientific awards and grants ...
- **Teaching and education:** related to the learning environment and performance, such as graduates, number of students, learning quality, teachers ratio, facilities ...
- **Social:** aspects related to equality, inclusion, environment, social-break, community service,social economy, ethics such as gender equality, projects with non-profit organisations, social inclusion, suitability and environmental projects, programmes and cooperation with developing countries, community development ...
- **Regional engagement:** inclusion of regional or local demands into the programme orientation, such as internships in the region, projects with region companies, regional income ...
- **International orientation:** international HEIs aspects (not related to research), such as international internships, international students/faculty, international projects and programmes, international income ...
- **Knowledge transfer:** related with the flow of HEIs knowledge to industry or new companies, such as partnerships with companies, graduate companies, spin-off, co-patents with industry, joint programmes with industry ...
- **Business and employability:** focused on the employability of graduates, such as graduates employability, employers reputation ...

Once all indicators are classified into categories, to be objective showing the representation of each concept, the weighting of each category have to be counted. The weighting of each indicator assigned to a category is used in order to count the weighting of each category. Category weighting is computed as the sum of the percentages of the indicators assigned to it (when rankings use percentages to rank) or as a counting of the total number of indicators in the category (when rankings use algorithms rather than use weightings or percentages).

Chapter 5

U-MULTIRANK

U-Multirank rank published on June 2011 a feasibility study [12] where U-Multirank was presented and detailed. This study brings transparency to U-Multirank, at the same time that it provides all the information shown in this chapter, and that we have used to apply the *Method of Informational Analysis for University Rankings* (described at section 2.1).

5.1 Ranking Process

The Analysis of ranking assessment process describes how U-Multirank does the process of ranking universities, it is explained in five phases – contact process, data collection process, data cleaning and validation process, data analysis process, and results publication process.

5.1.1 Contact process

According to *U-Multirank's feasibility study* [12], U-Multirank first sends a letter to presidents of universities asking for an official confirmation of participation. Once the confirmation is done, a contact form is sent to identify the contact person at the institution. After the contact is filled and sent back, U-Multirank sends the access codes for questionnaires. If the institution does not fill the contact form in two weeks, a reminder is sent. In the worst case, if the first reminder is not answered, U-Multirank call the institution. To sum up the process, we have represented it by the following BPMN process:

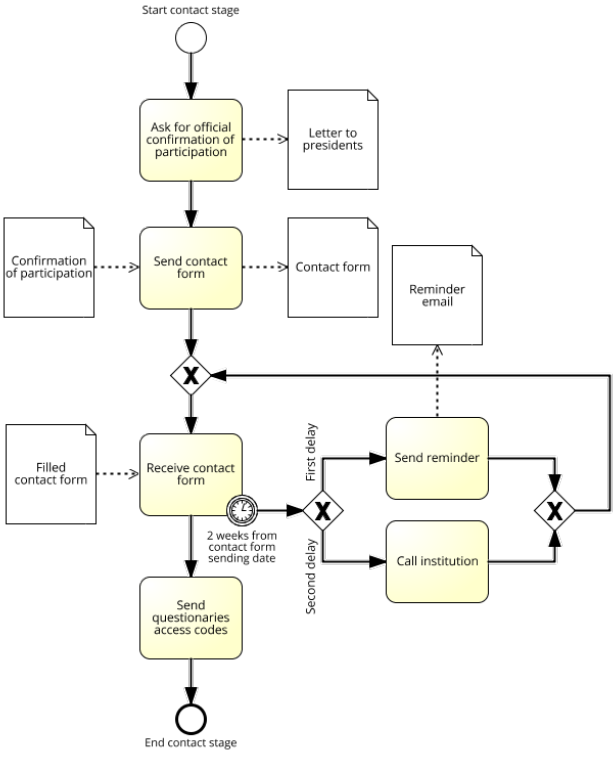


Figure 5.1: U-Multirank: Contact process

5.1.2 Collection Process

U-Multirank has two clear and distinguished different data collection processes: the process related to scientific performance, *Scientific Data Gathering process*, that gathers data from trusted and international databases; and the process related to institutional data, *Institutional Data Collection process*, where data has to be provided by universities.

Scientific Data Gathering Process

Both bibliometric data from [23] and patent data from PATSTAT [44] are gathered by U-Multirank after institution accept formally to participate in the ranking.

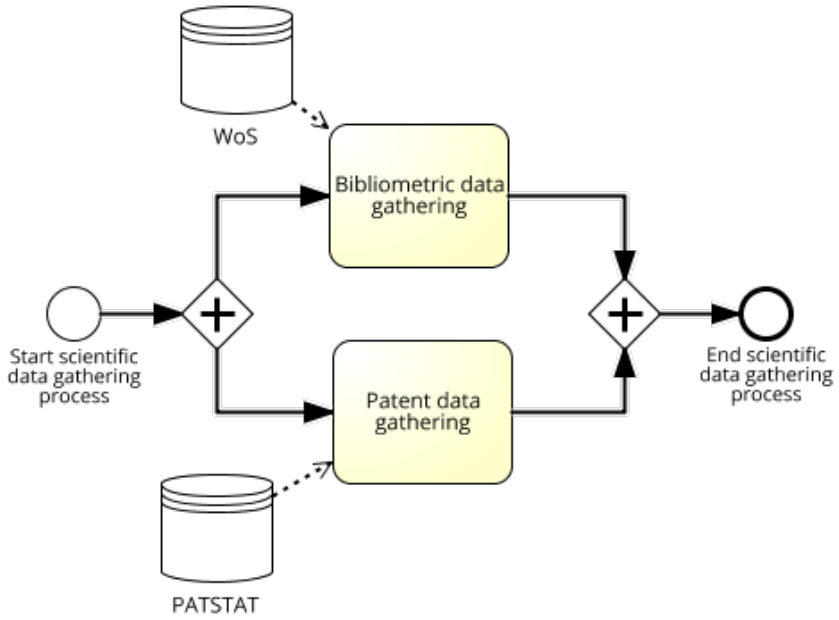


Figure 5.2: U-Multirank: Scientific Data Gathering process

Institutional Data Collection Process

U-Multirank gives to institutions seven weeks to collect the data, with deadlines set according to the dates the institution confirmed their participation. If the account had not been accessed four weeks after sending out the access information, U-Multirank emails a reminder and ask whether there had been any problem with the account. After deadlines for data submission had passed, U-Multirank checks the questionnaires submitted by the institutions: if only one of the two institutional questionnaires had been submitted, reminders are sent. Once the institutions had submitted the questionnaires, data is checked and U-Multirank provides comments and questions. This feedback provides to institutions an opportunity for a second submission, in which they can answer the questions, check their data, correct inconsistencies, and fill the missing information.

After the completion of data collection process, U-Multirank asks those institutions that submitted data to fill various surveys, in order to share their experience with the process and provide comments or suggestions for the further improvement of the procedures and instruments.

However, U-Multirank uses national datasets and other public sources to reduce the load of data collection. As an example: in both HEI systems at US and UK, data is extracted from national datasets. In the UK, the data is retrieved from the HESA database [45], and in the US, the data is retrieved from the IPEDS database [46].

We have summarised the Institutional Data Collection process in the following BPMN diagram:

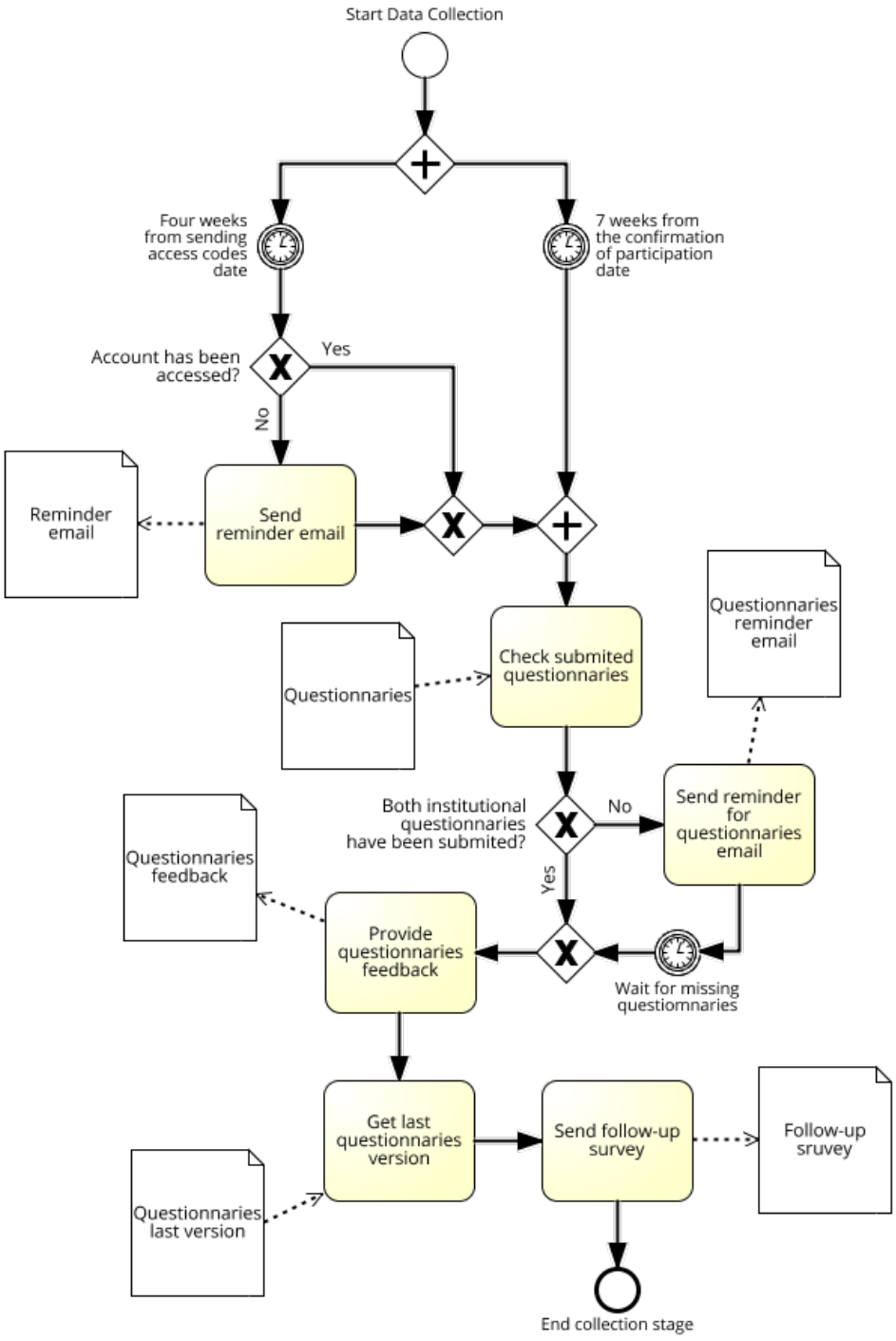


Figure 5.3: U-Multirank: Institutional Data Collection process

5.1.3 Cleaning Process

U-Multirank establishes different mechanisms for cleaning and data validation for each questionnaire, as it is described below. Despite these mechanisms, the general and central feature of these procedures to correct data is the direct communication with the institutions.

When an outlier or missing is detected, the website of the institution is checked in order to find information regarding the relevant data element. If the website did not provide the information, then other publicly available data sources are identified and studied to find out whether the outlier was due to inadequate interpretation and data provision regarding the question/data element or to a particular characteristic of the institution.

We have summarised the process in the following diagram:

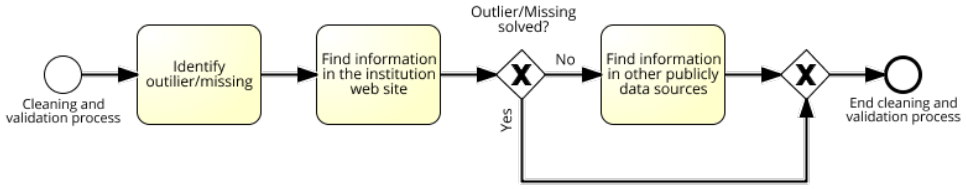


Figure 5.4: U-Multirank: Cleaning process

Institutional Questionnaires

With the **institutional questionnaires** U-Multirank checks:

- **Outliers in the data elements, outliers in indicators scores and missing values**: values of each institution are compared with the values of other universities in order to identify outliers, checking if the outlier value is extremely high or low compared with the values of the other institutions.
- **Consistency in reference dates**

Departmental Questionnaires

With the **department questionnaires** U-Multirank checks:

- **Outliers**: for each indicator, outliers are identified and analysed and compared with the total average of scores of a given number/indicator, field-based averages, and national averages.
- **Differences within a country**: as far as the sample allowed, an analysis took place to identify country-specific outliers or inconsistencies.
- **Trends over time**: most indicators refer to three-year averages. The data provided are studied over time and specific changes in trends are analysed.

Student Survey

With the **students survey** U-Multirank checks:

- **Missing data on the students' information**.
- **Incomplete questionnaires**.
- **Incorrect data or information**.
- **Inconsistent answers**.

5.1.4 Assessment Process

The Assessment process of U-Multirank applies three distinct rank methods, which are specific to the three different kinds of indicator: *quantitative ranking indicators* based on continuous measures on particular scales; *rating indicators* based on multi-measures; and *student satisfaction indicators* from the student surveys. All procedures applied for rank calculation are described in detail in the Rank Group Calculation documents of U-Multirank [47][48][49]. This process is done after the cleaning and validation process and we have summarised it in the following diagram whereas each rank method is brief by explained in section 5.3.

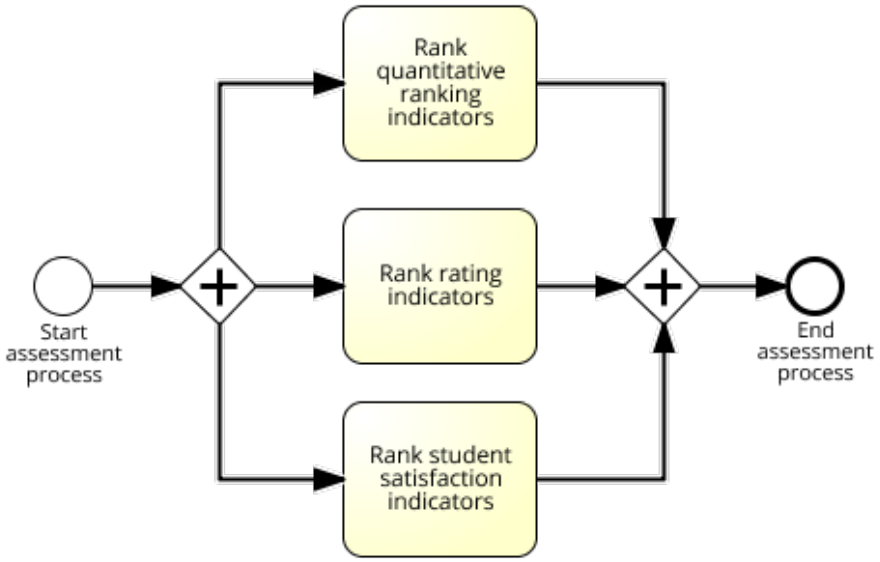


Figure 5.5: U-Multirank: Assessment process

5.1.5 Results publication process

Results are published after the assessment process is done and all ranks have been computed. Moreover, results are presented with different levels of aggregation as are: institutions, departments, and programs. U-multirank uses four different representation tools: *interactive tables*, *personalised ranking tables*, *sunburst charts*, and *detailed results*.

Interactive tables are tables listing all institutions included in the ranking and all (or a selection of) indicators. Personalised ranking tables are tables defined by users where they can select the individual indicators they feel are relevant. Sunburst charts are graphical representations of the performance of the institution as a whole, presented without being aggregated into one composite indicator. Detailed results are a text representation of the detailed information about institutions results.

With the following diagram we summarise the result publication process:

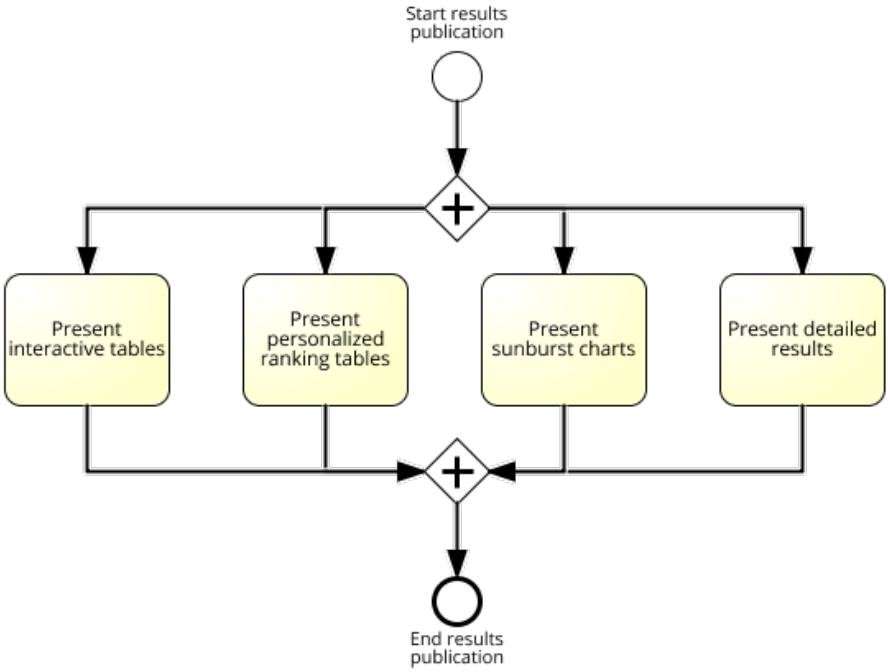


Figure 5.6: U-Multirank: Results publication process

5.2 Ranking Conceptual Model

Data is gathered from university questionnaires and bibliometrics, and patent sources; and after U-Multirank has validated all data, it produces the indicators.

Institutional questionnaire data is detailed at *List of terms and concepts used in the 2017 institutional questionnaire of U-Multirank* [50] (an example of institutional questionnaire can be found at *Questionnaire for institution* [51]), Subject questionnaire data information is available at *List of terms and concepts used in the 2016 subject questionnaire of U-Multirank* [52] (an example of subject questionnaire can be found at *Subject Questionnaire* [53]), and the Student survey can be found at *Student questionnaire 2016* [54]. Programmes and degrees are organised according to the *U-Multirank 2017 Specification of programmes and degrees included* [55]. Bibliometric and Patent data specifications are described at *U-Multirank Bibliometrics 2017: Technical Specifications* [56].

Indicators detailed descriptions and how they are computed and which data is used to produce them is found at *Indicator Book 2017* [57]. U-Multirank uses its own indicators classification based on 6 categories:

- General
- Teaching & Learning
- Research
- International orientation
- Regional engagement
- Knowledge transfer

Using all information related to data sources and indicators provided by U-Multirank, we done the conceptual model of university data and indicators shown in the following diagrams. All concepts have **granularity by year and degree programme** when it is suitable. The representation is done with a high level of abstraction that can capture all the needed data for U-Multirank, in order to be easy to understand, flexible and adaptable.

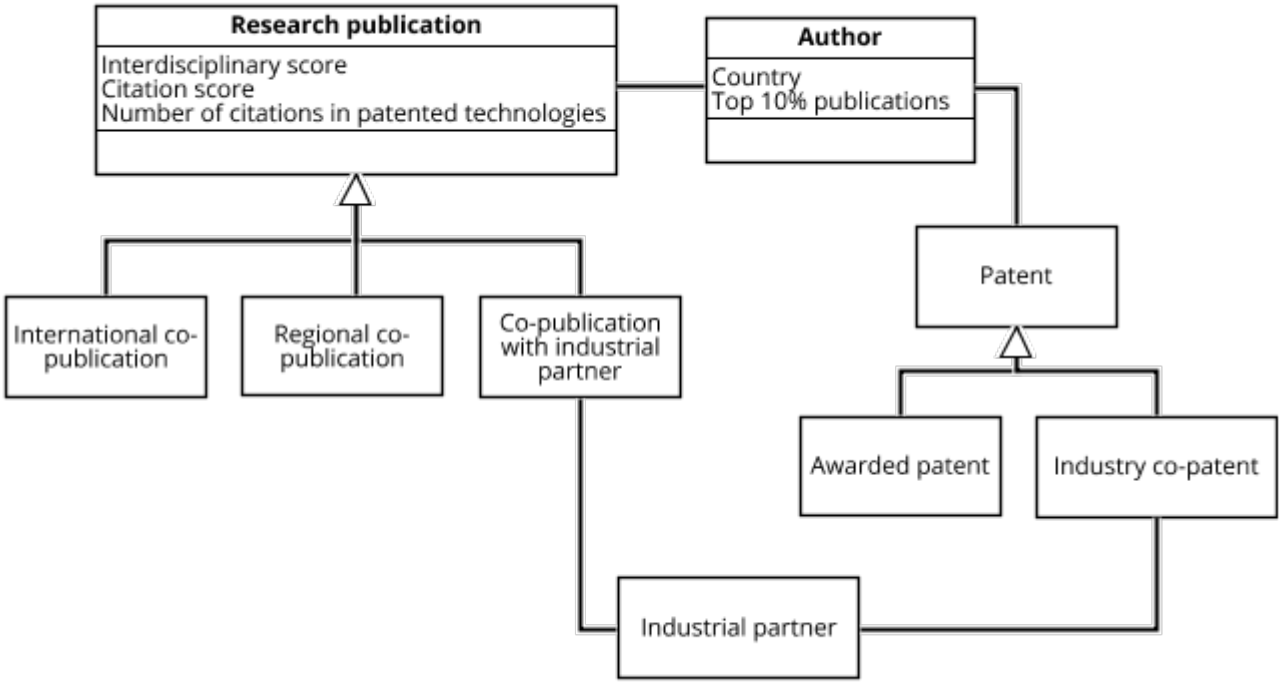


Figure 5.7: U-Multirank: Bibliometrics and Patent Model

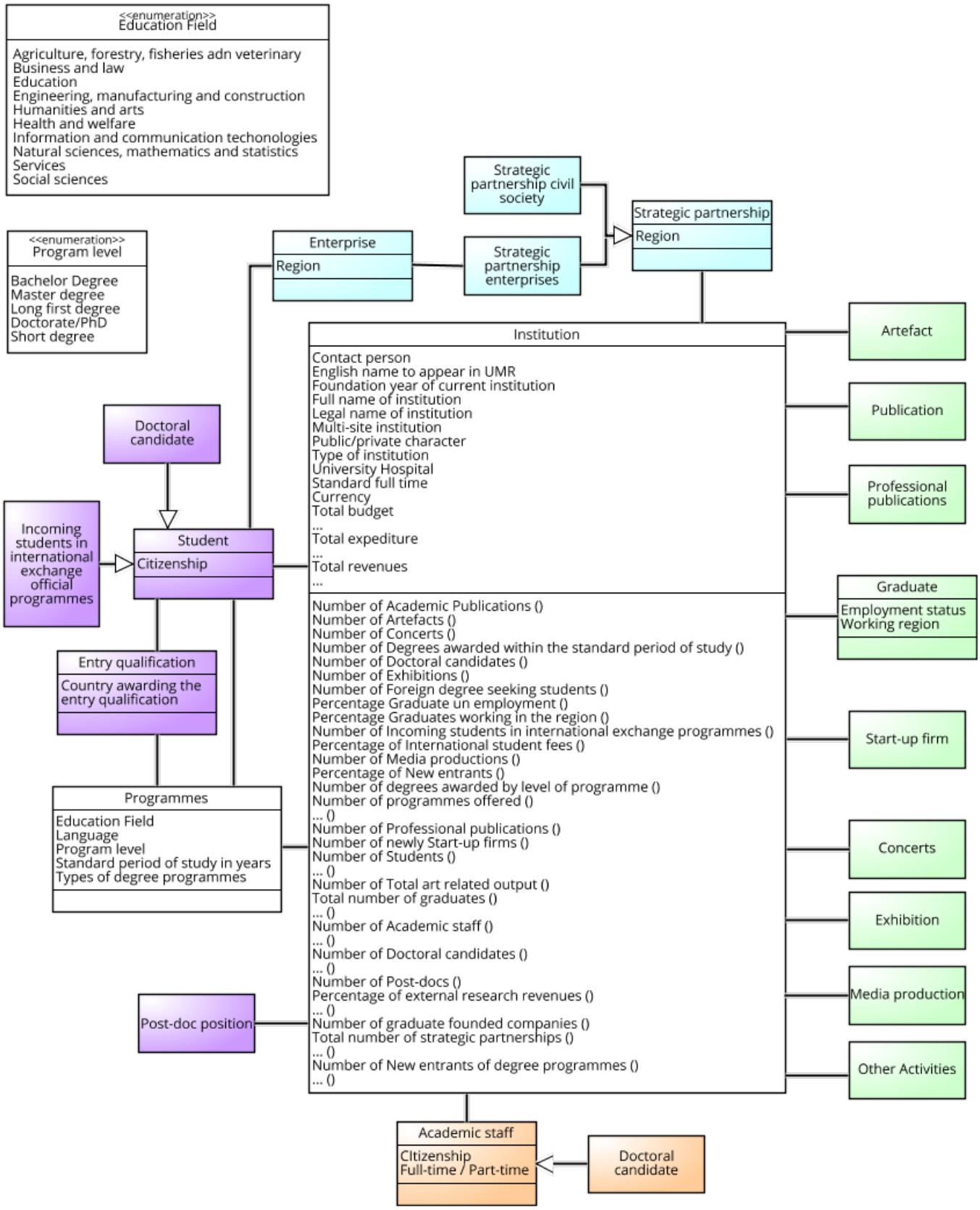


Figure 5.8: U-Multirank: Institution Model

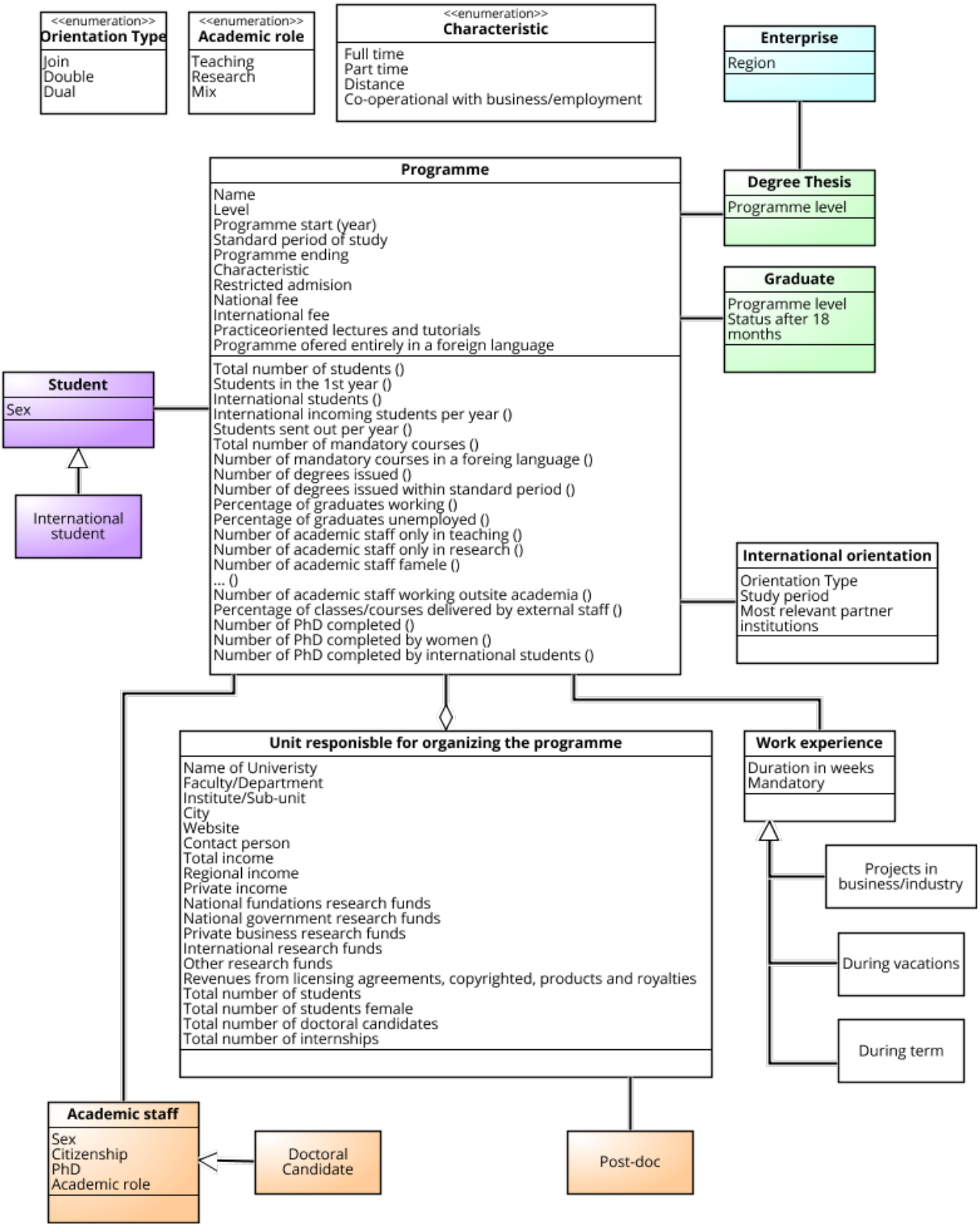


Figure 5.9: U-Multirank: Subject Model

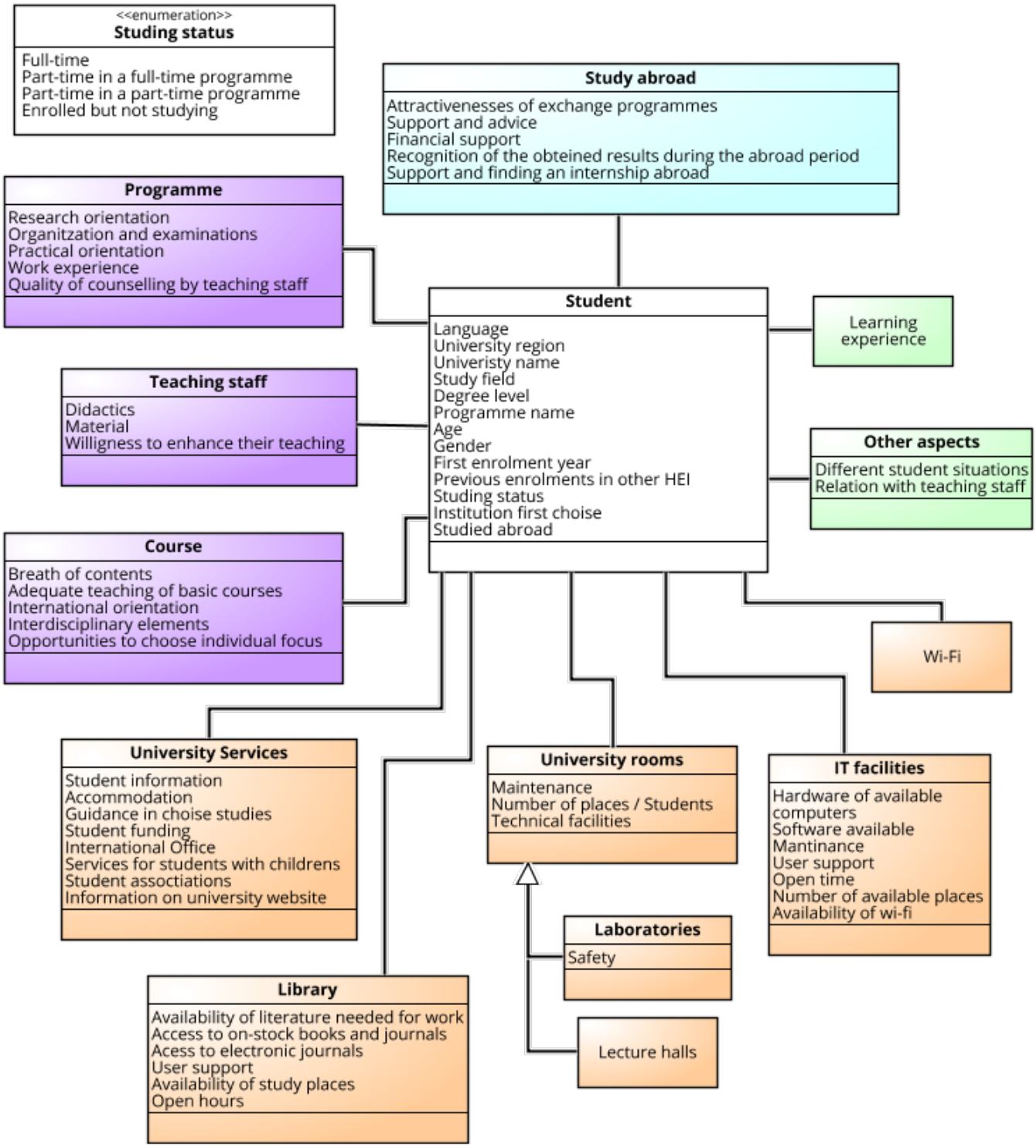


Figure 5.10: U-Multirank: Student Survey Model

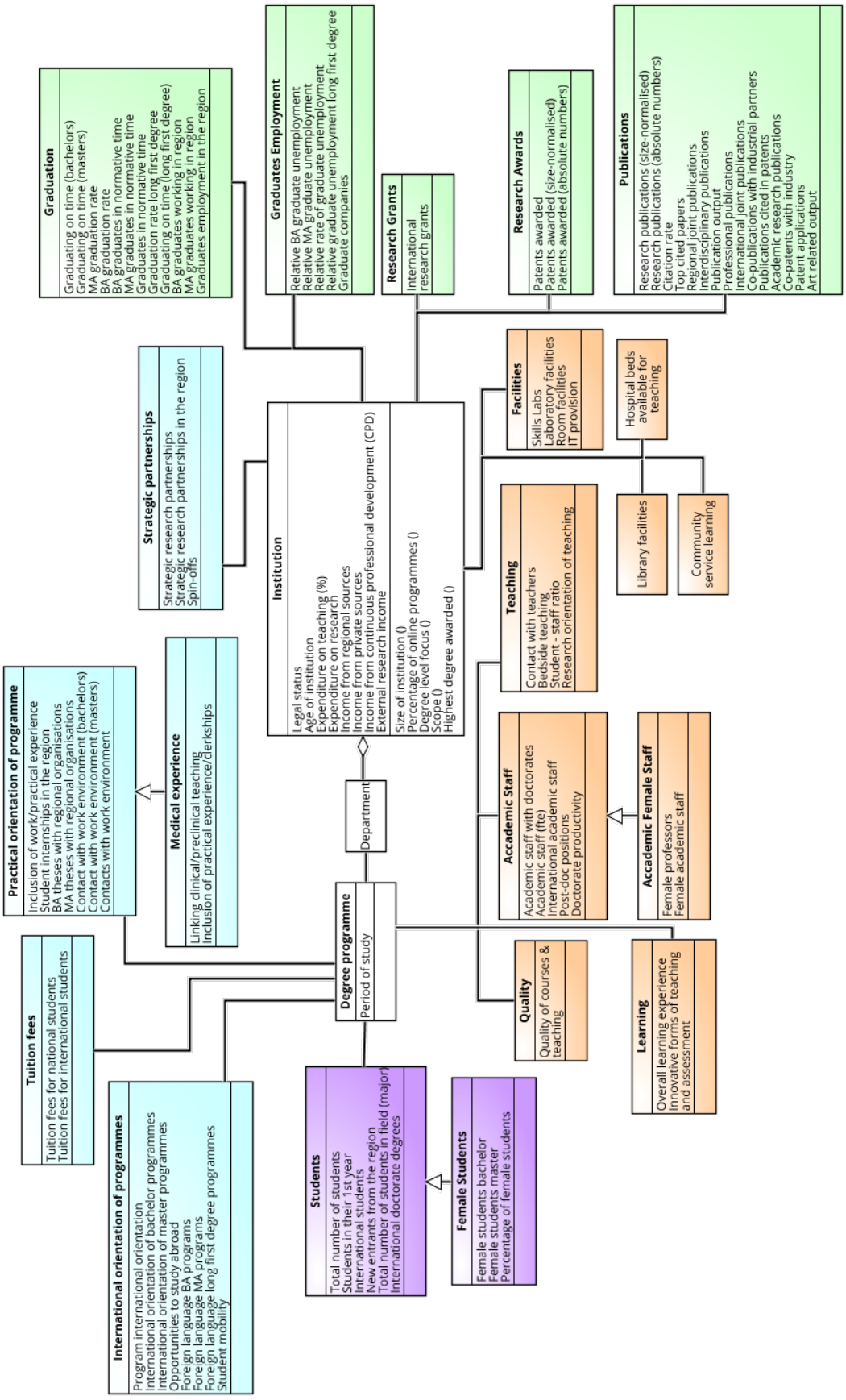


Figure 5.11: U-Multirank: Indicators Model

5.3 Ranking Calculus Method

U-Multirank applies rank group algorithms instead of using weights for each indicator. Indicators are split into three different groups according to their nature: *quantitative ranking indicators* based on continuous measures on particular scales, *rating indicators* based on multi-measures, and *student satisfaction indicators* from the student surveys. The following sections briefly describe each rank group procedure for each kind of indicator.

5.3.1 Quantitative Ranking Indicators

The rank process for the quantitative ranking indicators divides each indicator into five different groups according to the median of the total sample per indicator. The fact that the scores of some indicators are not normal distributed causes a problem as the within group variance is very large. For that reason, U-multirank uses the log normalised scores for all indicators where the ratio median/mean is outside the 25% bandwidth around 1 (- or + 12,5%).

The detailed information about groups, procedures, algorithms and justifications can be find at the *Rank Groups Calculation* document [47] at the Appendix A.

5.3.2 Rating Indicators

The rank process for the rating indicators defines the groups in terms of grades, assigning a maximum number of points to each indicator and defining criteria to grade it.

The detailed information about groups, procedures, criteria and justifications can be found at *Rating Criteria & Rank Group Thresholds 2017* document [48] at the Appendix B.

5.3.3 Student Satisfaction Indicators

The rank process for student satisfaction indicators uses the confidence interval to incorporate the uncertainty of the judgement values in the ranking calculation to classify the indicators inside groups.

The detailed information about groups, procedures, algorithms and justifications can be found at *The construction of rank groups: Significant deviations from the average score* document [49] at the Appendix C.

5.4 Ranking Evaluation

This section evaluates U-Multirank in terms of transparency and ranking scope as it is explained at section 2.1.

5.4.1 Transparency Evaluation

Transparency is focused on how U-Multirank opens its ranking system method to the general public and users. U-Multirank gets the maximum transparency score: 30 over 30 points, that it is equivalent to 10 over 10. Justifications of each transparency point are detailed in the following tables.

Ranking process		
Concept	**Grade**	**Justification**
University contact process	3	The information available at [12] achieves the objectives of the contact process. Using U-Multirank's information, at section 5.1.1 the process and information produced are explained and modelled with a BPMN diagram.
Data collection process	3	The information available at [12] achieves the objectives of the data collection and gathering process. Using U-Multirank's information, at section 5.1.2 the process, sources and information produced are explained and modelled with BPMN diagrams.
Data cleaning process	3	The information available at [12] achieves the objectives of the data cleaning and validation process. Using U-Multirank's information, at section 5.1.3 the process, information used and cleaning procedures are explained and modelled with a BPMN diagram.
Assessment process	3	The information available at [47][48][49] and appendix A, B and C achieves the objectives of the assessment process. Using U-Multirank's information, at section 5.1.4 and 5.3 the process and information are explained and modelled with a BPMN diagram.
Results publication	3	The information available at [12] achieves the objectives of the different results publications ways. Using U-Multirank's information, at section 5.1.5 the different publications ways are explained and modelled with a BPMN diagram.
Total	**15**	

Table 5.1: U-Multirank: Transparency of ranking process

Ranking conceptual model		
Concept	**Grade**	**Justification**
Description/definition of ranking data	3	All references to data sources and descriptions are cited at section 5.2.
Conceptual model of ranking data	3	Using the description provided on the citations at section 5.2, the conceptual model can be done in UML as is shown on the same section.
Description of validation and clean mechanisms	3	Data validation and clean mechanism are described at [12] and explained at section 5.1.3.
Total	**9**	

Table 5.2: U-Multirank: Transparency of conceptual model

Ranking calculus method		
Concept	Grade	Justification
Weights or algorithms for each concept or indicator	3	U-Multirank does not use weights for indicators, instead of it, it use algorithms to compute indicators and rank. These algorithms are explained at [57] and the data model of indicators can be find at 5.2.
Algorithms for ranking universities	3	The Algorithms for ranking universities are explained at [47][48][49] and appendix A, B and C. At section 5.3 the process is explained.
Total	**6**	

Table 5.3: U-Multirank: Transparency of ranking calculation

Transparency Grades	
Concept	**Grade**
Ranking process of university ranking	15
Conceptual model of university ranking	9
Identification of weights and ranking calculus	6
Total	**30**

Table 5.4: U-Multirank: Transparency assessment grades total

5.4.2 Scope Evaluation

Scope evaluation classifies U-Multirank's indicators into 7 different categories, based on the ranking profiling explained in the *Method for Informational Analysis of University Rankings*. These categories are Scientific and research, Teaching and education, Social, Regional engagement, International orientation, Knowledge transfer, and Business and employability. U-Multirank is focused firstly on teaching and education performance and secondly in scientific and research output, as it is shown in the following graph, as a result of classifying U-Multirank's indicators (see tables below).

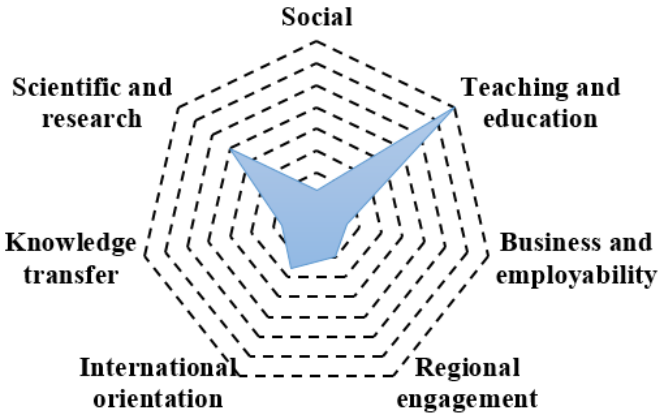


Figure 5.12: U-Multirank: Scope

	Scientific and research	Teaching and education	Social	Regional engagement	International orientation	Knowledge transfer	Business and employability
Total number of students		✘					
Students in their 1st year		✘					
International students					✘		
Total number of students in field (major)		✘					
Percentage of female students			✘				
Academic staff (fte)		✘					
Period of study		✘					
Tuition fees for national students		✘					
Tuition fees for international students		✘					
Female students bachelor			✘				
Female students master			✘				
Female academic staff			✘				
Female professors			✘				
Student - staff ratio		✘					
Graduating on time (bachelors)		✘					
Graduating on time (masters)		✘					
Academic staff with doctorates		✘					
Contact with work environment (bachelors)							✘
BA graduation rate		✘					
MA graduation rate		✘					
BA graduates in normative time		✘					
MA graduates in normative time		✘					
Relative BA graduate unemployment							✘
Relative MA graduate unemployment							✘
Contacts with work environment							✘
Contact with work environment (masters)							✘
Graduates in normative time		✘					
Relative rate of graduate unemployment							✘
Hospital beds available for teaching		✘					
Innovative forms of teaching and assessment		✘					
Graduation rate long first degree		✘					
Graduating on time (long first degree)		✘					
Relative graduate unemployment long first degree							✘
Community service learning			✘				
Total	0	20	6	0	1	0	7

Table 5.5: U-Multirank: Indicators scope (I)

	Scientific and research	Teaching and education	Social	Regional engagement	International orientation	Knowledge transfer	Business and employability
Overall learning experience		✘					
Quality of courses & teaching		✘					
Organisation of program		✘					
Contact with teachers		✘					
Inclusion of work/practical experience		✘					
Library facilities		✘					
Laboratory facilities		✘					
IT provision		✘					
Room facilities		✘					
Linking clinical/preclinical teaching		✘					
Skills Labs		✘					
Bedside teaching		✘					
Inclusion of practical experience/clerkships		✘					
External research income	✘						
Doctorate productivity	✘						
Research publications (absolute numbers)	✘						
Citation rate	✘						
Top cited papers	✘						
Interdisciplinary publications	✘						
Research orientation of teaching		✘					
Post-doc positions	✘						
External research income	✘						
Research publications (size-normalised)	✘						
Publication output	✘						
Art related output	✘						
Research publications (absolute numbers)	✘						
Professional publications	✘						
Strategic research partnerships	✘						
International orientation of bachelor programmes					✘		
International orientation of master programmes					✘		
Opportunities to study abroad					✘		
International doctorate degrees					✘		
International joint publications	✘						
International research grants	✘						
Foreign language BA programs					✘		
Student mobility					✘		
International academic staff					✘		
Foreign language MA programs					✘		
Program international orientation					✘		
Foreign language long first degree programmes					✘		
Total	16	14	0	0	10	0	0

Table 5.6: U-Multirank: Indicators scope (II)

	Scientific and research	Teaching and education	Social	Regional engagement	International orientation	Knowledge transfer	Business and employability
Student internships in the region				✘			
BA theses with regional organisations				✘			
MA theses with regional organisations				✘			
Regional joint publications	✘						
Income from regional sources				✘			
BA graduates working in region				✘			
MA graduates working in region				✘			
Graduates employment in the region				✘			
Strategic research partnerships in the region				✘			
Income from private sources						✘	
Co-publications with industrial partners						✘	
Patents awarded	✘						
Co-patents with industry						✘	
Publications cited in patents	✘						
Patents awarded (size-normalised)	✘						
Industry co-patents						✘	
Spin-offs						✘	
Income from continuous professional development (CPD)						✘	
Patents awarded (absolute numbers)	✘						
Graduate companies						✘	
Size of institution		✘					
Percentage of online programmes		✘					
Expenditure on teaching (%)		✘					
Degree level focus		✘					
Scope		✘					
Highest degree awarded		✘					
Expenditure on research	✘						
Academic research publications	✘						
Professional publications	✘						
Income from international sources					✘		
Foreign degree seeking students					✘		
Income from regional sources				✘			
New entrants from the region				✘			
Income from private sources						✘	
Patent applications	✘						
Total	9	6	0	10	2	8	0

Table 5.7: U-Multirank: Indicators scope (III)

	Sum	%
Scientific and research	25	23%
Teaching and education	40	37%
Social	6	5%
Regional engagement	10	10%
International orientation	13	12%
Knowledge transfer	8	7%
Business and employability	7	6%
Total	**109**	**100%**

Table 5.8: U-Multirank: Indicators scope summary

Chapter 6

QS RANKING

QS World University ranking annually publishes its methodology [11][58], where ranking metrics are explained. This methodology explains the meanings of each metric and the overall weights. Although QS has more than 10 different rankings with different focuses and scopes, the *Method for Informational Analysis of University Rankings* is mainly applied to QS World University ranking using the information found at the QS' published methodology, because this ranking is the most global and known QS' ranking. However, this study takes into account all the data used in the other QS' ranking, in order to get a better information and data perspective.

6.1 Ranking Process

The analysis of ranking assessment process describes how QS does the process of ranking universities, that it is explained in four phases – data collection process, data cleaning and validation process, data analysis process, and results publication process. The phase *contact process* is not explained, due to the lack of information.

6.1.1 Contact Process

There is no both bibliographic and published information in open format about contact process at official QS sources.

6.1.2 Collection Process

QS World University rank has not an established general process, instead of it, it has a different process for each indicator. The collection process is done both from institutions submit at QS' Core platform [59], and data retrieve from institutional or HEIs data bases.

- **Academic reputation:** is done using a survey answered by institutions with many peer evaluation questions about top domestic and international institutions in their same fields.
- **Alumni Outcome** (from QS Graduate Employability rankings): based on the information at companies such as Forbes, Fortune, LinkedIn and TIME, it retrieves the outcome of highly influential employers, sector leaders, and award-winning professionals and where they studied.
- **Employer reputation:** is done using a survey answered by worldwide employers that came from QS' employers database, partners and proposed employers from institutions, with many peer evaluation questions about top domestic and international institutions they consider best for recruiting graduates.
- **Employers' presence on campus**(from QS Graduate Employability rankings): information about employers participating in careers fairs, organising company presentations, or any other self-promoting activities on the part of employers, comes from university or it is collected on official university reports.

- **Faculty Student ratio:** data about FTE students and FTE faculty come from different data sources, such as government ministries, agencies, web sources and other third-parties.
- **Graduate employment rate** (from QS Graduate Employability rankings): data comes from an official government report, official university report or it is supplied to QS for HEIs.
- **H-index:** two h-indices are calculated; one for all the papers that are attributable to the given subject (h1), and one to the papers that are only attributable to that subject (h2). These are aggregated with double weight given to h2.[1] Despite that, there is no information about the sources of h-index.
- **Proportion of International Students/Faculty:** there is no information about the source of the data.
- **Citations per faculty:** QS use data from Scopus [60] to gather the citations information.
- **Papers & Citations** (from QS University Ranking): data is retrieved from Scopus.
- **Partnership with employers** (from QS Graduate Employability rankings): QS us the research production of partnerships, using the information found at Scopus.
- **Staff with PhD** (from QS University Ranking): there is no information about the source of the data.
- **Web impact** (from QS University Ranking): data is retrieved from Webometrics [61].

[1] This paragraph is largely copied from the explanatory text on the [58].

With the following figure we summarise and model the QS' data collection process:

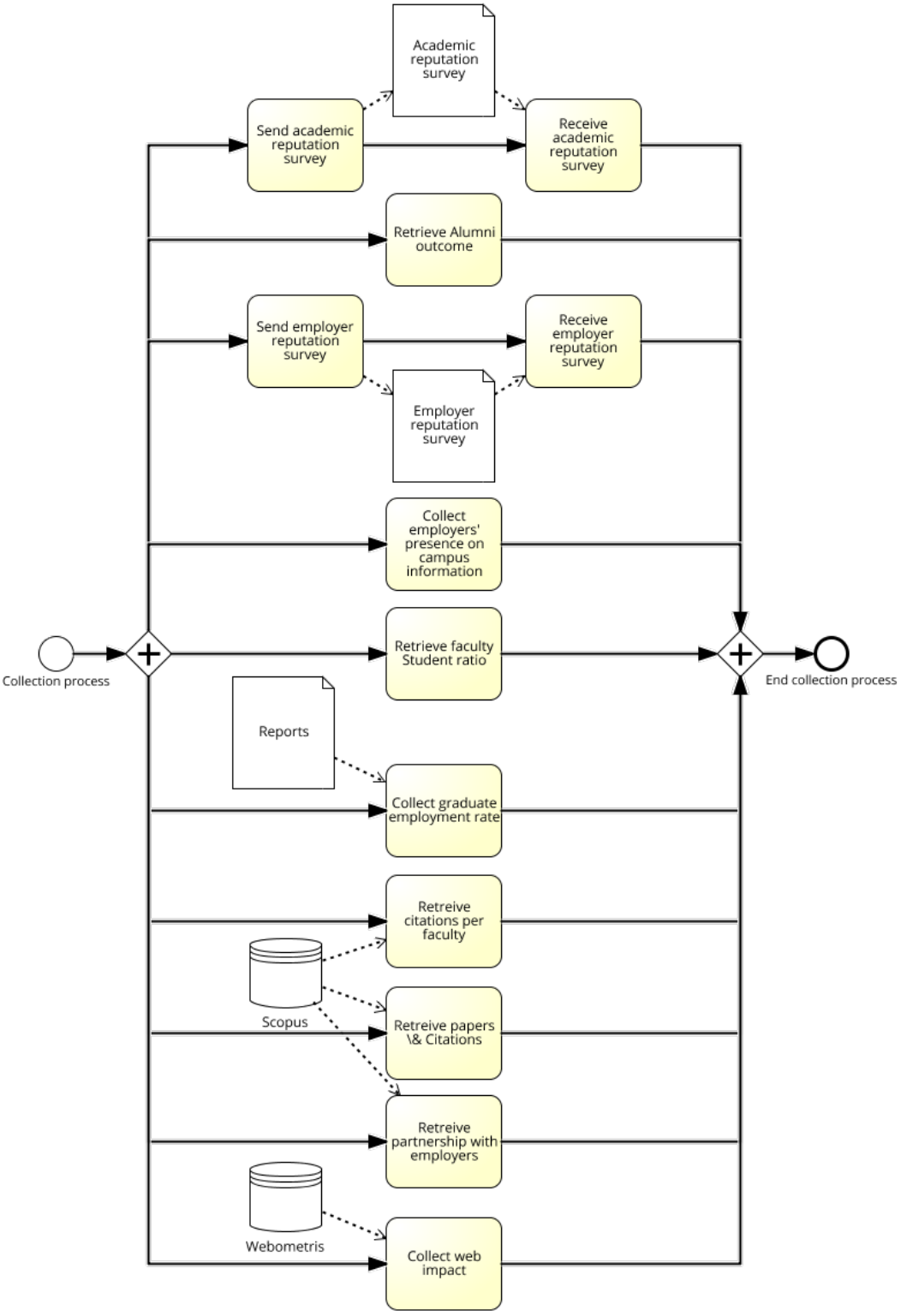


Figure 6.1: QS: Data Collection process

6.1.3 Cleaning Process

QS applies different cleaning and validation processes for each indicator:

- **Academic reputation** and **employer reputation**: combines responses from the last 5 year, where any respondent has responded more than once in the five year period, previous responses are discarded in favour of the latest numbers. In addition, QS does a junk filtering with online surveys, because it receives a volume of test or speculative responses. QS runs an extensive filtering process to identify and discard responses of this nature. Furthermore, QS does an anomaly test to screen for any manipulation of survey responses. If evidence is found to suggest any institution has attempted to overtly influence their performance, any responses acquired are discarded.[1]
- **Alumni Outcome** (from QS Graduate Employability rankings): excludes duplicate entries of individuals that were listed more than once in different awards.[1]
- **Employers' presence on campus** (from QS Graduate Employability rankings): there is no information about the cleaning or validation process of the data.
- **Faculty Student ratio:** data is checked against multiple sources to verify their authenticity.[1]
- **Graduate employment rate** (from QS Graduate Employability rankings): there is no information about the cleaning or validation process of the data.
- **H-index:** there is no information about the cleaning or validation process of the data.
- **Proportion of International Students/Faculty:** there is no information about the cleaning or validation process of the data.
- **Citations per faculty:** papers featuring authors from more than ten affiliated institutions are excluded and QS also applies a *Faculty Area Normalization* (see Appendix D)
- **Papers & Citations** (from QS University Ranking): groups distinct affiliations in Scopus under the single university entity in QS database. For example, Scopus records for Harvard Medical School and Harvard Business School are folded for Harvard University.[1]
- **Partnership with employers:** universities and governments (including ministries and other agencies controlled by governments) are excluded.
- **Staff with PhD** (from QS University Ranking): there is no information about the cleaning or validation process of the data.
- **Web impact** (from QS University Ranking): the Scholar component of the Webometrics methodology is eliminated, due to its overlap with our Scopus analysis.[1]

In the following figure we represent the data cleaning and validation process model:

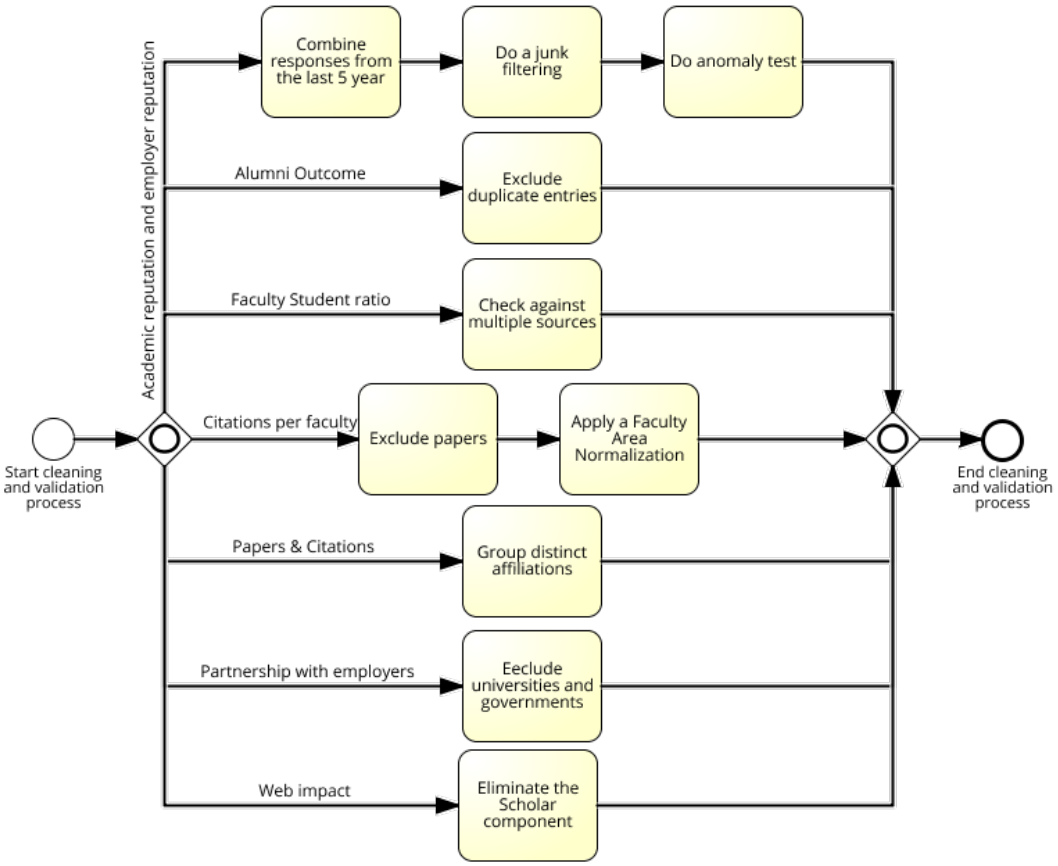


Figure 6.2: QS: Data Cleaning process

6.1.4 Assessment Process

Once the data is collected, cleaned, validated and the weightings are decided upon, QS applies z-scores, in order to standardise and normalise the data of each column. This process allows to combine the data reliably and apply the weightings fairly in the calculation of the overall score. After the scores are calculated, their position on the normal curve is plotted, resulting in the score for each indicator. The resulting scores are finally scaled between 1 and 100 for each indicator to result in a set of results compatible with those for the other indicators.[1] Later, to compute the overall score, QS applies weightings to all computed scores. More information can be found at QS' web site [62].

In the following figure we represent the model of the data assessment and process:

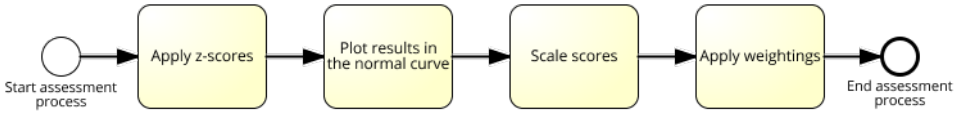


Figure 6.3: QS: Data Assessment process

6.1.5 Results Publication Process

QS World University Rankings provides a leading table of HEIs, based on six performance indicators. Results are presented in an interactive table, which can be filtered by both location and indicator. Institutions are presented in rank order to 400, in ranges of 10 to 50, in ranges of 50 to 800, and in a final 801-1000 range. In the following figure we summarise the model of the results publication process:

Figure 6.4: QS: Results publication process

6.2 Ranking Conceptual Model

Data is gathered from a variety of sources, as it is explained at section 6.1.2. Even though, the QS' conceptual model is composed by the information gathered and used to understand the sources and compute the indicators (shown at the figure 6.5), and the indicators. We represent the indicators conceptual model at figure 6.6, with a granularity of subjects, years and institutions. Definition of both data and indicators can be found at [58]. Representation is done with a high level of abstraction that can capture all the needed data for QS, in order to be easy to understand, flexible and adaptable.

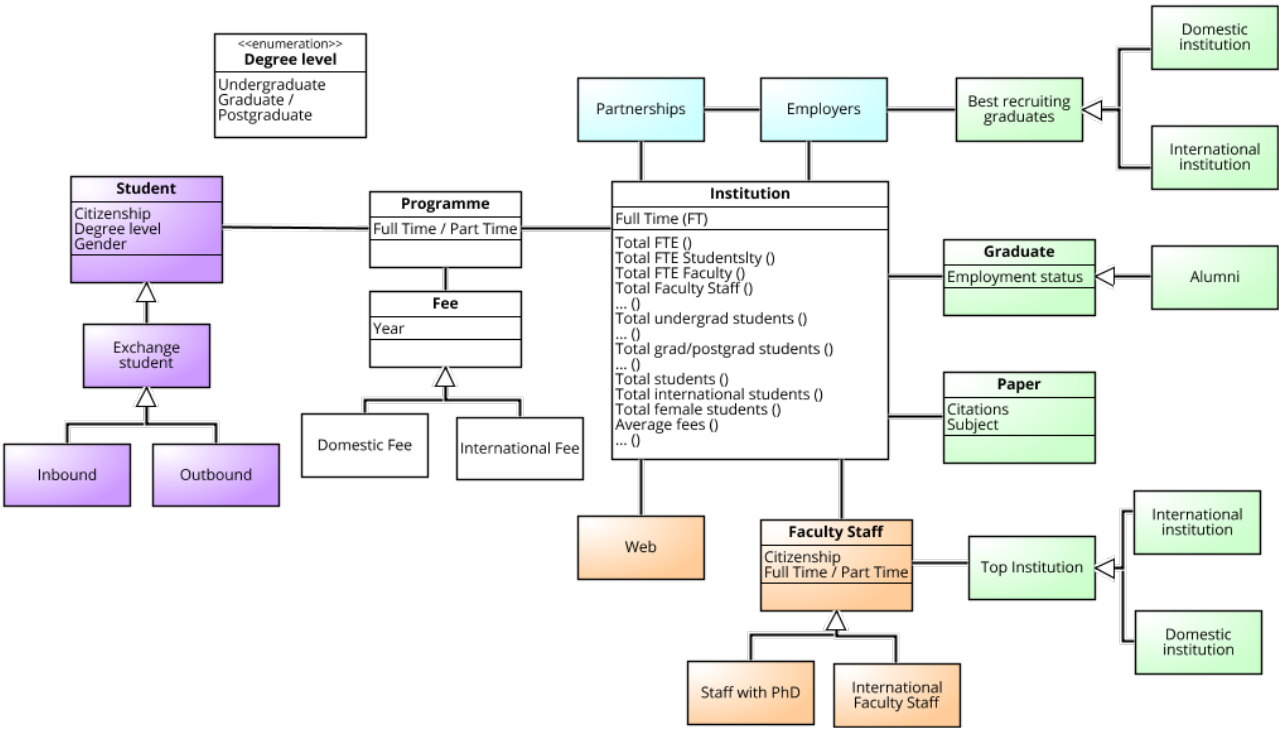


Figure 6.5: QS: Information Model

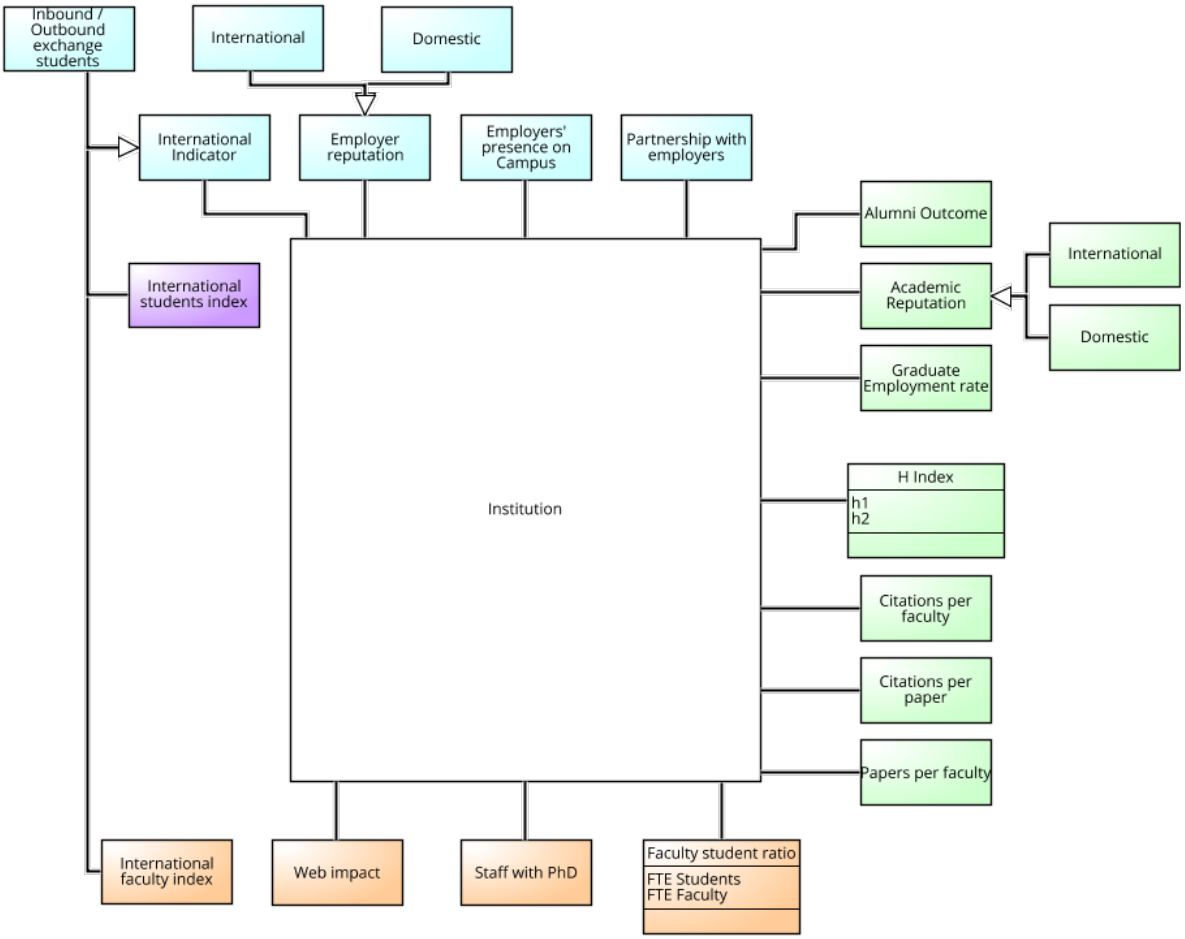


Figure 6.6: QS: Indicators Model

6.3 Ranking Calculus Method

Once the z-scores are calculated and scaled, QS uses different weightings for each indicator to compute the overall score in the leading tables. Due to the variety of indicators and indicators' percentages along the different QS' rankings, this section takes only the QS World University Ranking's indicators as a reference to explain the weightings.

- **Academic reputation** (40%): represents teaching and research quality at the world's universities, and it is based on an academic survey.
- **Employer reputation** (10%): assesses how successful institutions are at providing most competent, innovative, effective graduates, and it is based on the QS Employer survey.
- **Faculty/Student Ratio** (20%)
- **Citations per faculty** (20%): the total number of citations received by all papers produced by an institution across a five-year period by the number of faculty members at that institution.[1]
- **International faculty ratio** (5%)
- **International student ratio** (5%)

6.4 Ranking Evaluation

This section evaluates QS World University Ranking in terms of transparency and ranking scope, as it is explained at section 2.1.

6.4.1 Transparency Evaluation

Transparency is focused on how QS opens to the general public and users its ranking system method. QS gets a transparency score of 20 over 30 points, that it is equivalent to 6'7 over 10. Justifications of each transparency point are detailed in the following tables.

Ranking process		
Concept	**Grade**	**Justification**
University contact process	0	No information available.
Data collection process	1	There is no information about the data collection process for the proportion of international students/faculty, H-Index, and Staff with PhD at [11][58].
Data cleaning process	1	There is no information about cleaning mechanism for employers' presence on campus, graduate employment rate, H-index, and proportion of international students/faculty at [11][58].
Data assessment process	3	The information available at [62] achieves the objectives of the data assessment process. Using QS' information, at section 6.1.4 and 6.3 the process and information are explained and modelled with a BPMN diagram.
Results publication	3	The information available at [11][58] achieves the objectives of the results publication. Using QS' information, at section 6.1.5 the process and information are explained and modelled with a BPMN diagram.
Total	**8**	

Table 6.1: QS: Transparency of ranking process

Ranking conceptual model		
Concept	**Grade**	**Justification**
Description/definition of ranking data	2	Data used is described but there is not enough information about data sources and surveys' questions at [11][58]
Conceptual model of ranking data	2	Indicators and data related to indicators are presented but there is not enough information at [11][58] to explain which data is used in each indicators and how this data is used to compute them.
Description of validation and clean mechanisms	2	Cleaning mechanisms are explained at [11][58], but for some indicators there is not any information about how they are cleaned or validated.
Total	**6**	

Table 6.2: QS:Transparency of conceptual model

Ranking calculus method		
Concept	Grade	Justification
Weights or algorithms for each concept or indicator	3	QS uses weights and z-scores for indicators, as it is explained at section 6.1.4 and 6.3, and some algorithms to normalise data, as it is explained at appendix D
Algorithms for ranking universities	3	QS uses leading tables to rank universities, as it is explained at section 6.1.5 .
Total	**6**	

Table 6.3: QS: Transparency of ranking calculation

Transparency Grades	
Concept	**Grade**
Ranking process of university ranking	8
Conceptual model of university ranking	6
Identification of weights and ranking calculus	6
Total	**20**

Table 6.4: QS: Transparency assessment grades total

6.4.2 Scope Evaluation

Scope evaluation classifies QS' indicators into 7 different categories, based on the ranking profiling explained in the *Method for Informational Analysis of University Rankings*. These categories are Scientific and research, Teaching and education, Social, Regional engagement, International orientation, Knowledge transfer, and Business and employability. QS is focused firstly on scientific and research output and secondly but with large gap in teaching and education performance, as it is shown in the following graph, as a result of classifying QS' indicators (see tables below).

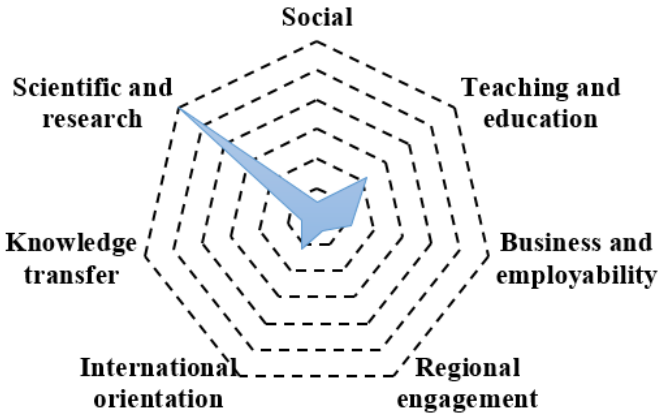


Figure 6.7: QS: Scope

	Scientific and research	Teaching and education	Social	Regional engagement	International orientation	Knowledge transfer	Business and employability
Academic eputation	40%						
Employer reputation							10%
Faculty/Student ratio		20%					
Citations per faculty	20%						
International faculty ratio					5%		
International student ratio					5%		
Total	60%	20%	0	0	10%	0	10%

Table 6.5: QS: Indicators scope

	%
Scientific and research	60%
Teaching and education	20%
Social	0%
Regional engagement	0%
International orientation	10%
Knowledge transfer	0%
Business and employability	10%
Total	**100%**

Table 6.6: QS: Indicators scope summary

Chapter 7

TIMES HIGHER EDUCATION

THE World University Ranking is annually audited by PwC [6] THE publishes its annual methodology [5] and audit, both are used as a reference to apply the *Method for Informational Analysis of University Rankings*.

7.1 Ranking Process

The analysis of ranking assessment process describes how THE does the process of ranking universities, that it is explained in four phases – data collection process, data cleaning and validation process, data analysis process, and results publication process. The phase *contact process* is not explained, due to the lack of information.

7.1.1 Contact Process

There is no both bibliographic and published information in open format about contact process at official THE sources.

7.1.2 Collection Process

THE ranking's data is provided directly by institutions, *Academic Reputation Survey* [63] and Elsevier's Scopus database. Last academic reputation survey was answered between January 2016 and March 2016 by scholars drawn from Elsevier's extensive database of published journal article authors.

After gathering all data, for some indicators and data points, THE joints the new data with the data from previous years:

- **Teaching**: data is combined with data from the previous year.
- **Citations** and **International collaboration**: data includes all indexed publications at Scopus from the previous 5 years windows and citations to these publications made in the six previous years.

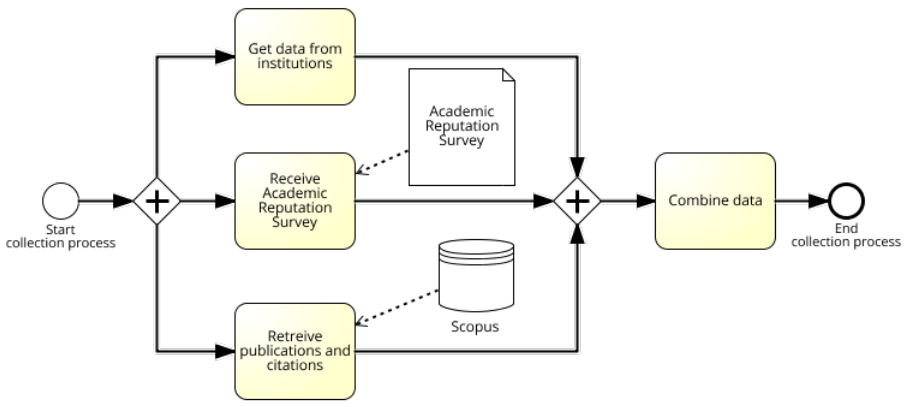


Figure 7.1: THE: Data Collection process

7.1.3 Cleaning Process

THE applies two different cleaning mechanism. Firstly, THE excludes HEIs from World University Ranking based on the following criteria:

- If HEIs do not teach undergraduates.
- If HEIs research output amounted to fewer than 1,000 articles between 2011 and 2015 (and a minimum of 150 a year).
- If 80 per cent or more of their activity is exclusively in one of THE eight subject areas.
- If HEIs have not supplied any “overall” numbers for the ranking year.
- If more than two of the critical overall values are null, the institution is marked as invalid.
- an institution must supply numbers for at least one applicable subject. If no applicable subjects have been reported, the institution is marked as invalid.
- HEIs that have requested not to participate in the ranking or that are not eligible for other institution-specific reasons have been excluded.

For the eight subject ranking tables, there is an additional threshold within the subject: At least 500 papers over 2011 – 2015 for subjects that generate a high volume of publications; and at least 250 papers over 2011 – 2015 in the social sciences, in the arts and humanities and in business and economics (where the volume tends to be lower). And also, is expected for an institution to have at least 5% of its staff working in the relevant discipline, 4% for engineering and technology or 2% for computer science, to be eligible for World University Ranking by Subject.[1]

Afterwards, when a particular data point is not provided (missed or zero) THE enter a low estimate between the average value of the indicators and the lowest value reported: the 25th percentile of the other indicators.[1]

Besides that, when a data error occurs, THE follows a clear policy, explained at [64] and check the data only with highly trusted third party data providers where necessary.

We show the process in the following figure:

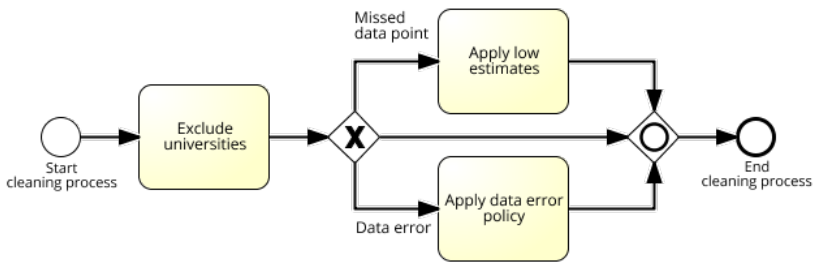


Figure 7.2: THE: Data Cleaning process

[1]This paragraph is largely copied from the explanatory text on the [5] and [6].

7.1.4 Assessment Process

To move from series of specific data points to indicators, and finally, to a total score for an institution, THE uses a standardisation approach for each indicator and then, combines the indicators with weightings. The standardisation approach used for all indicators except for the Academic Reputation Survey is based on a cumulative probability function using a version of Z-scoring. For data in the Academic Reputation Survey, THE adds an exponential component.

Even though, THE applies different processes to some data points to normalise it before standardisation approach:

- **Institutional income**, **research income** and **industry income**: data is scaled against academic staff numbers and normalised for purchasing-power parity.
- **Research productivity**: data is scaled for institutional size and normalised for subject.
- **Citations**: data is normalised. For papers with more than 1000 authors, a fractional counting approach is applied that ensures that all universities where academics are authors of these papers will receive at least 5 per cent of the value of the paper.

We explain the assessment process in the following BPMN diagram:

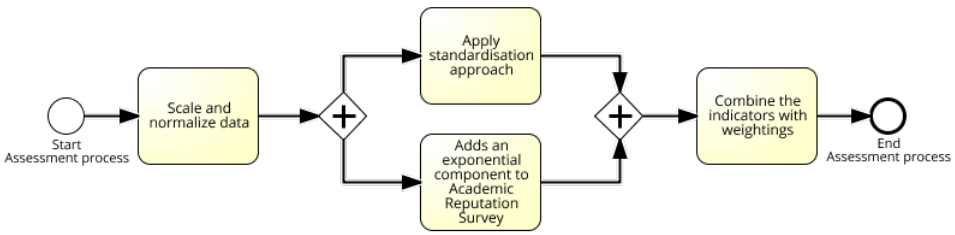


Figure 7.3: THE: Data Assessment process

7.1.5 Results Publication Process

THE makes public every year the HEIs ranking results at THE World Academic Summit in September. THE publishes the results in interactive leading tables where is represented the overall scores, indicators results and some statistic related with each HEI. We draw this process in the following diagram:

Figure 7.4: THE: Results publication process

7.2 Ranking Conceptual Model

Data is gathered from institutions and surveys, as it is explained at section 7.1.2. The conceptual model of THE is composed of the data points, indicators and the statistics related to HEIs, as it is shown at the figure 7.5. THE classifies its data in 5 different groups, using each of them as a global indicator to rank universities:

- Teaching
- Research
- Citations
- International outlook
- Industry income

We done the conceptual model representation with a high level of abstraction that can capture all the needed data for THE, in order to be easy to understand, flexible and adaptable.

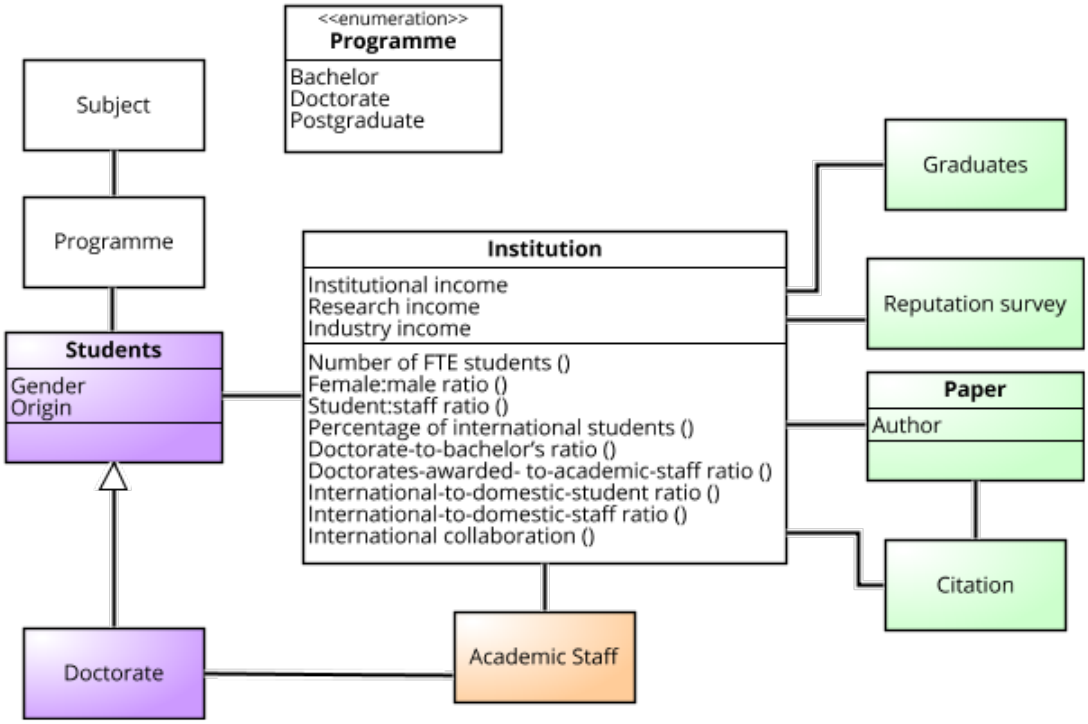


Figure 7.5: THE Model

7.3 Ranking Calculus Method

Once the standardisation approach is computed, THE uses weightings for each data point to compute the overall score of indicators and ranking positions in the leading tables. The following weightings of data points are grouped by indicators.

- **Teaching (the learning environment)**: 30%
  - Reputation survey: 15%
  - Staff-to-student ratio: 4.5%
  - Doctorate-to-bachelor's ratio: 2.25%
  - Doctorates-awarded- to-academic-staff ratio: 6%
  - Institutional income: 2.25%
- **Research (volume, income and reputation)**: 30%
  - Reputation survey: 18%
  - Research income: 6%
  - Research productivity: 6%
- **Citations (research influence)**: 30%
- **International outlook (staff, students, research)**: 7.5%
  - International-to-domestic-student ratio: 2.5%
  - International-to-domestic-staff ratio: 2.5%
  - International collaboration: 2.5%
- **Industry income (knowledge transfer)**: 2.5%

7.4 Ranking Evaluation

This section evaluates THE in terms of transparency and ranking scope as it is explained at section 2.1.

7.4.1 Transparency Evaluation

Transparency is focused on how THE opens its ranking system method to the general public and users. THE gets a transparency score of 24 over 30 points, that it is equivalent to 8 over 10. Justifications of each transparency point are detailed in the following tables.

Ranking process		
Concept	**Grade**	**Justification**
University contact process	0	No information available.
Data collection process	2	There is not enough information at [5], to explain when starts the retrieve process of institutional data, and which data is asked to HEIs and what happens when HEIs do not answer.
Data cleaning process	3	The information available at [5][6][64] achieves the objectives of the data cleaning process. Using the THE information, the process and information are explained and modelled with a BPMN diagram at section 7.1.3.
Data assessment process	3	The information available at [5] achieves the objectives of the data assessment process. Using the THE information, the process and information are explained and modelled with a BPMN diagram at section 7.1.4.
Results publication	3	The information available at [5] achieves the objectives of the results publication. Using the THE information, the process and information are explained and modelled with a BPMN diagram at section 7.1.5.
Total	**11**	

Table 7.1: THE: Transparency of assessment process

Ranking conceptual		
Concept	**Grade**	**Justification**
Description/definition of ranking data	1	Data used is described, but there are not enough definitions of each data point, and there is no information about which specific data is retrieved from each source and the contents of surveys at [5][63].
Conceptual model of ranking data	3	All indicators and data related to indicators are presented at [5], and the conceptual model is done in UML at section 7.2.
Description of validation and clean mechanisms	3	The description of validation and clean mechanism are described at [5][64] and explained at section 7.1.3.
Total	**7**	

Table 7.2: THE: Transparency of conceptual model

Ranking calculus method		
Concept	Grade	Justification
Weights or algorithms for each concept or indicator	3	THE uses weights and z-scores for indicators as it is explained at section 7.1.4 and 7.1.
Algorithms for ranking universities	3	THE uses leading tables to rank universities with as it is explained at section 7.1.5 .
Total	**6**	

Table 7.3: THE: Transparency of ranking calculation

Transparency Grades	
Concept	**Grade**
Ranking process of university ranking	11
Conceptual model of university ranking	7
Identification of weights and ranking calculus	6
Total	**24**

Table 7.4: THE: Transparency assessment grades total

7.4.2 Scope Evaluation

Scope evaluation classifies THE's indicators into 7 different categories, based on the ranking profiling explained in the *Method for Informational Analysis of University Rankings*. These categories are Scientific and research, Teaching and education, Social, Regional engagement, International orientation, Knowledge transfer, and Business and employability. THE is focused firstly on scientific and research output and secondly but with large gap in teaching and education performance, as it is shown in the following graph, as a result of classifying THE's indicators data points (see tables below).

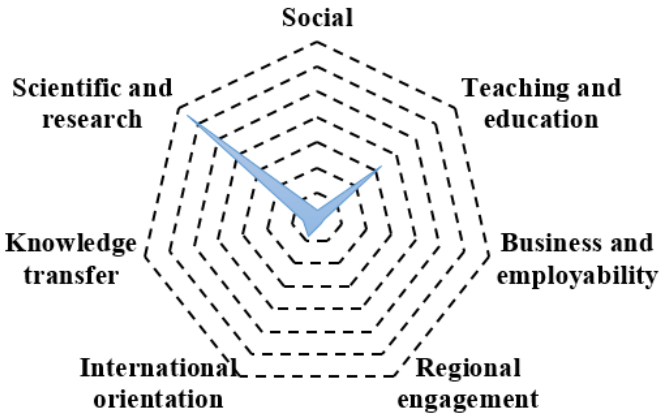


Figure 7.6: THE: Scope

	Scientific and research	Teaching and education	Social	Regional engagement	International orientation	Knowledge transfer	Business and employability
Reputation survey (teaching)		15%					
Staff-to-student ratio		4.5%					
Doctorate-to-bachelor's ratio		2.25%					
Doctorates-awarded- to-academic-staff ratio		6%					
Institutional income		2.25%					
Reputation survey (research)	18%						
Research income	6%						
Research productivity	6%						
Citations	30%						
International-to-domestic-student ratio					2.5%		
International-to-domestic-staff ratio					2.5%		
International collaboration	2.5%						
Industry income						2.5%	
Total	62.5%	30%	0	0	5%	2.5%	0

Table 7.5: THE: Indicators scope

	%
Scientific and research	62.5%
Teaching and education	30%
Social	0%
Regional engagement	0%
International orientation	5%
Knowledge transfer	2.5%
Business and employability	0%
Total	**100%**

Table 7.6: THE: Indicators scope summary

Chapter 8

BEST GLOBAL UNIVERSITIES RANKING

The Best Global Universities Rankings third annual edition is carried by U.S. News, who ranked intuitions from USA and other around 60 countries in the last 2017 edition. Best Global Universities publishes its methodology at [17]. Furthermore, U.S News has been ranking U.S universities for more than 30 years.

8.1 Ranking Process

The analysis of ranking assessment process describes how U.S News does the process of ranking universities, that it is explained in three phases – data collection process, data analysis process, and results publication process. The phases *contact process* and data cleaning and validation process are not explained, due to the lack of information.

8.1.1 Contact Process

There is no both bibliographic and published information in open format about contact process at official U.S News sources.

8.1.2 Collection Process

U.S News' first step in ranking the Best Global Universities is creating a pool of around 1200 universities from *Clarivate Analytics InCity* [16]. This pool is composed first by the top 200 universities form results of Clarivate Analytics' global reputation survey, and second by the universities that had published the largest number of articles during the most recent five-year period de-duplicated with the top 200 from the reputation survey.

Once U.S News gets the final pool of universities, it retrieves the bibliometrics data from the Web of Science and the other needed data from the Clarivate Analytics' global reputation survey results and answers. Publications results of the 2017 edition were limited to those published between 2010 to April 2016, and citations results were getting up to the most recent available at the moment.

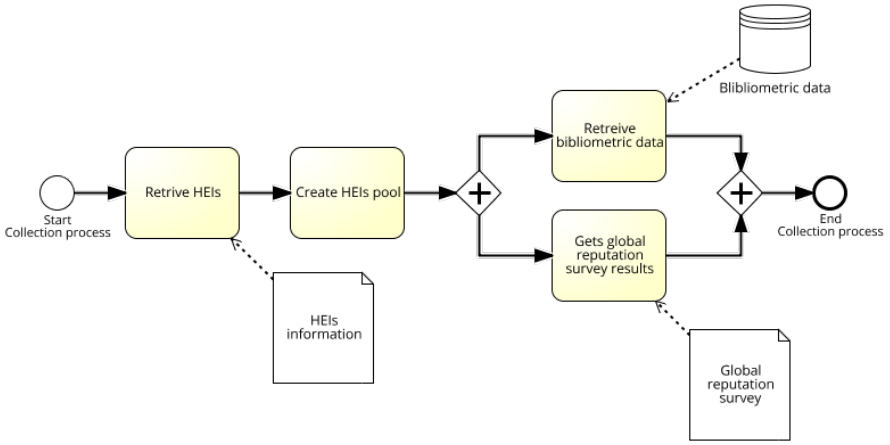


Figure 8.1: BEST: Data collection process

8.1.3 Cleaning Process

There is no both bibliographic and published information in open format about cleaning and validation process at official U.S News sources.

8.1.4 Assessment Process

U.S News uses weighting for each indicator to compute the overall score and rank universities. Before that, z-scores are applied to each indicator, in order to allow for fair comparisons between the different types of data. However, some indicators need a logarithmic transformation of the original values, due to their highly skewed nature. Those skewed indicators are:

- Publications
- Books
- Conferences
- Total citations
- Number of publications that are among the 10 percent most cited
- Global research reputation
- Regional research reputation
- Number of highly cited papers that are among the top 1 percent most cited in their respective field
- International collaboration

The overall score for each school was calculated by summing the school's weighted values for each indicator. The minimum score from the pool of schools was then subtracted from each of the scores to make zero the lowest possible score.[1]

The scores were then rescaled by multiplying the ratio between the overall performance of each university and the highest-performing university by 100. This forced the scores to fall on a 0-100 scale, with the highest-performing school earning an overall global score of 100.[1]

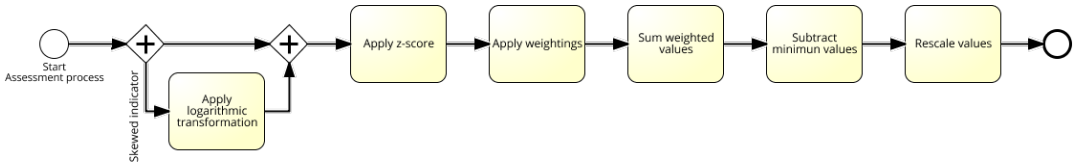


Figure 8.2: BEST: Data assessment process

[1]This paragraph is largely copied from the explanatory text on the [17].

8.1.5 Results Publication Process

U.S News publishes annually the results of HEIs ranking at the Best University Rankings, either by global, regional, country, city and subject views.

Figure 8.3: BEST: Publication process

8.2 Ranking Conceptual Model

Data used to rank universities is gathered from both Web of Science and Clarivate Analytics' global reputation survey. Those sources allow producing the 12 indicators used by U.S News. Indicators have both granularities global and specific by subject, in order to produce the geographical and subject view.

We done the conceptual representation with a high level of abstraction that can capture all the needed data for the Best Global Universities, in order to be easy to understand, flexible and adaptable.

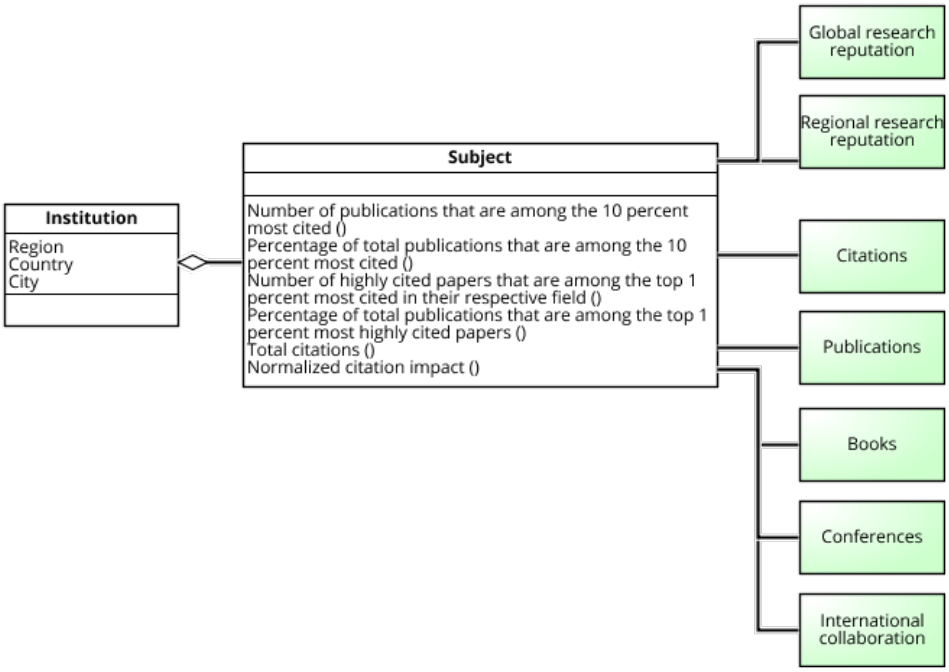


Figure 8.4: BEST: Model

8.3 Ranking Calculus Method

Once algorithmic transformations and z-scores are applied, U.S News uses the following weightings to compute the overall score by summing all:

- Global research reputation (12.5%)
- Regional research reputation (12.5%)
- Publications (10%)
- Books (2.5%)
- Conferences (2.5%)
- Normalized citation impact (10%)
- Total citations (7.5%)
- Number of publications that are among the 10 percent most cited (12.5%)
- Percentage of total publications that are among the 10 percent most cited (10%)
- International collaboration (10%)
- Number of highly cited papers that are among the top 1 percent most cited in their respective field (5%)
- Percentage of total publications that are among the top 1 percent most highly cited papers (5%)

8.4 Ranking Evaluation

This section evaluates the Best University Rankings in terms of transparency and ranking scope as it is explained at section 2.1.

8.4.1 Transparency Evaluation

Transparency is focused on how U.S News opens its ranking system method to the general public and users. Best Global University Rankings gets a transparency score of 19 over 30 points, that it is equivalent to 6.4 over 10. Justifications of each transparency point are detailed in the following tables.

Ranking process		
Concept	**Grade**	**Justification**
University contact process	0	No information available.
Data collection process	2	There is not enough information at [17], to explain when starts the retrieve process of data.
Data cleaning process	0	No information available.
Data assessment process	3	The information available at [17] achieves the objectives of the data assessment process. Using the U.S News information, the process and information are explained and modelled with a BPMN diagram at section 8.1.4.
Results publication	3	The information available at [17] achieves the objectives of the results publication. Using the U.S News information, the process and information are explained and modelled with a BPMN diagram at section 8.1.5.
Total	**8**	

Table 8.1: BEST: Transparency of ranking process

Ranking conceptual model		
Concept	**Grade**	**Justification**
Description/definition of ranking data	2	Data used is described, but there is no information about the survey questions at [17].
Conceptual model of ranking data	3	All indicators and data related to indicators are presented at [17], and the conceptual model is done in UML at section 8.2.
Description of validation and clean mechanisms	0	No information available.
Total	**5**	

Table 8.2: BEST: Transparency of conceptual model

Ranking calculus method		
Concept	Grade	Justification
Weights or algorithms for each concept or indicator	3	U.S News uses weights and z-scores for indicators as it is explained at section 8.1.4 and 8.1.
Algorithms for ranking universities	3	U.S News uses leading tables to rank universities with as it is explained at section 8.1.5 .
Total	**6**	

Table 8.3: BEST: Transparency of ranking calculation

Transparency Grades	
Concept	**Grade**
Ranking process of university ranking	8
Conceptual model of university ranking	5
Identification of weights and ranking calculus	6
Total	**19**

Table 8.4: BEST: Transparency assessment grades total

8.4.2 Scope Evaluation

Scope evaluation classifies Best Global University Ranking's indicators into 7 different categories, based on the ranking profiling explained in the *Method for Informational Analysis of University Rankings*. These categories are Scientific and research, Teaching and education, Social, Regional engagement, International orientation, Knowledge transfer, and Business and employability. Best Global University Rankings is only focused on scientific and research output, as it is shown in the following graph, as a result of classifying Best Global Universities Ranking's indicators data points (see tables below).

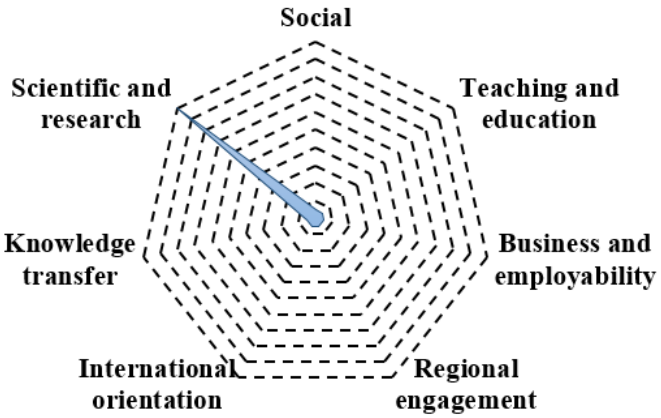


Figure 8.5: BEST: Scope

	Scientific and research	Teaching and education	Social	Regional engagement	International orientation	Knowledge transfer	Business and employability
Global research reputation	12.5%						
Regional research reputation	12.5%						
Publications	10%						
Books	2.5%						
Conferences	2.5%						
Normalized citation impact	10%						
Total citations	7.5%						
Number of publications that are among the 10 percent most cited	12.5%						
Percentage of total publications that are among the 10 percent most cited	10%						
International collaboration	10%						
Number of highly cited papers that are among the top 1 percent most cited in their respective field	5%						
Percentage of total publications that are among the top 1 percent most highly cited papers	5%						
Total	100%	0	0	0	0	0	0

Table 8.5: BEST: Indicators scope

	%
Scientific and research	100%
Teaching and education	0%
Social	0%
Regional engagement	0%
International orientation	0%
Knowledge transfer	0%
Business and employability	0%
Total	**100%**

Table 8.6: BEST: Indicators scope summary

Chapter 9

ACADEMIC RANKING OF WORLD UNIVERSITIES

Academic Ranking of World Universities (ARWU), also known as Shanghai Ranking, was first published with the initial purpose of finding the global standing of top Chinese universities. However, in 2003 ARWU becomes an international ranking. ARWU publishes join with the ranking tables its yearly methodology for each ranking. The last publication of the Shanghai Ranking 2017 and its methodology [65] is used to apply the *Method for Informational Analysis of University Rankings*.

9.1 Ranking Process

The analysis of ranking assessment process describes how ARWU does the process of ranking universities, that it is explained in four phases – data collection process, data cleaning and validation process, data analysis process, and results publication process. The phase *contact process* is not explained, due to the lack of information.

9.1.1 Contact Process

There is no both bibliographic and published information in open format about contact process at official ARWU sources.

9.1.2 Collection Process

First, the universities that are candidates to participate in the ranking process have to be defined. For that reason, ARWU only ranks those universities that have any Nobel Laureates, Fields Medalists, Highly Cited Researchers, papers published in Nature or Science, or universities with a significant amount of papers indexed by Science Citation Index-Expanded (SCIE) and Social Science Citation Index (SSCI).

Once ARWU has the selected set of candidate HEIs, it starts gathering the needed information for ranking:

- **Nobel laureates**: gathered from Nobel Prize organisation [66].
- **Fields Medals**: gathered from International Mathematical Union (IMU) [67].
- **Highly cited researchers**: gathered from Highly Cited Researchers of Clarivate Analytics [68].
- **Papers published in Nature and Science, and Articles indexed in Science Citation Index-Expanded and Social Science Citation Index**: gathered from Web of Sciene [23] but only publications of 'Article' type are considered.
- **Number of academic staff**: Data is obtained from national agencies such as National Ministry of Education, National Bureau of Statistics, National Association of Universities and Colleges, National Rector's Conference.

We show the collection process in the following figure:

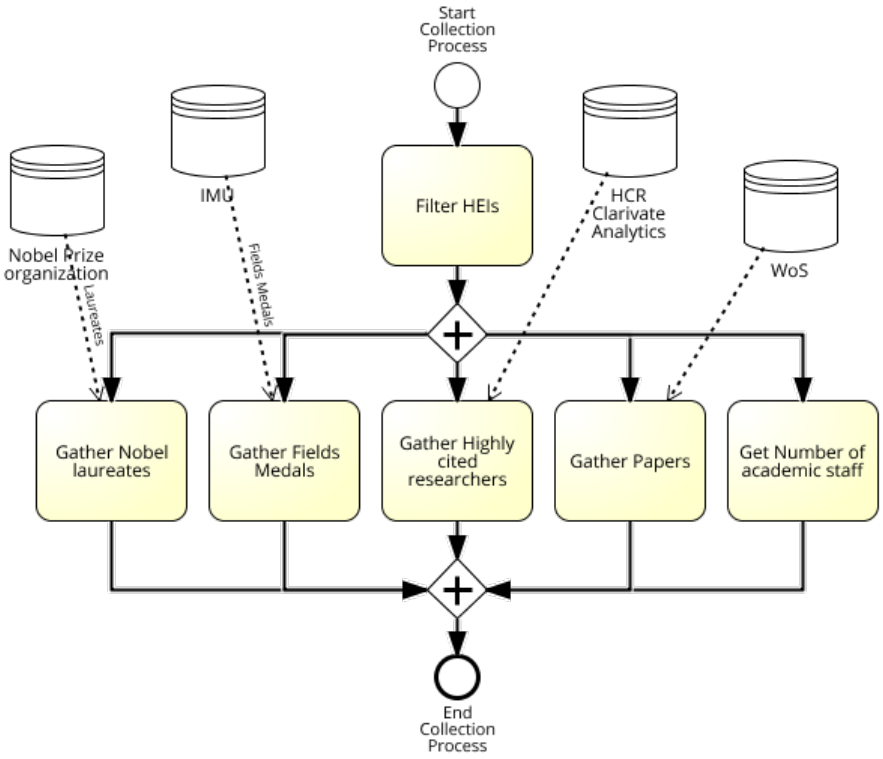


Figure 9.1: ARWU: Data Collection process

9.1.3 Cleaning Process

The distribution of data for each indicator is examined for any significant distorting effect; standard statistical techniques are used to adjust the indicator if necessary.[1]

9.1.4 Assessment Process

ARWU applies specific distributions to some indicators before computing the overall score using weightings. Per capita academic performance indicator is the only one that needs to be computed after applying the distributions and weightings of the other indicators. The different applied distributions are the following ones:

- **Alumni of an institution winning Nobel Prizes and Fields Medals**: Different weights are set according to the periods of obtaining degrees. The weight is 100% for alumni obtaining degrees in 2001-2010, 90% for alumni obtaining degrees in 1991-2000, 80% for alumni obtaining degrees in 1981-1990, and so on, and finally, 10% for alumni obtaining degrees in 1911-1920.[1]
- **Staff of an institution winning Nobel Prizes and Fields Medals**: Different weights are set according to the periods of winning the prizes. The weight is 100% for winners after 2011, 90% for winners in 2001-2010, 80% for winners in 1991-2000, 70% for winners in 1981-1990, and so on, and finally, 10% for winners in 1921-1930.[1]

[1]This paragraph is largely copied from the explanatory text on the [65] .

- **Papers published in Nature and Science**: To distinguish the order of author affiliation, a weight of 100% is assigned for corresponding author affiliation, 50% for first author affiliation (second author affiliation if the first author affiliation is the same as corresponding author affiliation), 25% for the next author affiliation, and 10% for other authors. affiliations.[1]

Finally, after applying distributions, weightings and compute per capita academic performance indicators, the overall score is computed and both indicators and overall score are scaled. We summarise the process in the following figure:

Figure 9.2: ARWU: Data Assessment process

9.1.5 Results Publication Process

ARWU ranks more than 1300 universities and makes two different ranking tables based on the overall score of HEIs: the main leading table ARWU with the top best 500 HEIs and the second table of those universities ranked between 501 and 800 (a.k.a ARWU World Top 500 Candidates). In both tables, HEIs can be filtered by country, and the different results of each indicator can be shown.

We represent the results publication process in following figure:

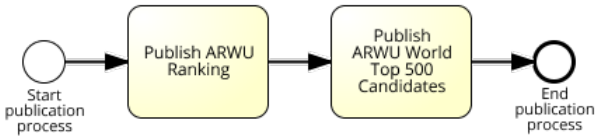


Figure 9.3: ARWU: Results Publication process

9.2 Ranking Conceptual Model

All indicators used to rank institutions at ARWU are explained at [65]. All indicators are gathered directly from sources, except *Per capita academic performance of an institution* indicator that it is computed from the other five indicators.

Shanghai Ranking classify the indicators used within 4 groups:

- Quality of Education
- Quality of Faculty
- Research Output
- Per Capita Performance

We represent the conceptual model of the Shanghai Ranking in following figure; it is done with a high level of abstraction that can capture all the needed data for ARWU, in order to be easy to understand, flexible and adaptable.

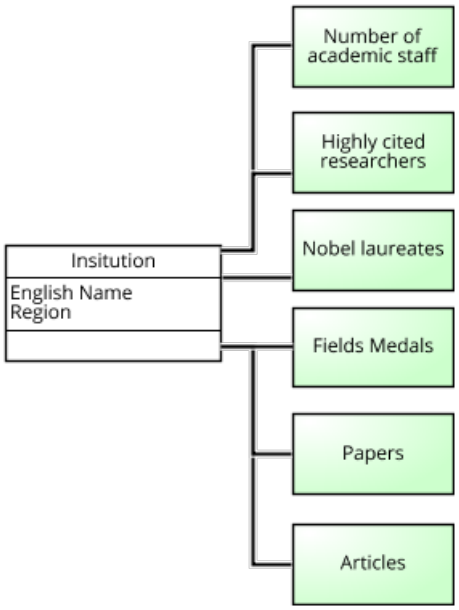


Figure 9.4: ARWU: Model

9.3 Ranking Calculus Method

ARWU uses weighting for indicators to compute the overall score, as it is explained below:

- **Alumni of an institution winning Nobel Prizes and Fields Medals**: 10%
- **Staff of an institution winning Nobel Prizes and Fields Medals**: 20%
- **Highly cited researchers in 21 broad subject categories**: 20%
- **Papers published in Nature and Science**: 20%
- **Papers indexed in Science Citation Index-expanded and Social Science Citation Index**: 20%
- **Per capita academic performance of an institution**: 10%

Before applying weightings to *Per capita academic performance of an institution* indicator it has to be computed with the weighted scores of the other five indicators divided by the number of full-time equivalent academic staff of the institution.

Once indicators and overall scores are computed, for each of them, the highest scoring institution is assigned a score of 100, and other institutions are calculated as a percentage of the top score.

9.4 Ranking Evaluation

This section evaluates the ARWU in terms of transparency and ranking scope as it is explained at section 2.1.

9.4.1 Ranking Transparency

Transparency is focused on how ARWU opens its ranking system method to the general public and users. Shanghai Ranking gets a transparency score of 22 over 30 points, that it is equivalent to 7.4 over 10. Justifications of each transparency point are detailed in the following tables.

Ranking process		
Concept	**Grade**	**Justification**
University contact process	0	No information available.
Data collection process	2	There is not enough information at [65], to explain when starts the retrieve process of data, and when HEIs are filtered.
Data cleaning process	1	There is not enough information at [65], to explain which standardisation techniques are used and under which conditions or in which cases are used.
Data assessment process	3	The information available at [65] achieves the objectives of the data assessment process. Using the ARWU information, the process and information are explained and modelled with a BPMN diagram at section 9.1.4.
Results publication	3	The information available at [65] achieves the objectives of the results publication. Using the ARWU information, the process and information are explained and modelled with a BPMN diagram at section 9.1.5.
Total	**9**	

Table 9.1: ARWU: Transparency of ranking process

Ranking conceptual model		
Concept	**Grade**	**Justification**
Description/definition of ranking data	3	All indicators used and their definitions are explained at [65].
Conceptual model of ranking data	3	All indicators and data related to indicators are presented at [65], and the conceptual model is done in UML at section 9.2.
Description of validation and clean mechanisms	1	Validation and clean mechanisms are named but not explained at [65].
Total	**7**	

Table 9.2: ARWU: Transparency of conceptual model

Ranking calculus method		
Concept	Grade	Justification
Weights or algorithms for each concept or indicator	3	ARWU uses weighting for indicators as it is explained at section 9.1.4 and 9.3.
Algorithms for ranking universities	3	ARWU uses leading tables to rank universities with as it is explained at section 9.1.5 .
Total	**6**	

Table 9.3: ARWU: Transparency of ranking calculation

Transparency Grades	
Concept	**Grade**
Ranking process of university ranking	9
Conceptual model of university ranking	7
Identification of weights and ranking calculus	6
Total	**22**

Table 9.4: ARWU: Transparency assessment grades total

9.4.2 Ranking Scope

Scope evaluation classifies ARWU's indicators into 7 different categories, based on the ranking profiling explained in the *Method for Informational Analysis of University Rankings*. These categories are Scientific and research, Teaching and education, Social, Regional engagement, International orientation, Knowledge transfer, and Business and employability. Shanghai Ranking is only focused on scientific and research output, as it is shown in the following graph, as a result of classifying ARWU's indicators (see tables below).

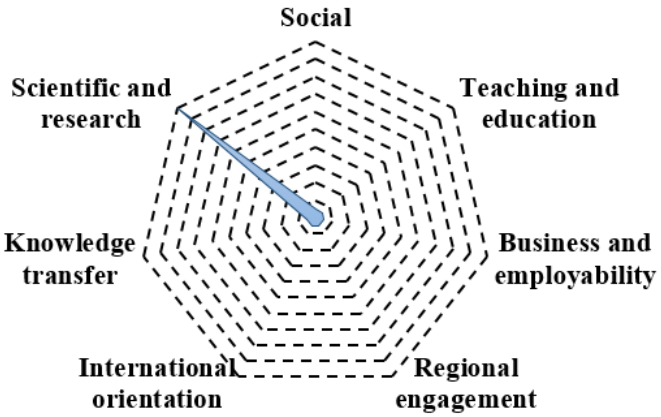


Figure 9.5: ARWU: Scope

	Scientific and research	Teaching and education	Social	Regional engagement	International orientation	Knowledge transfer	Business and employability
Alumni of an institution winning Nobel Prizes and Fields Medals	10%						
Staff of an institution winning Nobel Prizes and Fields Medals	20%						
Highly cited researchers in 21 broad subject categories	20%						
Papers published in Nature and Science	20%						
Papers indexed in Science Citation Index-expanded and Social Science Citation Index	20%						
Per capita academic performance of an institution	10%						
Total	100%	0	0	0	0	0	0

Table 9.5: ARWU: Indicators scope

	%
Scientific and research	100%
Teaching and education	0%
Social	0%
Regional engagement	0%
International orientation	0%
Knowledge transfer	0%
Business and employability	0%
Total	**100%**

Table 9.6: ARWU: Indicators scope summary

Chapter 10

NATIONAL TAIWAN UNIVERSITY RANKING

The *Performance Ranking of Scientific Papers for World Universities* (as known as NTU Ranking) is released by National Taiwan University. NTU Ranking provides an overall ranking, rankings by six fields [69], and rankings by 14 selected subjects [70]. The last publication of the NTU 2016 and its methodology [20] are used to apply the *Method for Informational Analysis of University Rankings*.

10.1 Ranking Process

The analysis of ranking assessment process describes how NTU does the process of ranking universities, that it is explained in four phases – data collection process, data cleaning and validation process, data analysis process, and results publication process. The phase *contact process* is not explained, due to the lack of information.

10.1.1 Contact Process

There is no both bibliographic and published information in open format about contact process at official NTU sources.

10.1.2 Collection Process

NTU first selects the top 900 HEIs from Essential Science Indicators (ESI) [71] based on the numbers of published journal articles and numbers of citations. Then the non-university institutions are removed from the list. After that filtering, the NTU staff compares the remaining universities to those included in other rankings such as ARWU, THE, QS, and U.S. News. This process results in a set of 938 universities.

Data used to rank universities is drawn from ISI's ESI and Web of Science Core Collection (WoS), which includes Science Citation Index (SCI) and Social Science Citation Index (SSCI), and Journal Citation Reports (JCR) [72]. The retrieved information is classified into 3 groups and gathered from each source as follows (more information, and data definitions and specifications at [20]):

- **Research productivity**: The number of articles published in peer-reviewed academic journals. Data comes from ESI and it is extracted every April.
- **Research impact**: The number of citations of a particular academic article within a specific time frame. Data comes from ESI and WoS.
- **Research excellence**: The h-index of the last 2 years, the number of Highly Cited Papers from ESI, and the number of articles in the current year in high-impact journals from JCR.

Due to the different indexed forms of a university's name in the aforementioned databases, the concept of authority control is introduced to retrieve data. Authority control considers the different forms of a university's name, such as the official name, the abbreviated name and other possible forms of the name. For that reason, NTU ranking system merges and splits universities (or different campuses in a university system) and includes publications by university-affiliated institutions such as research centres and university hospitals.

The collection process is explained in the following figure using our proposed BPMN diagram:

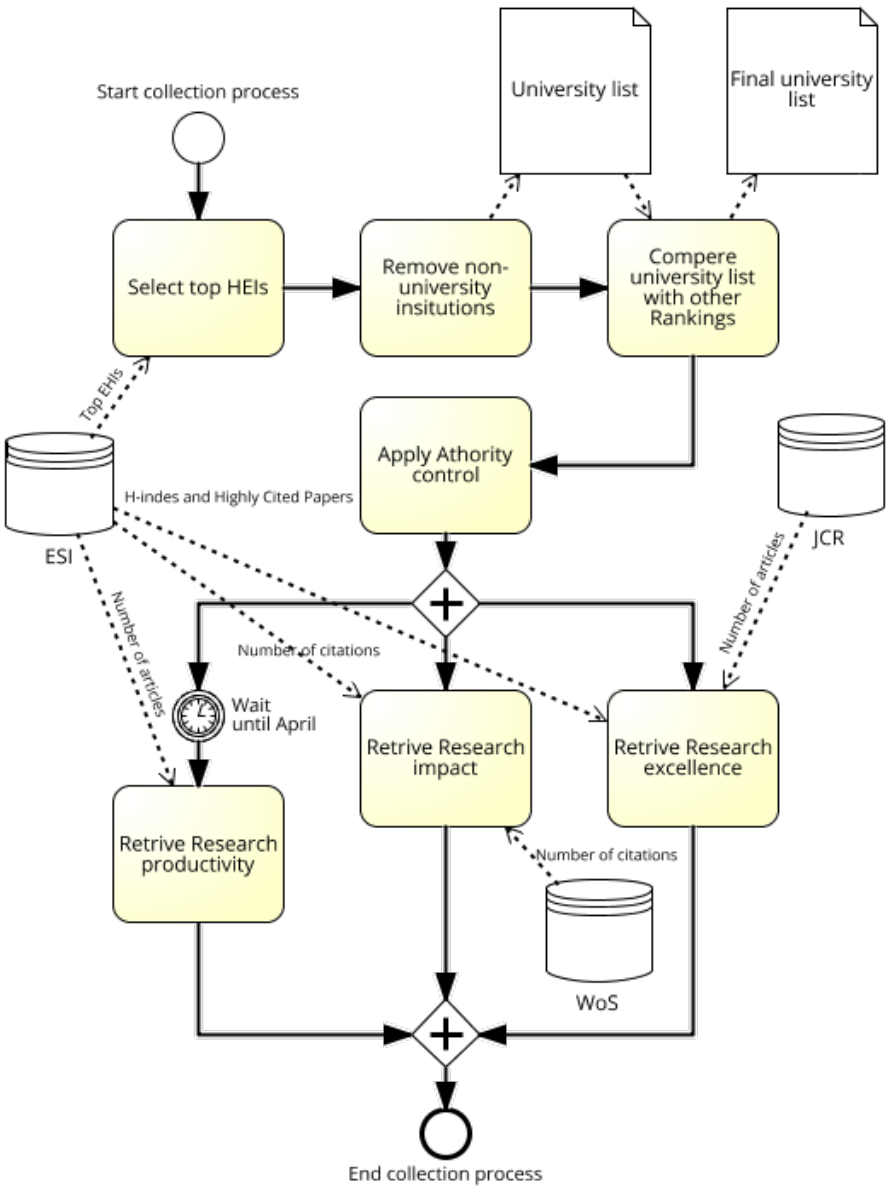


Figure 10.1: NTU Ranking: Data Collection process

10.1.3 Cleaning Process

Due to the authority control, NTU removes duplicate articles records containing different forms of that university's name to obtain the accurate number of the total articles from a university.

We explain the process of removing duplicates in the following figure:

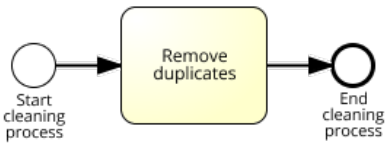


Figure 10.2: NTU Ranking: Data Cleaning process

10.1.4 Assessment Process

First, all indicators are normalised using T-score to obtain a finalised score. After, the final score of each university is calculated using the indicator weightings and universities are sort by their final scores. In case of same scores, universities are sorted alphabetically.

We show in the following BPMN diagram the assessment process:

Figure 10.3: NTU Ranking: Data Assessment process

10.1.5 Results Publication Process

Results are published every October 10th. NTU publish leading tables by overall score, field and subject.

We express the results publication process in the following BPMN diagram:

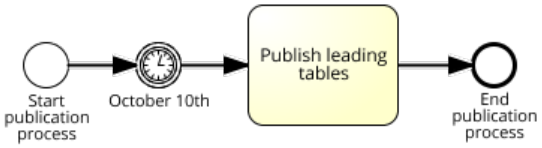


Figure 10.4: NTU Ranking: Results publication process

10.2 Ranking Conceptual Model

All indicators used to rank institutions at NTU are explained at [20]. Indicators are gathered directly from sources.

NTU classify the indicators used within 3 groups:

- Research productivity
- Research impact
- Research excellence

We represent in the following figure the conceptual model of the NTU Ranking; it is done with a high level of abstraction that can capture all the needed data for NTU, in order to be easy to understand, flexible and adaptable.

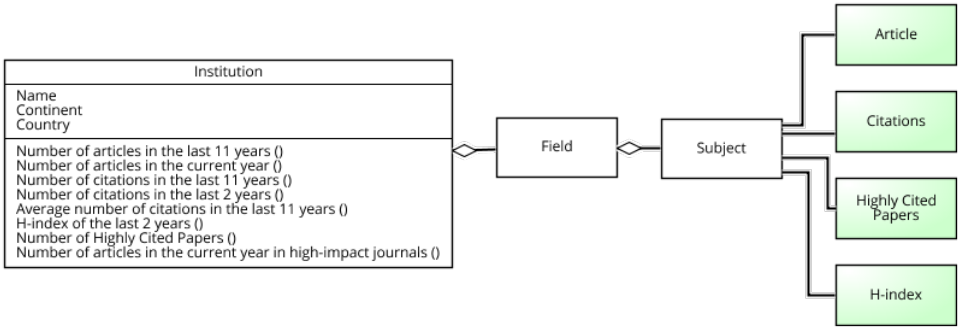


Figure 10.5: NTU Ranking: Model

10.3 Ranking Calculus Method

NTU first normalises all indicators using T-scores and after computes the scores using weighting. Indicators are grouped by 3 different categories and a weighting is assigned to each indicator, as follows:

- **Research productivity**: 25%
  - Number of articles in the last 11 years: 10%
  - Number of articles in the current year: 15%
- **Research impact**: 35%
  - Number of citations in the last 11 years: 15%
  - Number of citations in the last 2 years: 10%
  - Average number of citations in the last 11 years: 10%
- **Research excellence**: 40%
  - H-index of the last 2 years: 10%
  - Number of Highly Cited Papers: 15%
  - Number of articles in the current year in high-impact journals: 15%

10.4 Ranking Evaluation

This section evaluates the NTU Ranking in terms of transparency and ranking scope as it is explained at section 2.1.

10.4.1 Ranking Transparency

Transparency is focused on how NTU Ranking opens its ranking system method to the general public and users. NTU Ranking gets a transparency score of 27 over 30 points, that it is equivalent to 9 over 10. Justifications of each transparency point are detailed in the following tables.

Ranking process		
Concept	**Grade**	**Justification**
University contact process	0	No information available.
Data collection process	3	The information available at [20] achieves the objectives of the data collection process. Using the NTU Ranking information, the process and information are explained and modelled with a BPMN diagram at section 10.1.2.
Data cleaning process	3	The information available at [20] achieves the objectives of the data cleaning process. Using the NTU Ranking information, the process and information are explained and modelled with a BPMN diagram at section 10.1.3
Data assessment process	3	The information available at [20] achieves the objectives of the data assessment process. Using the NTU Ranking information, the process and information are explained and modelled with a BPMN diagram at section 10.1.4.
Results publication	3	The information available at [20] achieves the objectives of the results publication. Using the NTU Ranking information, the process and information are explained and modelled with a BPMN diagram at section 10.1.5.
Total	**12**	

Table 10.1: NTU: Transparency of ranking process

Ranking conceptual model		
Concept	**Grade**	**Justification**
Description/definition of ranking data	3	All indicators used and their definitions are explained at [20].
Conceptual model of ranking data	3	All indicators are presented at [20], and the conceptual model is done in UML at section 10.2.
Description of validation and clean mechanisms	3	Clean mechanism for duplicates is explained at section 10.1.3 and [20].
Total	**9**	

Table 10.2: NTU: Transparency of the conceptual model

Ranking calculus method		
Concept	Grade	Justification
Weights or algorithms for each concept or indicator	3	NTU Ranking uses weighting for indicators as it is explained at section 10.1.4 and 10.3.
Algorithms for ranking universities	3	NTU Ranking uses leading tables to rank universities as it is explained at section 10.1.5 .
Total	**6**	

Table 10.3: NTU: Transparency of ranking calculation

Transparency Grades	
Concept	**Grade**
Ranking process of university ranking	12
Conceptual model of university ranking	9
Identification of weights and ranking calculus	6
Total	**27**

Table 10.4: NTU: Ranking Transparency assessment grades total

10.4.2 Ranking Scope

Scope evaluation classifies NTU Ranking's indicators into 7 different categories, based on the ranking profiling explained in the *Method for Informational Analysis of University Rankings*. These categories are Scientific and research, Teaching and education, Social, Regional engagement, International orientation, Knowledge transfer, and Business and employability. NTU Ranking is only focused on scientific and research output, as it is shown in the following graph, as a result of classifying NTU Ranking's indicators (see tables below).

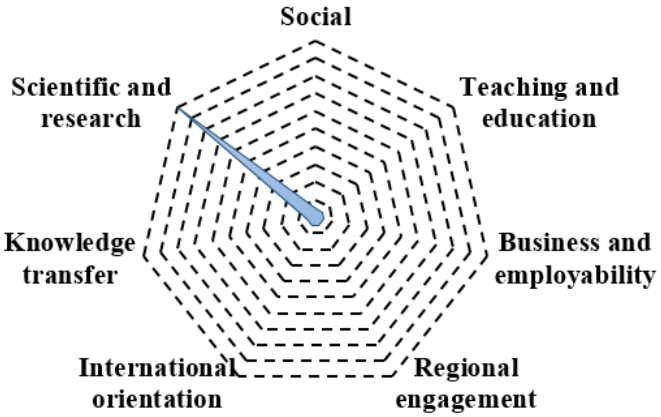


Figure 10.6: NTU: Ranking Scope

	Scientific and research	Teaching and education	Social	Regional engagement	International orientation	Knowledge transfer	Business and employability
Number of articles in the last 11 years	10%						
Number of articles in the current year	15%						
Number of citations in the last 11 years	15%						
Number of citations in the last 2 years	10%						
Average number of citations in the last 11 years	10%						
h-index of the last 2 years	10%						
Number of Highly Cited Papers	15%						
Number of articles in the current year in high-impact journals	15%						
Total	100%	0	0	0	0	0	0

Table 10.5: NTU: Ranking Indicators scope

	%
Scientific and research	100%
Teaching and education	0%
Social	0%
Regional engagement	0%
International orientation	0%
Knowledge transfer	0%
Business and employability	0%
Total	**100%**

Table 10.6: NTU: Ranking Indicators scope summary

Chapter 11

CWTS LEIDEN RANKING

CWTS Leiden Ranking is also known as Leiden Ranking, and it not only provides ranking information, but also provides aggregated and processed information about statistics on the scientific impact of universities and on universities' involvement in scientific collaboration. Leiden ranking has a published article at *Nature* about its ranking principles [73], a ranking manifesto at [74], and it also has a public discussion about its principles and other well-known rankings at [75]. In addition, CWTS has an extended information about its methodology at [76], that it is used to conduct the *Method for Informational Analysis of University Rankings*.

11.1 Ranking Process

The analysis of ranking assessment process describes how CWTS Leiden Ranking does the process of ranking universities, that it is explained in five phases – contact process, data collection process, data cleaning and validation process, data analysis process, and results publication process.

11.1.1 Contact Process

Leiden Ranking points out that HEIs do not need to apply to be included in the Leiden Ranking because CWTS takes universities from the WoS.

11.1.2 Collection Process

The first step is the identification and selection of universities for the CWTS Leiden Ranking of 2017. Leiden Ranking takes all universities worldwide that have produced at least 1000 Web of Science [23] indexed publications in the period 2012–2015. Leiden only takes into account the so-called *core publications* (publications in international scientific journals)[1], from these publications only research articles and review articles are taken into account.

Due to the complexity of the different kinds university organisation (collegiate universities, university systems, federal universities, or university hospitals), CWTS evaluates each university in the context of its particular mission and responsibilities, which are strongly linked to national and regional academic systems, in order to define the proper unit of analysis. For that reason, some universities organisations are split or merged according to CWTS' criteria based on each particular case.

The Leiden Ranking uses data from the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index.

[1] Core publications are those publications that have been written in English, have one or more authors, have not been retracted, and have appeared in a core journal. A journal is considered core journal when it has an international scope, as reflected by the countries in which researchers publishing in the journal and citing to the journal are located, and it has a sufficiently large number of references to other core journals, indicating that the journal is situated in a field that is suitable for citation analysis.

We synthesised the collection process in the following figure using our BPMN diagram:

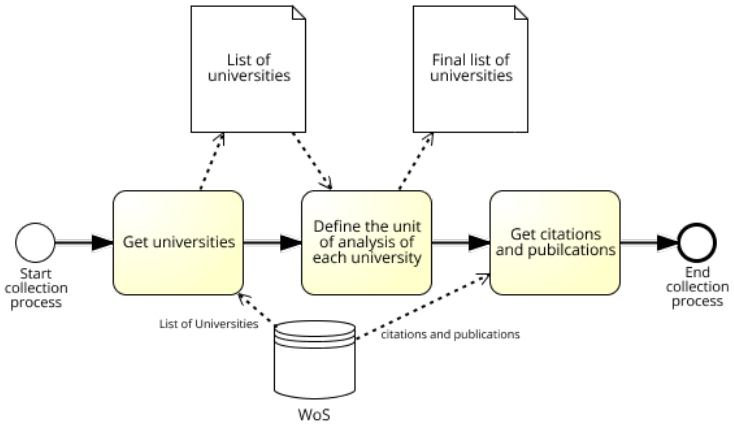


Figure 11.1: CWTS Leiden Ranking: Data Collection process

11.1.3 Cleaning Process

CWTS distinguishes between two types of errors in publication assignments to universities: false positives and false negatives. On the one hand, false positives are publications that have been assigned to a university when in fact they do not belong to the university. On the other hand, false negative are publications that have not been assigned to a university when in fact they do belong to the university. Manually checking all errors is unfeasible and those are a 5% of frequently occurring addresses in WoS, for that reason, this is considered a reasonable upper bound for errors and CWTS does not handle with them.

11.1.4 Assessment Process

First of all, CWTS performs its own citation matching and geocoding of the addresses listed in publications, in order to calculate the distance-based collaboration indicators. The citation matching algorithms are presented in a paper by Olensky, Schmidt, and Van Eck (2016) [77], and the geocoding of addresses are introduced at a paper by Waltman, Tijssen, and Van Eck (2011) [78].

Simultaneously, publications are assigned to fields using two algorithmic approaches explained at [79], [80], and [81]. Those algorithms first assign each publication in WoS to one of the 4003 micro-level fields. After, for each of the 4003 micro-level fields, the overlap with each of the 249 journal subject categories defined in WoS is determined. Each of subject categories at WoS is linked to one of the five main fields; and then each of the 4003 micro-level fields is linked to one or more of the five main field, based on the link between subject categories and main fields. A micro-level field is assigned to a main field, using the following criteria: at least 25% of the publications in the micro-level field belong to subject categories linked to the main field.

Finally, after citation matching, geocoding and field classification, CWTS produces the indicators that allow to rank and sort universities by their bibliometric output performance. These indicators are grouped into two types: impact indicators and collaboration indicators.

We show in the following BPMN diagram the assessment process:

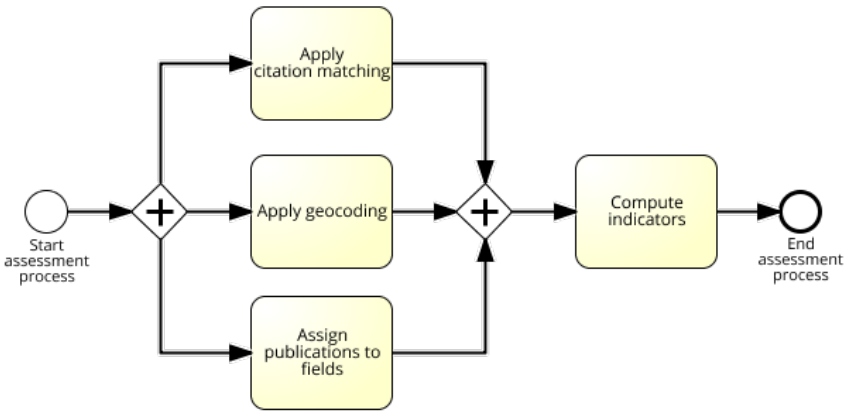


Figure 11.2: CWTS Leiden Ranking: Data Assessment process

11.1.5 Results Publication Process

Results are published using three different kinds of interactive views: list, chart and map. List view is a leading table, where universities are sort by selected indicators. Chart view is a scatter plot of universities using two indicators as axes. Map view represents universities in a map with bubbles, and the bubbles' size represents the indicator performance. The different kind of views can be filtered by time period, field, region/country, and minimum publication output; and also the type of indicator and indicators can be selected to sort universities.

We express the results publication process in the following BPMN diagram:

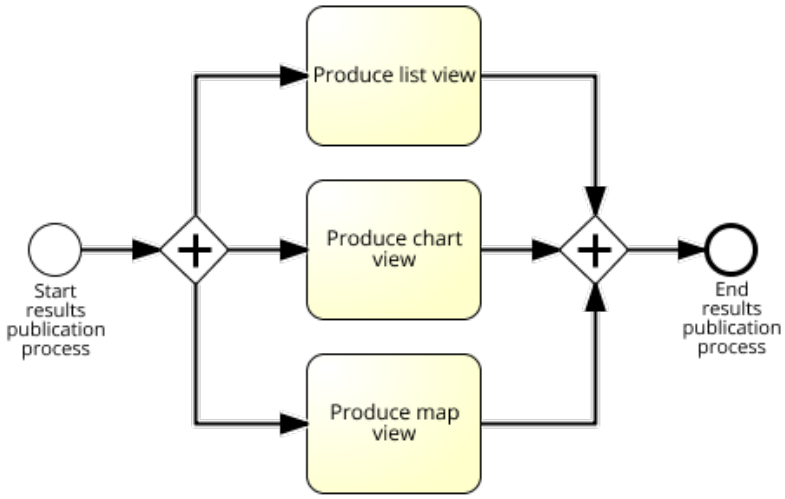


Figure 11.3: CWTS Leiden Ranking: Results publication process

11.2 Ranking Conceptual Model

The enriched data and indicators data used at CWTS ranking are explained at [76]. We represent in following figure the conceptual model of the CWTS Leiden ranking; it is done with a high level of abstraction that can capture all the needed data for Leiden ranking, in order to be easy to understand, flexible and adaptable.

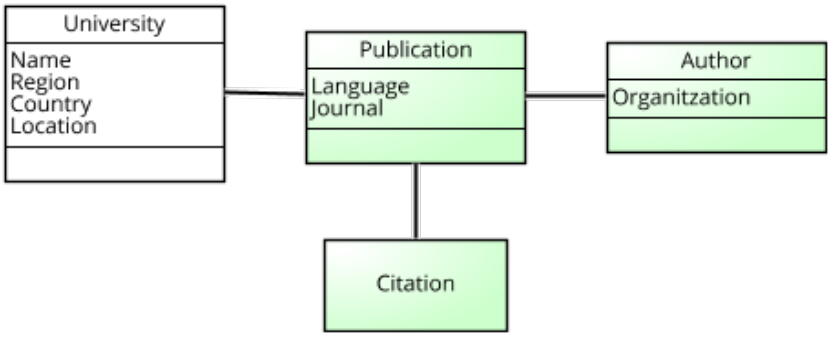


Figure 11.4: CWTS Leiden Ranking: Model

11.3 Ranking Calculus Method

Leiden Ranking uses two kinds of indicators: impact indicators and collaboration indicators. Impact indicators are based on the total number of publications, and collaboration indicators are based on those publications that are co-authored with one or more other organisations. Furthermore, for impact indicators, collaborative publications are counted fractionally (if a publication includes five authors of which two belong to a particular university, the publication is counted with a weight of 2 / 5 = 0.4 for that university).

Both impact an collaboration indicators has two variants: a size-dependent (*P("property")*) and a size-independent (*PP("property")*) variant. The size-dependent *P("property")* is the number of publications with a certain property from the total number of publications *P*. And the size-independent *PP("property")* is the proportion of publications with a certain property as percentage from the total number of publications *P*.

Impact indicators are the following ones:

- **P(top 1%, 10% or 50%) and PP(top 1%, 10% or 50%)**: The number and proportion of a university's publications that, compared with other publications in the same field and in the same year, belong to the top 1%, 10% or 50% most frequently cited.
- **TCS and MCS**: The total (TCS) and the average (MCS) number of citations of the publications of a university.
- **TNCS and MNCS**: The total (TNCS) and the average (MNCS) number of citations of the publications of a university, normalized for field and publication year.

Collaboration indicators are the following ones:

- **P(collab) and PP(collab)**: The number and the proportion of a university's publications that have been co-authored with one or more other organizations.
- **P(int collab) and PP(int collab)**: The number and the proportion of a university's publications that have been co-authored by two or more countries.
- **P(industry) and PP(industry)**: The number and the proportion of a university's publications that have been co-authored with one or more industrial organizations.
- **P(<100 km) and PP(<100 km)**: The number and the proportion of a university's publications with a geographical collaboration distance of less than 100 km.
- **P(>5000 km) and PP(>5000 km)**: The number and the proportion of a university's publications with a geographical collaboration distance of more than 5000 km.

After computing all indicators, universities can be sorted by each indicators. This way of ranking universities allows to have leading tables based on pre-selected indicators.

11.4 Ranking Evaluation

This section evaluates the CWTS Leiden ranking in terms of transparency and ranking scope as it is explained at section 2.1.

11.4.1 Ranking Transparency

Transparency is focused on how CWTS Ranking opens its ranking system method to the general public and users. Leiden Ranking gets a transparency score of 27 over 30 points, that it is equivalent to 9.4 over 10. Justifications of each transparency point are detailed in the following tables.

Ranking process		
Concept	**Grade**	**Justification**
University contact process	1	CWTS Leiden ranking explains that universities do not need to contact with the ranking organisation, but it is not explained how universities are informed about that they are being ranked.
Data collection process	3	The information available at [76] achieves the objectives of the data collection process. Using the CWTS Leiden Ranking information, the process and information are explained and modelled with a BPMN diagram at section 11.1.2.
Data cleaning process	3	CWTS Leiden ranking explains which kind of errors could happen and why these errors are not treated at [76], as it is explained at section 11.1.3.
Data assessment process	3	The information available at [76] achieves the objectives of the data assessment process. Using the Leiden Ranking information, the process and information are explained and modelled with a BPMN diagram at section 11.1.4.
Results publication	3	The information available at [76] achieves the objectives of the results publication. Using the Leiden Ranking information, the process and information are explained and modelled with a BPMN diagram at section 11.1.5.
Total	**13**	

Table 11.1: CWTS Leiden ranking: Transparency of ranking process

Ranking conceptual model		
Concept	**Grade**	**Justification**
Description/definition of ranking data	3	All indicators used and their definitions are explained at [76].
Conceptual model of ranking data	3	All indicators are presented at [76], and the conceptual model is done in UML at section 11.2.
Description of validation and clean mechanisms	3	Justification of errors and why CWTS Leiden ranking does not deal with them is explained at 11.1.3 and [76].
Total	**9**	

Table 11.2: CWTS Leiden ranking: Transparency of conceptual model

Ranking calculus method		
Concept	Grade	Justification
Weights or algorithms for each concept or indicator	3	CWTS Leiden ranking does not use weights, instead of it Leiden Ranking sorts universities by indicators as it is explained at section 11.1.4 and 11.3.
Algorithms for ranking universities	3	CWTS Leiden ranking ranks universities by indicators and use different kinds of visualisa-. tion as it is explained at section 11.1.5
Total	**6**	

Table 11.3: CWTS Leiden ranking: Transparency of ranking calculation

Transparency Grades	
Concept	**Grade**
Ranking process of university ranking	13
Conceptual model of university ranking	9
Identification of weights and ranking calculus	6
Total	**28**

Table 11.4: CWTS Leiden ranking: Ranking Transparency assessment grades total

11.4.2 Ranking Scope

Scope evaluation classifies CWTS Leiden Ranking's indicators into 7 different categories, based on the ranking profiling explained in the *Method for Informational Analysis of University Rankings*. These categories are Scientific and research, Teaching and education, Social, Regional engagement, International orientation, Knowledge transfer, and Business and employability. CWTS Leiden Ranking is only focused on scientific and research output, as it is shown in the following graph, as a result of classifying Leiden ranking's indicators (see tables below).

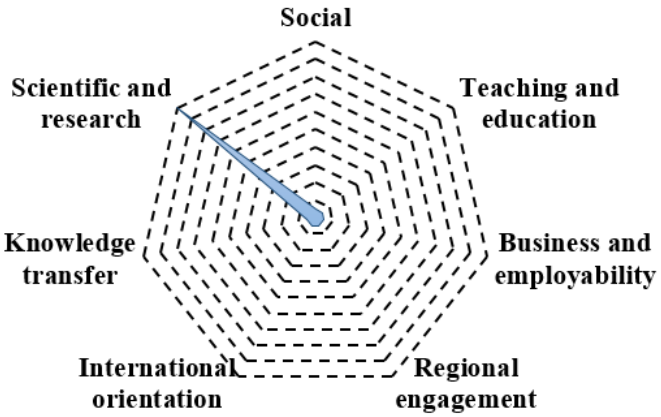


Figure 11.5: CWTS Leiden ranking: Scope

	Scientific and research	Teaching and education	Social	Regional engagement	International orientation	Knowledge transfer	Business and employability
P(top 1%)	✘						
P(top 10%)	✘						
P(top 50%)	✘						
PP(top 1%)	✘						
PP(top 10%)	✘						
PP(top 50%)	✘						
TCS	✘						
MCS	✘						
TNCS	✘						
MNCS	✘						
P(collab)	✘						
PP(collab)	✘						
P(int collab)	✘						
PP(int collab)	✘						
P(industry)	✘						
PP(industry)	✘						
P(<100 km)	✘						
PP(<100 km)	✘						
P(>5000 km)	✘						
PP(>5000 km)	✘						
Total	20	0	0	0	0	0	0

Table 11.5: CWTS Leiden Ranking: Indicators scope

	Sum	%
Scientific and research	20	100%
Teaching and education	0	0%
Social	0	0%
Regional engagement	0	0%
International orientation	0	0%
Knowledge transfer	0	0%
Business and employability	0	0%
Total	**20**	**100%**

Table 11.6: CWTS Leiden ranking: Indicators scope summary

Chapter 12

INFORMATIONAL GLOBAL VIEW

Informational global view shows a common conceptual and informational map of all ranking approaches studied at previous sections. This informational view is presented in four sections. The first section explains the common ranking concepts. The second section shows all ranking sources used at ranking systems. The third section presents a general ranking process that can be used for all ranking systems. And finally, the last section describes a ranking conceptual model that is a picture of the concepts used for all university rankings.

12.1 Ranking Common Concepts

There are some common concepts that appear along the different university rankings that have in some cases the same meaning and in other cases distinct significance. Pointing out these terms is important due to their relevance in the definition and contextualisation of university ranking systems. The most relevant terms that have to be remarked are:

- **HEI, universities and institutions**: similar terms and often used as synonyms, but used with different scope along ranking systems. For that reason is important to identify first which is the range of those terms in each ranking systems. Some ranking systems use HEI/university/institutions as synonyms that include any higher educational organisation (e.g. university or hospital school, autonomous business schools, or vocational higher-level studies). But other rankings use these terms to refer only to universities.

- **Academic staff, faculty staff**: terms used as synonyms to refer to those people working or associated at HEI that carry out tasks related to research or teaching at the institution.

- **FTE**: full-time equivalent is a concept that differs in its usage along ranking systems and it is very important to understand how it is computed in each different ranking. Some ranking systems use FTE as the number of hours that is equal to the full-time dedication of HEI's staff. Other ranking systems compute this concept as a sum of the proportion of the number of hours of full-time staff and the number of hours of those staff that doesn't work in a full time. At the same time, other ranking systems apply these measure to students too.

- **Publications**: is a general concept related to the research or HEI production that it is defined in many different forms along the different ranking systems. Ranking systems may delimit publications to specific kind of publications (e.g. articles, papers, books, artefacts) or publication places (e.g. ACM, Nature) and indexing platforms (e.g. Web of Science).

- **Field**: academic fields of programs and publications are defined differently in each ranking system. Some ranking systems use programme fields defined by UNESCO or other recognised institutions (e.g. Web of Science), and other ranking systems use their own definitions or systems for defining them.

- **Citizenship, nationality**: terms are used mainly as synonyms, but in some cases, the citizenship used is the first obtained and nationality used is the one expressed by the person.

12.2 Ranking Sources

Ranking systems use a large variety of sources to get data needed to rank HEIs. There are some sources that are repeated along ranking organisations and others are used only for some of them. Knowing which sources are used is important for HEIs in order to measure and establish their strategy or priorities when publishing content or review their impact in the sources used for ranking HEIs. The most important sources are:

- **HEI**: where ranking systems find information about programmes, subjects or send surveys.
- **Nobel prize organisation**: used to gather Nobel laureates.
- **Webometrics**: to retrieve the web impact of HEIs.
- **Mathematical Union**: to find the field medals.
- **WoS**: used to find HEIs and also retrieve information related to citations, publications, SSCI, SCIE, and interdisciplinary scores.
- **PATSTAT**: to get the information related to Patents.
- **Government organisations**: to get information and data related to students, professors, graduates, employment.
- **Scopus**: used to find information related to citations and scholars.
- **JCR**: used to find information related to citations.
- **ESI**: used to find HEIs.
- **Claribate Analytics InCity**: used to find HEIs, reputation survey and Highly cited researchers.

However, other sources are also used, such as LinkedIn, Forbes, FORTUNE, TIME used to retrieve alumni outcome information, or other ranking systems to observe which HEIs are ranked.

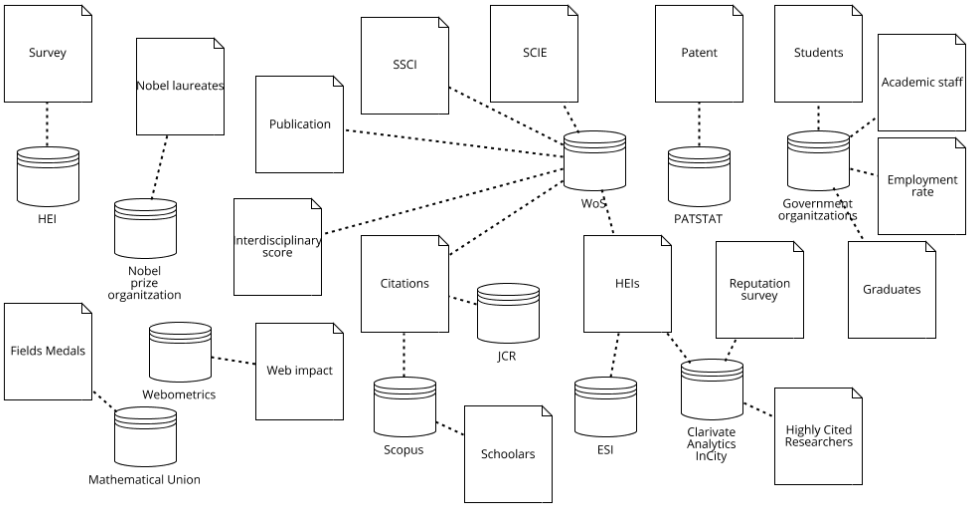


Figure 12.1: Sources

12.3 Ranking Process

This section describes a general process for ranking universities that is suitable for all international rankings systems studied and presented in this project. As each different ranking intuition has its own process, this proposal aims to be a model that could be used for all of them. The process' activities are not mandatory, these have to be used as a reference, and rankings should consider those activities that fit into their systems. A second and main objective of this model is to be used for HEIs to understand how ranking institutions work and which ranking processes they may expect.

12.3.1 Contact Process

The contact process is related to those tasks, prior to the data gathering, that is related to the definition of which HEIs will be ranked, the notice of the ranking process to these HEIs, and those activities that allow HEIs to participate in the ranking (e.g. send survey access codes).

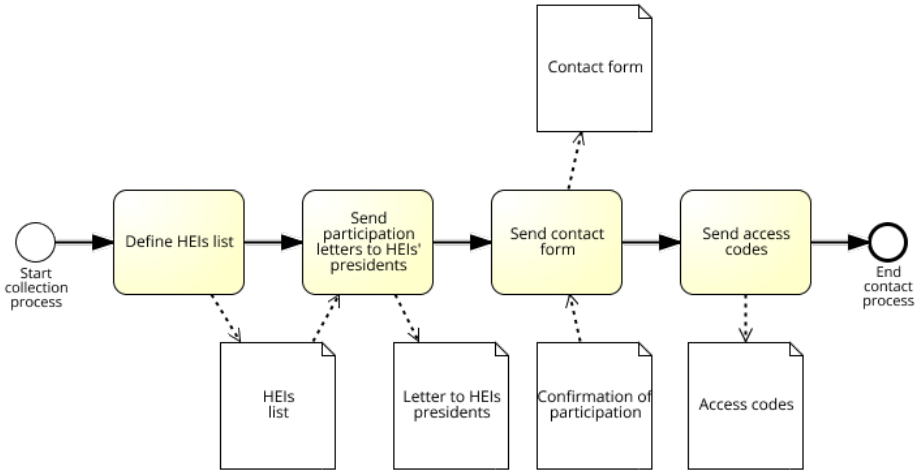


Figure 12.2: Contact process

The first step is defining the list of which HEIs will be involved in the ranking process. This list should be used to send a notification letter to HEIs presidents either to notice that their HEI will be ranked or ask for their participation. In case of asking for their participation, it will produce a list of HEIs that confirm their participation, and this list is will be used in the next step (send contact form). In both cases, the next step should send the contact form, because a contact person is needed in order to ask for their help, participation or to send the results, notices or news. Finally, if needed, the access codes to a platform where the data have to be uploaded or the access to surveys have to be sent, in order to start the gathering process.

In every single interaction with HEIs (e.g. send participation letter, send contact form or send access codes) should be implicit a contact protocol. This contact protocol should establish the procedure, mechanisms or timing of each interaction and which is the protocol in case of HEIs do not answer or the answer has any mistake or is wrong.

12.3.2 Collection Process

The collection process comprehends the tasks related to data gathering, data retrieval and data merging (e.q. merge data from different schools of the same HEIs, split data from HEIs into schools data). Those data can come either from HEIs, databases or other organisations. The process of collecting data is split into two branches, due to the fact that data can be obtained from two different ways: data can be submitted to ranking organisations, or data can be collected from databases and organisations or other recognised sources.

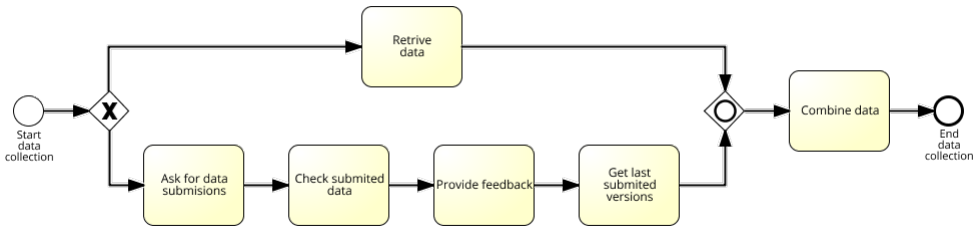


Figure 12.3: Data Collection process

The branch for submitted data starts asking for the submitted data to the actors in charge of submitting the data (i.e. actors can be HEIs, professors, employers or those people or organisations that have asked in order to provide the data). This step can be done either sending surveys, forms or notice saying that they can start the submission. After the data is submitted, it has to be checked in order to find any conflict (e.g. miss understanding, wrong answers, incorrect data). Often a feedback about the data submission is provided to inform either the data was successfully submitted or it has any kind of error. In both cases, the second period of submission is recommended to let actors the possibility to make data corrections.

The data collection branch embraces the activities related to data gathering and retrieving from databases (e.g. Web of Science, PATSTAT), governmental or institutional sources (e.g. HEIs' websites or reports, national databases, HESA) or other organisations or sources (e.g. Webometrics, Forbes, Clarivate Analytics).

After data collection and before validation and cleaning process, sometimes the data have to be merged, mixed or split due to the different organisation's entities of each HEIs (i.e. some university schools, university hospitals or campus can act as an independent centres or in the other way round, many different schools can act as only one entity, but in both cases these different kinds of entities may appear distinct from the reality in the sources).

12.3.3 Cleaning Process

The cleaning and validation process is focused on those activities related to data validation, errors detection, data verification and data cleaning and correction. Ranking institutions may have different protocols and systems to do the clean and validation process depending on which data they analyze. These different protocols can be grouped into data errors identification (e.g. missing and outlier detection, data inconsistency. strange values), data combination (e.g. combine data from previous years or different sources), excluding data (e.g. exclude proceedings from publications, remove duplicates), or checking data with other sources (e.g. comparison between data provided and data from databases).

After applying protocols, rankings could use their data policy to ensure good practices (e.g. remove those intuitions that have been done fraud in data) and/or correct the data (e.g. applying normalisation or standardisation algorithms, missing or outliers correction, remove data, find correct values).

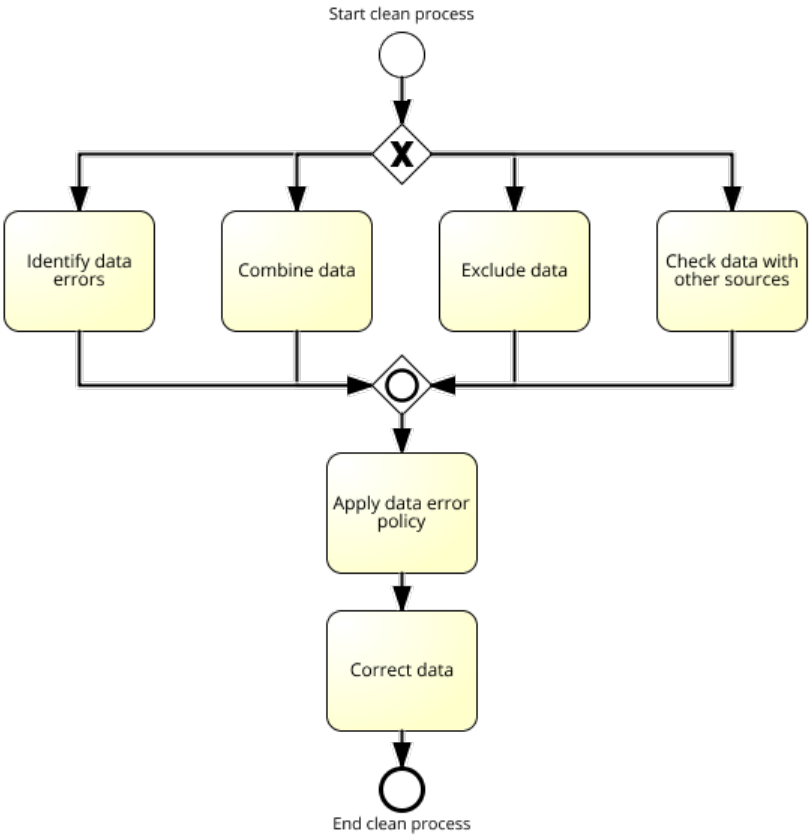


Figure 12.4: Data Cleaning process

12.3.4 Assessment Process

The assessment process is oriented to produce indicators, compute scores and rank HEIs. First, most of rankings systems have to produce indicators from data or make some transformations or apply algorithms (e.g. apply z-cores, logarithmic scales, normalisation, means, formulas). After, rankings sort universities using different systems such as overall scores, weightings or algorithms (e.g. grouping algorithms, normal curve, scales).

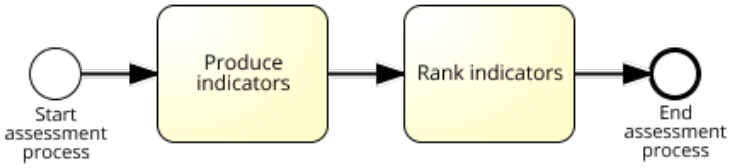


Figure 12.5: Data Assessment process

12.3.5 Publication Process

The publication process points to the activities that have the objective of making public the results of ranking HEIs. Ranking systems use a large number of different kinds of representations (e.g. interactive tables, leading tables, chart views) to show their results, and also different dates of publications, that in some cases those dates are announced before publication.

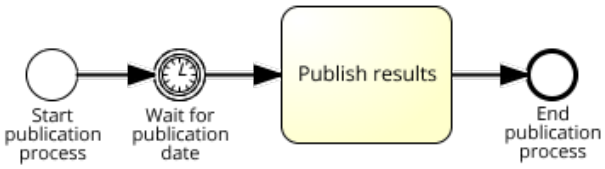


Figure 12.6: Publication process

12.4 Ranking Conceptual Model

This ranking conceptual model section describes the global view of how ranking systems understand in general terms HEIs. This model attempts to explain HEIs from ranking systems' point of view. Whereas, the model endeavours to be used for HEIs in order to organise their information or get new perspectives or concept to be measured.

All models presented configures the same model, but they are split into different concepts views. The first model is the representation of an HEI as an institution without its environment, as an infrastructure. Subsequent models represent the different environment concepts of HEIs.

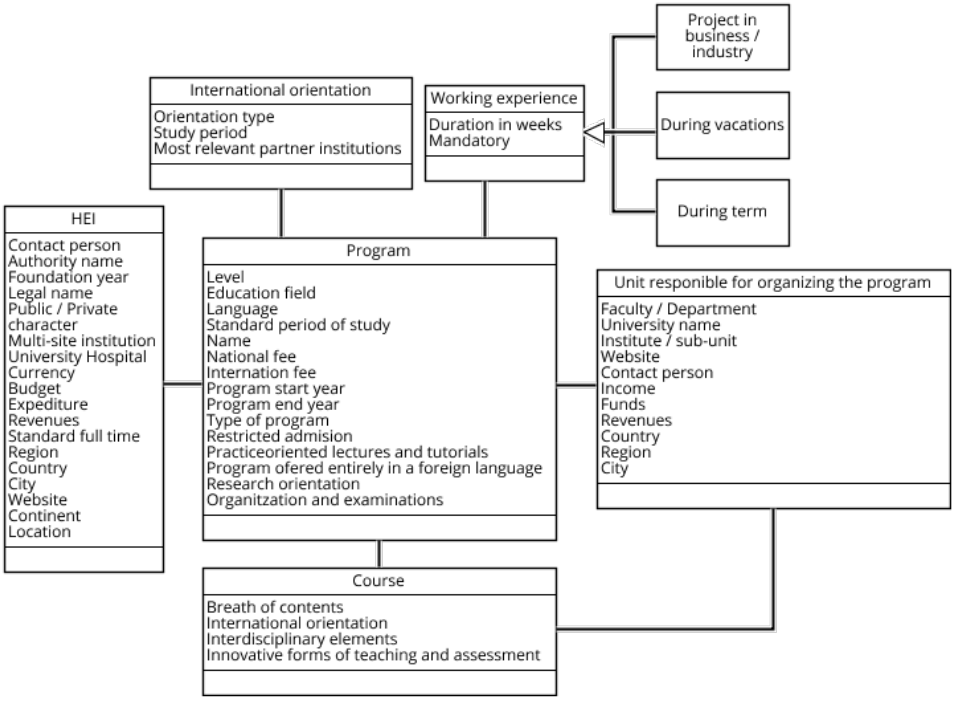


Figure 12.7: HEI Model

HEIs offer programmes that have courses (Subjects), and both programmes and courses have a unit responsible for them (e.g. department or group of research). HEIs have a legal name and an authority name (i.e. the international reference name, often the English name). HEIs have also information related to the characteristics of institution as foundation year, private or public status of the institution, multi-site form (i.e. a multi-site institution is an institution that has campuses spread along the territory), university hospital form (i.e. a university hospital is an HEI that is a hospital at the same time); information related to the location (continent, region, country, city, geo-location), detailed information about currency, budget, revenues and expenditures; and other information as contact person, website and standard full time. Units responsible for programmes and courses can be associated with a faculty or department and be an institute or a sub-unit, and these units have to be related to an HEI. Moreover, units have detailed information about funds, revenues and income, and they also have information about the contact person, website and location (country, region, city).

Whereas, programmes are related to an HEI, a unit responsible for the program and the courses that compound the program, and also have information related to the definition of the program itself. Programmes are defined with the level of studies (e.g. bachelor, MBA, PhD, Master), education field (Agriculture, education, social sciences), teaching language, standard period of study, types of degree program (e.g. full time, online, part-time), national and international fees, program start and end year (i.e. when the program was put in place and when the program was cancelled or ended), if the program has a restricted admission, if the program has practice-oriented lectures or tutorials, if the program is entirely offered in a foreign language, research orientation, and information about organisation and examinations. Also programmes are defined by their international orientation: type (e.g. join, double or dual degree program), study period (i.e. when the international orientation is produced) and most relevant partner institutions; and with the working experience in the program: the period of working experience, if this experience is mandatory or not, and which kinds of experience are. Although, the course contains information about the breath of contents they have, international orientation of the course, interdisciplinary contents that may have and the innovative forms of teaching and assessment that are used.

Students definition is the main aspect used to understand HEIs. Students are defined with personal details such as citizenship, age, gender, language and origin (i.e. origin can be different from citizenship, because citizenship is the first nationality and the origin refers to the family roots); enrolment information such as university name, university region, study field, degree level, program name, first enrolment year, previous enrolments in other HEIs, studying status (e.g. part-time. full time, graduate), institution first choice (i.e. information about other HEIs that could be selected in the same enrolment period), and studied abroad (i.e. information about the student had studied abroad or not). Students can have different categories, such as Doctoral student, International student (i.e. student citizenship is different from HEI's country) and exchange student (i.e. the student is coming or outgoing inside an exchange program). Besides that, students have a relation with programmes and HEIs, a student is associated with a program into an HEI with an entry qualification and the information of which country awards this qualification. Although exist another category that is Post-doc position, that it can be considered as a student even though it is not related to any program but it can be also considered as a researcher.

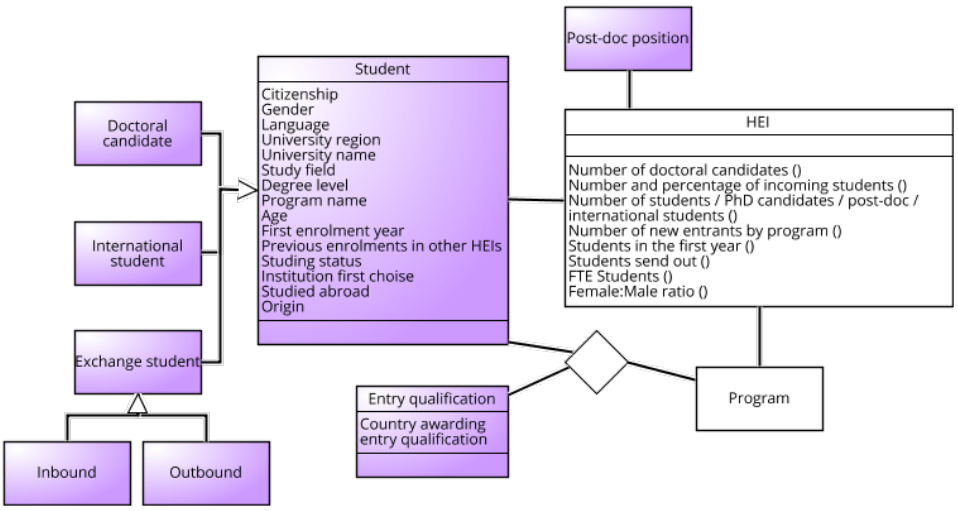


Figure 12.8: Students model

Moving from students to graduates there are 4 different aspects to take into account. Graduates have some important aspect to consider such as their employment status and their status after 19 months from graduation, working region, program level from which they get the graduate, and the graduation date. Often graduates conclude their studies throw a thesis of a specific degree level. These graduates can be considered alumni and an important measure could be their social outcome (i.e. the alumni relevance or success). The last aspect that may be observed is the existence of start-up firms or companies founded by graduates.

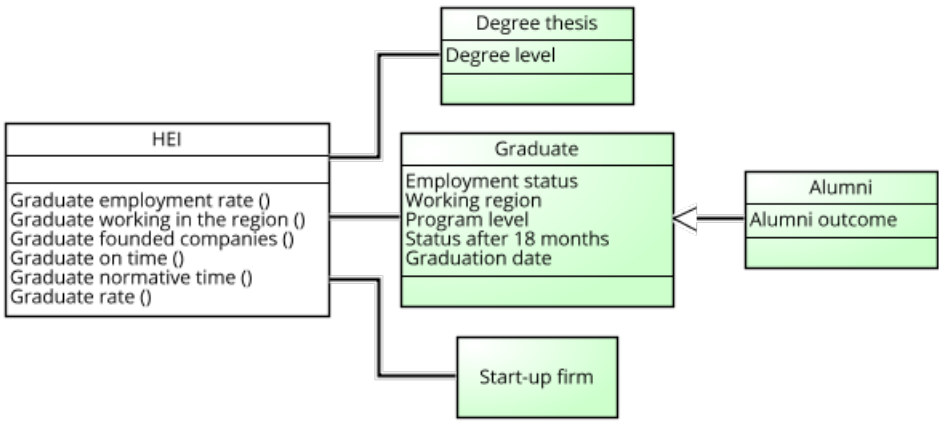


Figure 12.9: Graduates model

Academic staff are another core piece of HEIs. Academic staff are defined with their citizenship, sex and some categories as full/part-time, and which academic role they develop (e.g. research, teaching, associate/external professor). Besides that, academic staff can be classified into teaching staff (i.e. academic staff whose one of their tasks is teaching) and doctoral candidates (i.e. doctorate students whose have some role inside academia). For teaching staff information as didactic style, material, and willingness to enhance their teaching are obtained from surveys. In addition, post-docs appears again because they are involved in academic research.

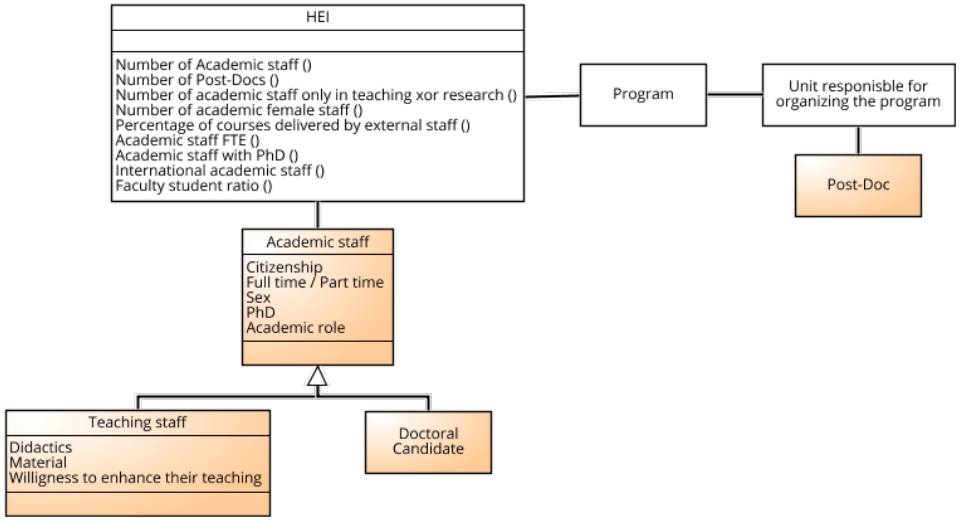


Figure 12.10: Academic staff model

The academic output or production is also measured and observed. In this way, there are two main groups to take into account: publications and patents, and the impact or results of the first group.

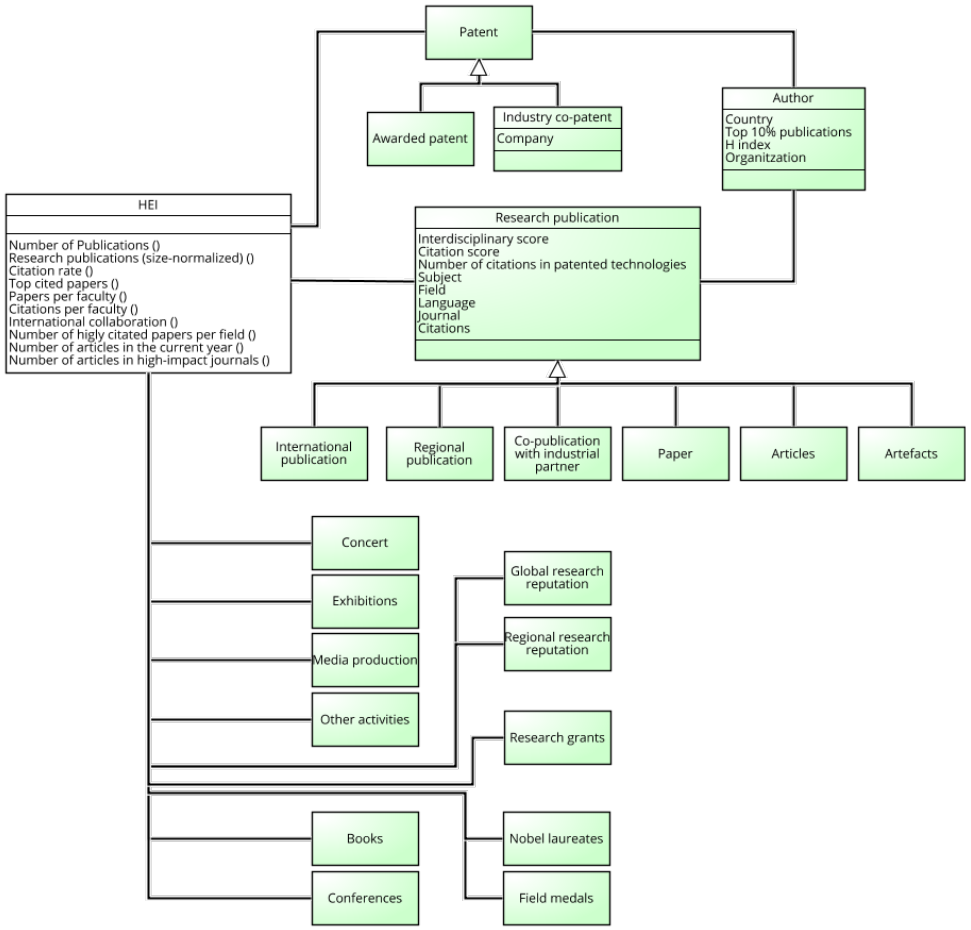


Figure 12.11: Academic output model

For publications, some data have to be observed such as subject, field, language and journal where it is published, and the most important information related to citations such as citations. citations scores, citations in patented technologies, and interdisciplinary score. Inside publication 6 different kind of publications can be distinguished: International publication (i.e. publications done with collaboration of at least one author from a different country), regional publications (i.e. all authors are from the same country), co-publication with industrial partner (i.e. publications done with at least one author working at company), paper, articles and artefacts. Patents can be both awarded patent or industry co-patents (i.e. patents produces at least with one author working at the company). Both publications and patents have to be related to the authors that produce it, and these authors related at the same time with HEIs or companies. The important aspects that have to be described for authors are country, the top 10% publications, H-Index, and organisation.

The second group of academic-related outputs takes into account academic activities (concerts, exhibitions, media production and others), another kind of academic productions (books and conferences), research grants, both global and regional research reputation get from surveys, academic recognition (Nobel laureates and field medals).

Another important aspect of HEIs' environment is the partnership with companies. HEIs can establish partnerships with enterprises or civil society (e.g. Non-Governmental Organisations, government). Both civil society or enterprises can be domestic or international. An important point of that partnership, is the capacity to hire graduates, done by employers (i.e. organisations that hire graduates) and their presence on campus. For all of these three different actors is important to know the region where the partnership or recruitment is done. An interesting aspect that could be measured with surveys or other instruments is both reputation of employers and the perception that employers have about the HEI.

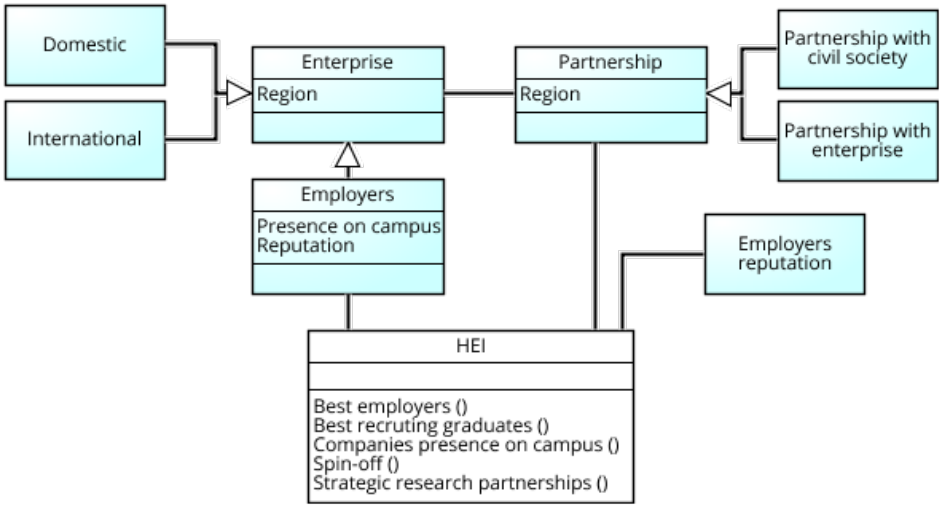


Figure 12.12: Partnerships model

HEIs' environment is also composed of the provided facilities such as university services, library, university rooms (lecture halls, laboratories, skills labs, hospital beds available for teaching), IT facilities, Wi-FI, community service learning and website.

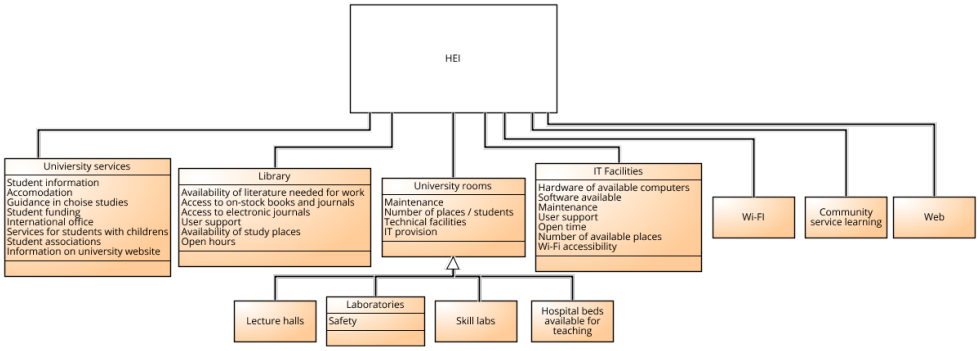


Figure 12.13: Facilities model

University services are related to those services offered by HEIs to students as information, accommodation, guidance in studies, funding, international office, services for students with children, student associations, website information. The library takes look at those aspects that library services cover such as the available literature needed for work, access to on-stock books, journals, electronic journals, user support, study places, and open hours. University rooms take into account the maintenance, number of places or student capacity, technical facilities, safety, and IT provision. The last aspect to cover is the HEIs IT facilities that can be analysed with hardware and software available, maintenance, user support, open hours, number of available places and Wi-Fi accessibility.

There are some other aspects that have to be observed and those are related to different aspects: study abroad, medical experience and strategic partnership. Study abroad looks the attractiveness of the abroad programs, support and advice received, financial support, recognition of the obtained results, and support and finding an internship abroad. Medical experience represents the linking between the clinical and preclinical teaching and the inclusion of practical experience and clerkships. Strategic partnerships represent that partnership that HEIs do with companies that can produce spin-offs.

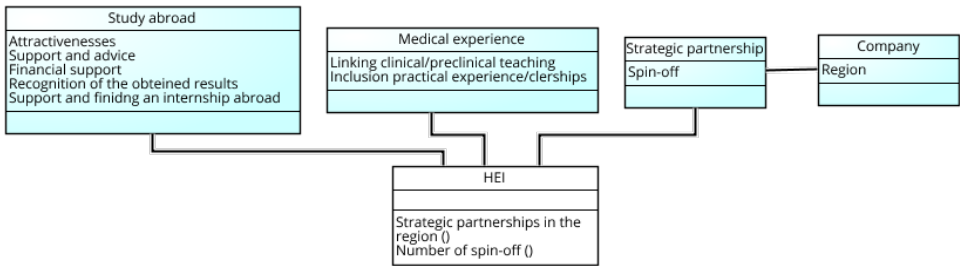


Figure 12.14: Other aspects model

There exist two important relationships between the different groups presented before. The first one, the two kinds of relationships that can be produced between a student and a company: internship and thesis (i.e. when a student does a thesis in a company), and when a thesis is done by a student into a company. The second one, the relationship between company and research, when the research is done jointly with a company.

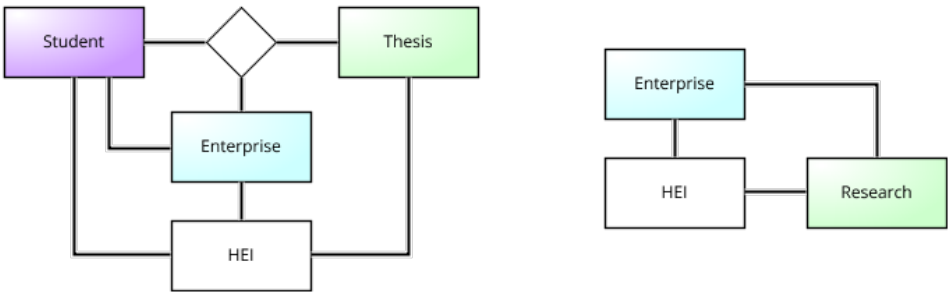


Figure 12.15: Relationships model

Whereas the previous conceptual models express the direct environment of HEIs, ranking systems take also into account the opinion of students and others actors. Both student's and others actors' opinions are gathered using surveys.

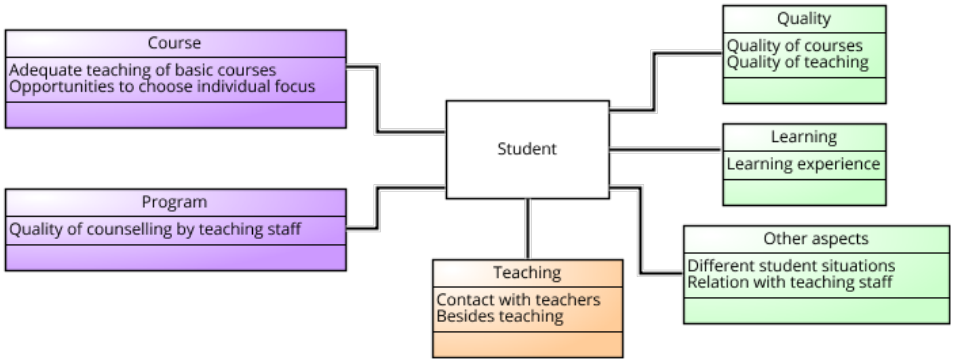


Figure 12.16: Student surveys model

Student surveys provide many different data and information. Along these variety some important aspects can be distinguished as the student opinion and experience about course (adequate teaching of basic courses, and opportunities to choose individual focus) and program (quality of counselling by teaching staff), teaching (contact with teachers, and besides teaching), quality of courses and teaching, learning experience, and other aspects (different student situations, and relation with teaching staff).

Other actors' surveys involve the opinion of faculty staff and employers about which HEIs they consider most relevant in their respective fields. Faculty staff are asked about which domestic and international HEIs they consider the best institutions in their field of domain. Employers are asked about which domestic and international HEI they give better reputation for hiring graduates or having strategic relationships.

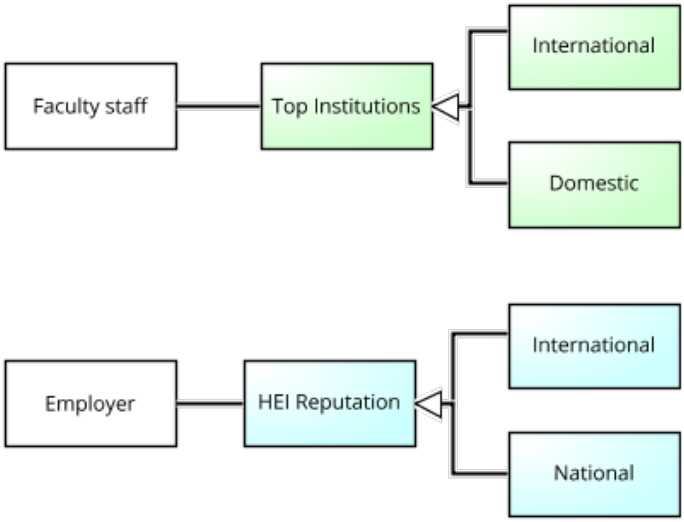


Figure 12.17: Other surveys model

Chapter 13

CONCLUSIONS

After applying the *Method for Informational Analysis of University Rankings* to the selected set of university rankings and perform the informational global view (presented at chapter 12) appear the two first conclusions about the evaluated university rankings and some considerations.

13.1 University Rankings Transparency

University rankings transparency conclusions are based on the results of assessing transparency to university rankings and focused on the possibility to reproduce all ranking processes and get the same or similar results only with the information provided at public rankings sources.

Due to the lack of resources and time to reproduce all the ranking process to get the same results, the conclusions about the possibility to replicate the same or similar results are only based on the accuracy of the information found. The information found is used by the *Method for Informational Analysis of University Rankings* and results are expresses as transparency grades (over 30), as shown in the following table.

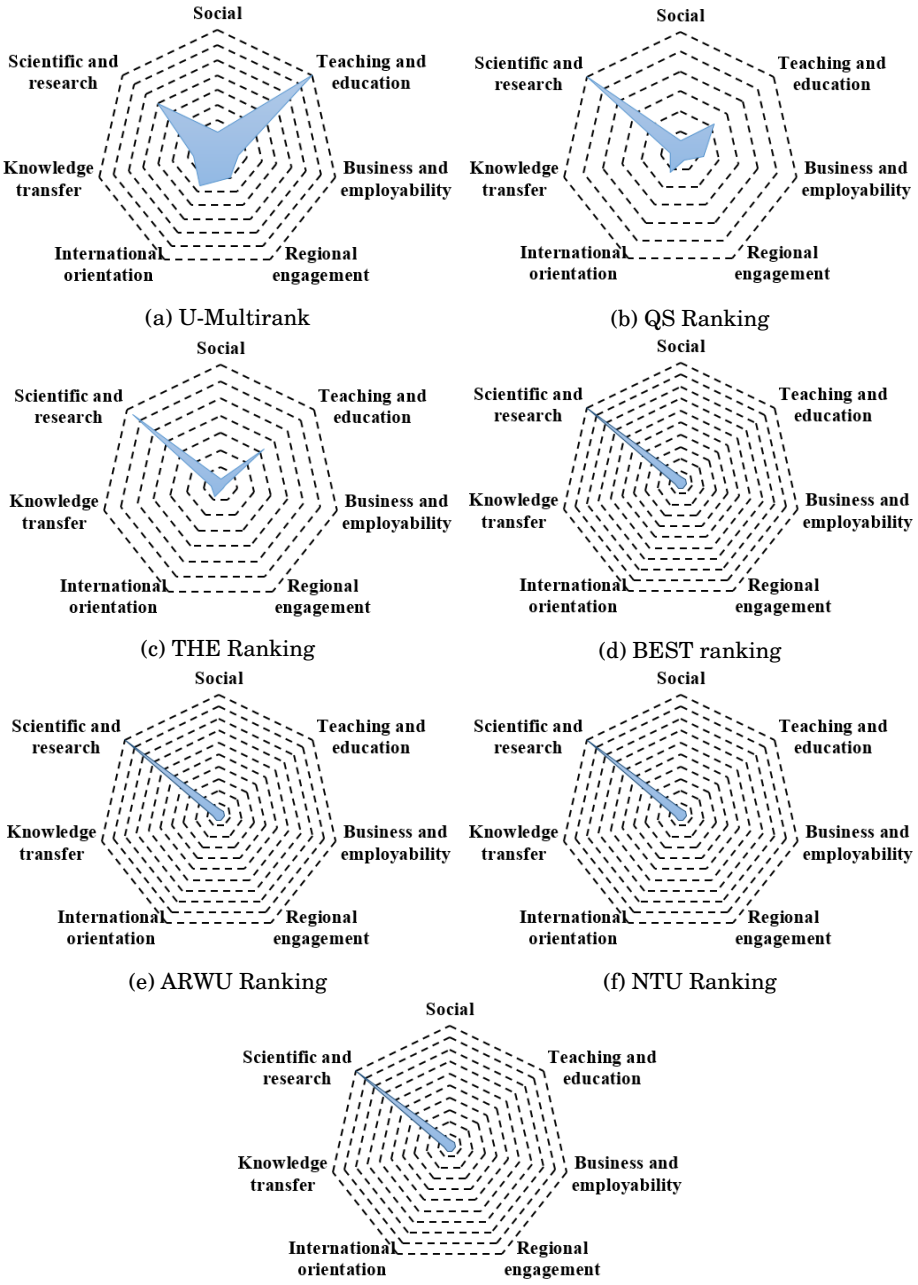
University Ranking	Transparency
U-Multirank	30
CWTS Leiden ranking	28
NTU Ranking	27
THE	24
ARWU	22
QS Ranking	20
BEST Global Universities	19

Table 13.1: University Rankings Transparency Results

Using all information found at the public university rankings' sources and the results of transparency assessment, the only ranking processes of university ranking systems that could be replicated and produce the same or similar results are the ones from **U-Multirank, CWTS Leiden ranking, and NTU Ranking**. Other rankings have some missing information in critical points as cleaning, gathering or assessment process. This lack of information makes unfeasible to reproduce the process from beginning to get the final results. However, in some cases, results could be reproduced if the university rankings provided the final data set that they use to compute results because the ranking method/algorithms are explained.

13.2 University Rankings Profiling

University rankings profiling conclusions present the results of profiling university rankings using the *Method for informational analysis of university rankings*. The Radial Diagrams with key scopes of rankings (scientific and research, teaching and education, social, regional engagement, international orientation, knowledge transfer, business and employability) are ideal tools to easily visualise ranking orientation.



(a) U-Multirank

(b) QS Ranking

(c) THE Ranking

(d) BEST ranking

(e) ARWU Ranking

(f) NTU Ranking

(g) CWTS Ranking

Figure 13.1: University rankings profiling results

As shown in the previous results of university ranking systems profiling, the scientific and research component is the strongest factor of rankings and in most cases the only component. However, at U-Multirank the weighting of the scientific and research component is decreased in favour of teaching and education, where it is the strongest factor. Another interesting case is the THE raking where the scientific and research component is the main one but teaching and education gets an important relevance.

13.3 Considerations

It is important to highlight some final considerations about the results obtained while doing the informational analysis of international university rankings.

first, our results of the informational global view (indicators, databases, ranking process, and the global view of how university rankings understand HEIs) have a high potential value for both rankings and HEIs. At the university rankings side, they can see a common and useful ranking process that it is easy to follow for all ranking systems. If all ranking systems follow the same o very similar processes, HEIs can understand easily the ranking process and provide the needed data and responses, faster and with greater quality. At the HEIs side, they can design strategies, prioritise publication channels or re-think their action plans in order to put more emphasis or take into account the different factors of ranking systems.

Second, transparency on rankings provides more veracity and avoid the misconception of following third-party interests. At the same time, understanding better how HEIs are ranked and evaluated could help universities to improve their institutions.

Third, profiling university rankings is a powerful tool to understand the focus of ranking systems, using an easy and visual representation. Moreover, profiling rankings is useful in order to get a more coherent and critic lecture of rankings results, that makes more reliable and valuable the domain of university rankings.

Finally, after analysing the most popular, used and known university ranking systems, a common weakness would be the lack of indicators for social responsibility, sustainability, ethics, and other social aspects. A second general limitation would be about languages, because many rankings only take into account publications in English, depraving other languages and throwing them into a second place or lower category,with the implications that this may have for many scientific fields.

Chapter 14

IMPROVEMENTS PROPOSAL

This proposal of improvements is mainly focused on the needed indicators for social responsibility, ethics and sustainability, but at the same time, the proposal does not forget the need for transparency in rankings.

Transparency on rankings stands out the importance of open and public university ranking process, methodology, data used and how HEIs are ranked. Open the details of each step of the ranking process with the specific information and actions performed empower users to understand how each ranking works, and to know the steps and indicators/data used. At the same time, making public the information makes easier the gathering process, helps to avoid the misconception of following third-party interests, and allows HEIs to provide more reliable information used to rank them.

In order to help rankings to introduce new indicators for social responsibility, ethics and sustainability, we propose a list of possible ranking indicators[1]:

- Students with disability or vulnerability
- Projects with NGO and social economies
- Voluntary activities
- Projects in developing countries
- Inclusion of ethics, moral, social economies, social responsibility, and sustainability on subjects or programs
- Usage of open source resources
- Open data/information usage
- Recycling/re-usage, e-waste, energetic plans
- Consolidation of working and family life
- Income per student's family

[1]Every indicator can be computed as total, mean, deviation, percentage, classification or any other kind of aggregation, or split into the different aspects that it covers.

Chapter 15

OPEN QUESTIONS

This chapter aims to present and open new lines of research taking as a starting point either the results or the method presented in this study. Some of the presented new research lines are proposals for new services, and the others are oriented to take benefit and use the results and knowledge obtained from the work undertaken in this thesis.

15.1 Tentative Presentation for an Eventual Tool to Analyse MBA Rankings

Rankings are often a key determinant factor for deciding on a degree program. This factor takes more importance in the decision for MBA program, where applicants expend an enormous amount of time and resources to find the best MBA program, to finally invest a huge amount of money (sometimes up to 150.000$ or more). For that reason, well-known outlets like *The Financial Times*, *Blooomberg Businessweek*, *The Economist*, and *Forbes* regularly publish rankings of MBA programs.

The framework of rankings as a key factor in deciding MBA programs makes sense to devise a service using the *Method for Informational Analysis of University Rankings* for providing information about ranking orientation and focus points, and the grade of transparency. This service should provide information about which aspects are evaluated and how they are represented in each ranking using the ranking profiling described at ranking evaluation of the method. At the same time, the service should also provide information about the rankings transparency using the ranking transparency evaluation explained in the method.

Event thought the *Method for Informational Analysis of University Rankings* is designed for ranking that evaluates universities instead of specific programs such as MBA program or specific units such as business schools, it can be easily adapted to any kind of ranking propose or focus by simply changing the key points on the profiling evaluation. This high adaptive grade to any kind of ranking propose makes the method flexible in order to be applied to a large number of different ranking or make it more specific to show up different aspects of rankings.

The service proposed should first study and define which focus points are the most relevant and significant for MBA applicants (e.g. post-graduation employment, new teaching methods, innovation, social aspects, sustainability) in order to be used in the method. Once the focus points are defined the service should provide both results of ranking transparency and ranking profiling for the desired rankings. Finally, users should find a platform where they can find information about MBA rankings (e.g. general information, information derived from the results of the *Method for Informational Analysis of University Rankings*) and information related to ranking profiling and transparency. This platform can help users to choose the MBA ranking that better fits in their interests and needs (e.g. platforms ranks/shows rankings based on selected focus points).

15.2 Usage of Ranking Information to Define University Positioning Strategies

Information and indicators used along all university rankings differ in each ranking system. Due to this high variety of data, it is important for HEIs to understand which data and sources of information are used, in order to establish a strategy to improve ranking results. It is important to point out that improving ranking results not only increases the ranking position, it may improve the university quality in some aspects or decrease it in others.

As ranking systems use only a limited set of publications databases and sometimes restrict publications to some parameters (e.g. field, language, references), it makes sense for HEIs to define a publications policy, in order to get more visibility or improve ranking results. This policy for publication it could use the informational global view presented in this study (see chapter 12), and the informational analysis done using the *Method for informational analysis of university rankings* to find which sources and restrictions use the most popular rankings. Using all the information found in this study, HEIs can give priority to some publication sources or languages for publications, instead of others, according to the ones used in ranking systems. Furthermore, the results of this study can be used to be applied in other strategies such as to improve facilities, teaching, partnerships and over any other indicator.

15.3 Usage of University Ranking Indicators to Improve and Design Academic Curricula

Design of academic curricula and plan is a complex task that has many different factors to be taken into account. Nevertheless, many of this factors answer academic, teaching and economic needs, and most of them can be easily related to indicators used in university ranks. At the same time, rankings offer an external and global view of HEIs through indicators that may answer the questions of students, universities and other actors (e.g. employers), that could be the same that can influence the design of each academic curriculum.

For that reason, the results of this study – the informational global view (at chapter 12) and the *Method for informational analysis of university rankings* – provide indicators that could help in the definition of new academic plans. New academic plans may use the method and the informational global view to find indicators that help to re-think the academic plans, adding a new dimension of clear needs or performance indicators that have to be answered.

15.4 Usage of University Ranking Profiling to Improve Institutional and International Relationships

A common situation at universities departments or research groups is to choose in which institutional relationships with other HEIs it is important to invest resources. Often these possible institutional relationships are new and the information about their potential is unknown. Due to that fact, it may happen that decisively point of reference could be the institution position in rankings. But as there are many different rankings, each ranking has its own way to rank universities and its own ranking focus, it could be unfair or misguiding to choose any ranking and take decisions based on ranking positions without having a prior knowledge on how each ranking system ranks universities.

For that reason, using the *Method for informational analysis of university rankings* or the result of the information global view presented in this study could be a good instrument to choose which university ranking can provide reliable and fair information. These tools can help on the decision of choosing institutional relationships because in each case the objectives of relationship can be aligned to some university ranking profiling or indicators used in ranking. By doing this analysis people in charge of institutional relationships are able to choose which university ranking use in every case.

15.5 Tentative Presentation for a Business Intelligence System for HEIs

University direction and administration teams need information to assess the results and evolution of their institutions. Nowadays each university/school have their own systems to measure these results and sometimes different institutions have different systems with different ways to view the HEI's environment. Most of these results and measures that each HEI uses to assess themselves are similar to those ones used at university rankings to rank universities.

According to the previous paragraph, it could be clear that it is feasible to develop a business intelligence tool with a standardised view of HEIs. This BI tool should have all indicators used in university rankings and be able to add those ones that are used only at the university level and from each different university. To get all indicators used at university ranking systems a good starting point is the information global view presented in this study. In order to expand the indicators set presented and analysed in this study, the *Method for Informational Analysis of University Rankings* gives an easy way to start an informational analysis of any ranking to find new information and indicators. Finally, the common conceptual model that can be adapted to any kind of HEI should be the one obtained at the informational global view after performing the analysis of the most popular rankings using the method presented in this study.

15.6 Tentative Presentation for a Service System or Portal to Provide HEI's Information for Rankings

Some rankings ask HEIs to collect and send the data needed for rank universities. This process sometimes becomes a mess, due to the confusion that universities may have about which data they have to provide and the tedious process of collecting the data.

The informational model presented at the informational global view could be good starting point to design a data model to gather and manage the data and information asked for university rankings. Moreover, by using the information results of the *Method for Informational Analysis of University Rankings* it is easy to know which data is asked by each university ranking and make the service system to produce the data according to ranking systems needs.

This service system could be used by any HEIs, as it uses a global view of a university that answers the information needs of all ranking systems.

15.7 Tentative Presentation for an Open Data Service for HEIs

In the same way of the service system or portal to provide HEI's information for rankings, it makes sense to propose an open data model for a service or portal for opening the information of universities. This open service should be useful for any kind of user interested in the information about universities. The government should find in the open data a good way to get or find updated information about their HEI. Rankings systems should find a way to get public data about institutions. At the same time, using enriched and semantic data would provide most valuable data for users and also for machines. These open and semantic data should follow the standards of the open world and the semantic web.

Appendix A

U-MULTIRANK: RANK GROUPS CALCULATION

Rank Group Calculation

U-Multirank applies three distinct rank group procedure which are specific to the three kind of indicators: Quantitative ranking indicator, rating indicators (on contacts to work contact and international orientation of programmes), and student satisfaction indicators.

a) "Regular" Quantitative Indicators

Most indicators used are based on continuous measures on particular scales (e.g. the percentage out of a total; a relation A : B). For those indicators the calculation of the five different groups is referring to the median (per indicator) of the total sample.

The median is the numerical value separating the higher half of a data sample from the lower half. This means that half of the data/cases are below and half are above the median. If there are an odd number of observations the median is exactly the middle number (e.g. out of 1, 2, 2, 3, 4: the median is 2). If there is an even number of observations the median will be calculated by the mean of the two middle numbers (for example 1, 2, 3, 4 the median is (2+3)/2 = 2.5).

U-Multirank rank groups are defined in terms of distance of the score of an institution from the median (for a single indicator). Groups range from the best group "A" to the lowest group "E":

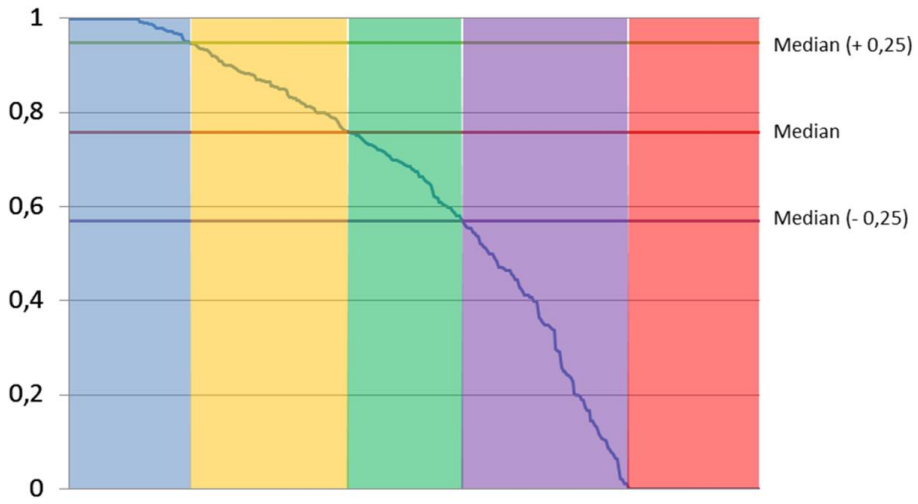
Group A: If the value of the indicator is above the median plus 25 % (value > median + 25 %)
Group B: If the value of the indicator is less than or equal to the median plus 25 % and greater than the median (median + 25 % ≥ value > median)
Group C: If the value of the indicator is less than or equal to the median and greater than the median minus 25 % (median ≥ value > median - 25 %)
Group D: If the value of the indicator is less than or equal to the median minus 25 % and above zero (median - 25 % ≥ value > 0)
Group E: If the value of the indicator is zero (value = 0).

Example: The median of an indicator is 60 %.
In group A are those with a value above 75 %
In group B are those with a value between 60 % and 74.99 %
In group C are those with a value between 45 % and 59.99 %
In group D are those with a value between 0 % and 44.99 %
In group E are those with 0 % 2

The fact that the scores of a number of indicators are not normal distributed causes a problem as the within group variance is very large. Therefore, we applied a method which takes into account the distribution of scores in a better way. Finally after testing and analysing various methods we decided to log normalise the scores for those indicators and apply the standard grouping method on those log normalised scores. To determine whether or not to use the log normalised scores the ratio median/mean is calculated and for all indicators that are outside the 25% bandwidth around 1 (- or + 12,5%) the log normalised score is applied. This procedure is applied for the first time in the 2016 release of U-Multirank both for institutional rankings and the six new subject rankings. In order not to modify rank groups without

changes in the underlying data in the 2014 and 2015 subject rankings, the new methodology will be applied to them when updating their data 2017 and 2018.

Figure 1: Grouping categories in U-Multirank



b) Rating Indicators

In addition we developed a few rating indicators measuring a particular aspect of performance by a multi-measure indicator. Those indicators are used where a single measure cannot adequately reflect complex aspects of performance and more complex indicators are needed. They refer to the international orientation of degree programmes and to the extend degree programmes offer contacts to the work environment to their students. In our view, for example, measuring the international orientation by the number or percentage of foreign students only does not take into account different strategies of internationalisation. Another advantage of those indicators is the fact that they can include yes/no information (e.g. about the existence of joint or dual degree programmes).

In international orientation, for example, the existence of joint degrees, student mobility (incoming and outgoing), international staff, and teaching in foreign language are taken into account. On each of those aspects a certain maximum number of points are allocated. The rank groups are defined in terms of grades of the maximum number of points. For example, the indicator “international orientation” has a maximum of 13 points. The rank groups are then 7+ points = group 1; 5 or 6 points = group 2; 3 or 4 points = group 3; 1 or2 points = group 5 and 0 points = group 5.

The detailed rating criteria and rank group thresholds can be found in our description of those indicators.

c) Student Survey Indicators

In the student survey current students enrolled in the degree programmes included in the subject rankings rated various aspects of their teaching experience on a six point Likert scale from “very good” to “very bad” (adding a category “I do not know”). The indicators reflect the average scores per unit (field and institution) on each aspect of assessment (e.g. quality of curses, contacts to teachers, and organisation of the programme). The results for a particular university depend on the judgments of those students who actually responded; compared to the complete sample of students at a university (including the non-respondents), the results are subject to uncertainty. How well the results meet the "true" judgment and score of a department depends largely on the number of respondents and the range of their reviews.

Hence the rank group calculation takes into account not only the mean score of all assessments but also the degree of uncertainty, the number of respondents per institutions and the variance of assessments within a university. How much "trust" you may have in such an average rating is expressed statistically by a so-called confidence interval. These confidence intervals can be utilized to incorporate the uncertainty of the judgment values in the ranking calculation. Instead of fixing limits for the average judgments and then determine the top and bottom groups, the length of the corresponding confidence interval is taken into account in the grouping procedure.

If the confidence interval is completely better than the total mean of all judgements on an indicator, we consider the reviews of the respective department as "better than the average"; if it is located totally on the right side of the mean the reviews are considered to be "below average". If the confidence interval is situated in the middle of the spread of judgements in total the reviews are considered to be intermediate.

A more in depth description of the procedure is available here.

Appendix B

U-MULTIRANK: RATING CRITERIA & RANK GROUP THRESHOLDS

Rating Criteria & Rank Group Thresholds 2017

Contacts with work environment 2017

Calculation and Rating

(Scores in parenthesis are grades of the maximum score)

	Points
1. Inclusion of internships/phases of work experience into programme	
a. Existence of mandatory internships/phases of work experience(projects outside HEI	2
b. Duration > 12 weeks	(1)
c. Duration > 26 weeks	3
<u>If not mandatory or data on 1a is missing:</u>	
Students who did an internship:	
>= 10 % of all students	(1)
>= 25 % of all students	(2)
>= 50 % of all students	(3)
2. Teaching by practitioners from outside higher education institutions	
>= 25 % and < 50 %	3
>= 10 %	(2)
>= 5 %	(1)
3. Degree theses in cooperation with enterprises/private organisations	
Percentage of all degree theses>= median	1
Maximum score	**9**

<u>Rating/ Rank groups:</u>

0 :	Group E
1 - 2	Group D
3 - 4	Group C
5 - 6	Group B
7+	Group A

Rating Criteria & Rank Group Thresholds 2017

International Orientation of Programmes

Calculation and Rating 2017

(Scores in parenthesis are grades of the maximum score)

	Points
4. Student Mobility: Outgoing	
a. Existence of joint degree programmes with mandatory stay at foreign partner institutions	5
Joint degree as option with mandatory stay abroad	(4)
Without mandatory exchange (but option to acknowledge degrees earned abroad)	(3)
b. *Mandatory* stay abroad outside joint degree programme	(3)
Stay abroad *recommended & transferability of credits* and places available for outgoing students (exchange)	(2)
Stay abroad *recommended*	(1)
5. Student Mobility: Incoming	
a. Incoming: Percentage of international students (degree seeking)	
>= 25 % of own students	3
>= 10 % of own students	(2)
>= 2 % of own students	(1)
b. Incoming: Percentage of incoming exchange students	
>= 25 % of own students	
>= 10 % of own students	3
>= 2 % of own students	(2)
	(1)
6. International experience of academic staff	
a. Percentage of international academic staff	
>= 25 % of academic staff	2
>= 5 % of academic staff	(1)
7. Teaching in foreign language	
Percentage >= 50 % of total mandatory classes	2
Percentage >= 10 % of total mandatory classes	(1)
Maximum score	**15**

Rating/ Rank groups:

0:	Group E
1 - 2	Group D
3 - 4	Group C
5 - 7	Group B
8 +	Group A

Appendix C

U-MULTIRANK: THE CONSTRUCTION OF RANK GROUPS

The construction of rank groups:

Significant deviations from the average score

Results for a particular university depend on the judgments of those students who responded; compared to the complete sample of students at a university they are subject to uncertainty. How well they meet the "true" judgment of a department depends largely on the number of respondents and the range of their reviews.

How much "trust" you may have in such an average rating is expressed statistically by a so-called confidence interval. These confidence intervals can be utilized to incorporate the uncertainty of the judgment values in the ranking calculation. Instead of fixing limits for the average judgments and then determine the top and bottom groups, the length of the corresponding confidence interval is taken into account in the grouping procedure.

For university i, let $\bar{x}_i$ be the average judgment of its students, s_i the standard deviation of the judgments and n_i the number of cases, and $\bar{x}$ be the overall average of judgments. Then:

- if $\bar{x}_i - 1.96 \cdot \frac{s_i}{\sqrt{n_i}} > \bar{x} \Rightarrow$ assign university i "below average",
- if $\bar{x}_i + 1.96 \cdot \frac{s_i}{\sqrt{n_i}} < \bar{x} \Rightarrow$ assign university i "above average",

For the remaining institutions which are a now mixture of "really" intermediate judgments and of those that could not be assigned to one of the extreme groups because their confidence intervals were too long we use two additional limits besides the mean. These limits deviate 0.25 from the mean plus one standard error on the department level, a normalized variation between the departments in one field. They differ for each field. Let $\bar{x}$ be the overall average of judgments, s the standard deviation "between" the universities, i.e. of $\bar{x}_i, i = 1, \ldots, n$, and n the number of universities ranked in this field:

- Lower limit: $\mathrm{L} = \bar{\mathrm{x}} - (0.25 + \left(1.96 \cdot \frac{\mathrm{s}}{\sqrt{\mathrm{n}}}\right))$,
- Upper limit: $\mathrm{U} = \bar{\mathrm{x}} + (0.25 + \left(1.96 \cdot \frac{\mathrm{s}}{\sqrt{\mathrm{n}}}\right))$.

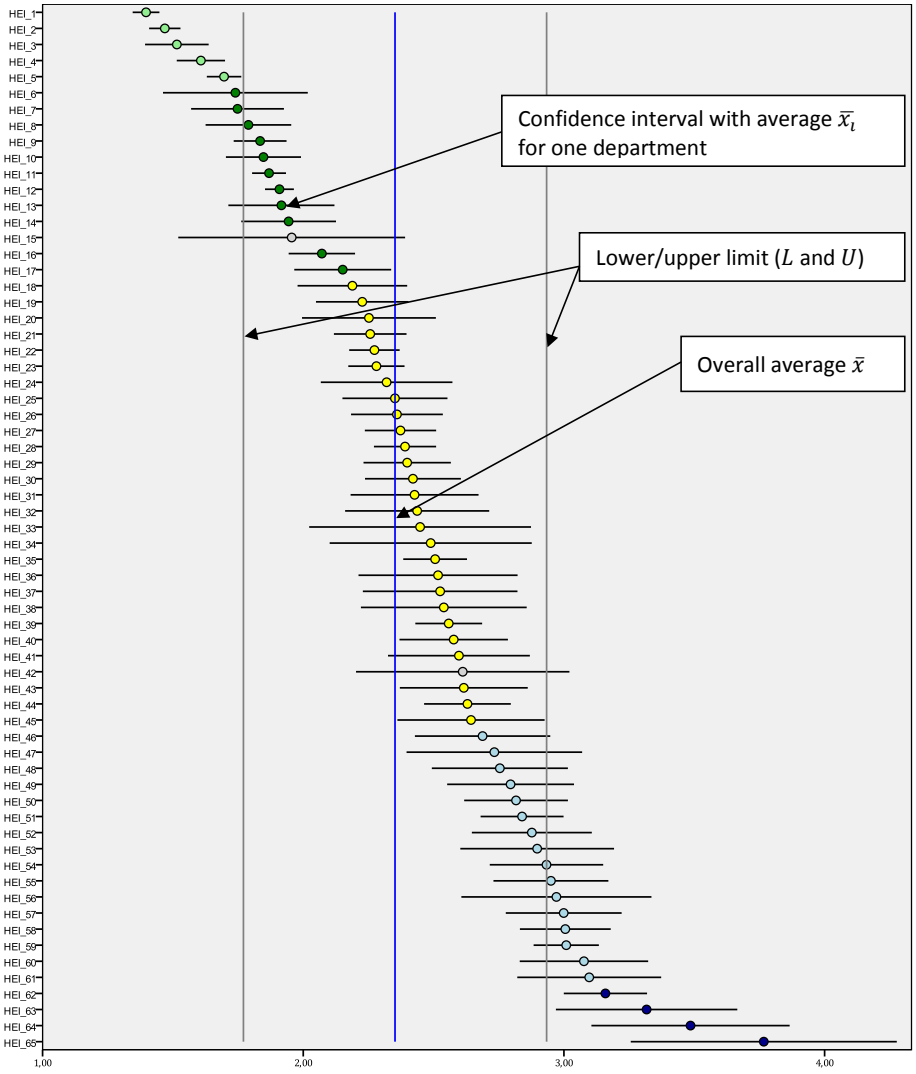
Departments with a confidence interval entirely between these two limits are, if they do not already belong to the top group, assigned to the middle group. However, if the confidence interval is so large that it extends across two of the three limits, its values are not included in the ranking because it is not clearly assignable to one group. In the example (see Figure 1 marked grey, HEI 15 and HEI 42. As no general statistical method for "proving" that something is intermediate exists, we had to develop something new. Testing this method with the data from several years of student surveys makes us confident that this is a method working well in practice.

As in U Multirank the number of HEIs compared is rather high two further groups are introduced, consisting of those HEIs beyond the lower and upper limit, so the rules for grouping are now:

- if $\bar{x}_i - 1.96 \cdot \frac{s_i}{\sqrt{n_i}} > U \Rightarrow$ assign university i to the "poor" group (dark blue in Figure 1),
- if $\bar{x}_i - 1.96 \cdot \frac{s_i}{\sqrt{n_i}} > \bar{x} \Rightarrow$ assign university i to the "below average" group (light blue in Figure 1),

- if $L < \bar{x}_i - 1.96 \cdot \frac{s_i}{\sqrt{n_i}}$ and $U > \bar{x}_i + 1.96 \cdot \frac{s_i}{\sqrt{n_i}} \Rightarrow$ assign university i to the "average" group (yellow in Figure 1),
- if $\bar{x}_i + 1.96 \cdot \frac{s_i}{\sqrt{n_i}} < \bar{x} \Rightarrow$ assign university i to the "good" group (dark green in Figure 1)
- if $\bar{x}_i + 1.96 \cdot \frac{s_i}{\sqrt{n_i}} < L \Rightarrow$ assign university i to the "excellent" group (light green in Figure 1
- if $\bar{x}_i - 1.96 \cdot \frac{s_i}{\sqrt{n_i}} < L$ and $\bar{x}_i + 1.96 \cdot \frac{s_i}{\sqrt{n_i}} > \bar{x}$ or if $\bar{x}_i + 1.96 \cdot \frac{s_i}{\sqrt{n_i}} > U$ and $\bar{x}_i - 1.96 \cdot \frac{s_i}{\sqrt{n_i}} < \bar{x} \Rightarrow$ university i is not ranked in this indicator group (grey in Figure 1).

Figure 1: Rank groups on the basis of confidence intervals



Advantages of this method are:

(a) Small departments still have the possibility to appear in the ranking.

(b) The validity of the group assignment even with small numbers of students is secured; doubtful cases are removed from the ranking in the subjective indicator.

As a consequence of this method departments with the same or similar averages, but different sized confidence intervals might be sorted into different ranking groups occasionally when they are placed on the border between an extreme group and the middle group. It is possible that a department ends up with a better mean in the middle group, while that with the worse mean is sorted into the top group.

Using the confidence intervals as basis for grouping ensures taking into account the homogeneity of the judgments, technically, however, the more trustworthy estimation of the "true" population mean in a statistical sense. In contrast to the grouping determined by quartile (where always a certain percentage of the universities is included in each group) or "top 10" lists in this process the size of the (top) group is not fixed, it results rather from the extent of internal variance within the different departments and the variance between them. If in a field the differences between individual universities are small and the responses in the departments are heterogeneous, very few institutions are to be found in the bottom or top group.

This method of comparing students' assessment of their own university which takes into account the relative assessment of a university compared to the average in that fields (on a particular indicator) and which refers to the degree of certainty of the means is more robust than just sorting universities simply by the mean scores. As this methods results in one group performing better than average, one lower than average and one in the middle it fits well to the he group approach of CHE ranking.

QS: FACULTY AREA NORMALIZATION

Faculty Area Normalization – Technical Explanation

From 2015, QS has adopted an approach to normalize publication and citation data across faculty areas. There are a number of reasons for this development.

Publication and citation data varies greatly across disciplines. It is possible to run highly complex calculations to adjust for this across large numbers of narrow disciplines – other exercises attempt to balance out between hundreds or even thousands of narrow subject areas. This delivers a degree of precision but is not without pitfalls:

1. Whilst the relative influence of citations in different disciplines can be adjusted for, the "size" of a discipline is typically defined by volume of publications where in reality a large proportion of institutional strength may be in disciplines which don't produce high volumes of journal articles
2. The narrow subject groups can amplify anomalies in some subject areas – particularly those where a large proportion of academic outputs are in forms other than journal articles or with low volumes
3. The definition of subject groups in any attempt at normalisation is somewhat arbitrary – the more groups defined, the larger the number of judgement calls that need to be made. Additionally the smaller the subject groupings, the greater the probability that an article will transcend disciplinary boundaries.

The QS World University Rankings methodology utilizes a Citations per Faculty indicator and thus the objective of this approach is to derive a "Normalized Total Citation Count" (NTCC). The primary approach is to simply equalize the influence of the same five faculty areas that are already deployed in the Academic Reputation analysis:

- Arts & Humanities
- Engineering & Technology
- Life Sciences & Medicine
- Natural Sciences
- Social Sciences & Management

Since 2004, these faculty areas have carried equal weight in our academic survey analysis. The adopted assumption is that, in a typical international comprehensive university, each of these faculty areas represents a roughly equitable share of activity. Looking at the distribution of students might inspire a great emphasis on Arts & Humanities and Social Sciences (data from the Higher Education Statistics Agency in the UK, for example, sees 55% of students studying in these areas) whilst looking at the allocation of research funding would lean towards medicine and sciences where research is, typically, more expensive. Equalizing these faculty areas has always seemed a fair and balanced approach.

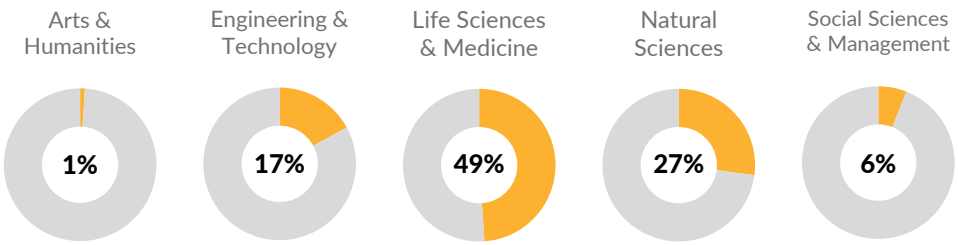


Fig.1 – The distribution of citations across faculty areas in Scopus (2010-2014)

However, it can be seen from Fig. 1 that the distribution of citations across faculty areas is far from equitable, leading to a situation where the Citations per Faculty indicator and, ultimately, the ranking overall favours institutions with a strong emphasis in the sciences.

The new approach described herein adopts the accepted philosophy used in the academic survey analysis and applies it to our citations analysis as well. A key advantage to using these broad sets, as opposed to a

narrower discipline focus, is that each will carry greater statistical strength and thus the analysis is less vulnerable to distortions which have been known to radically affect the fortunes of individual institutions in other analyses based on very small numbers of publications. Indeed, a key reason why QS feels in a position to implement this model from 2015 is due to the growth in the coverage of Arts & Humanities and Social Sciences in the Scopus database over the past few years. The five year window for Arts & Humanities now features over 500,000 citations.

The central intention of this new model, is to equalize the influence of the five faculty areas on the overall outcome of the citations per faculty measure – essentially weighting citations so that each area contributes 20% to the final indicator.

However, given that such a model places greater emphasis on areas where more is published in languages other than English and in forms other than journal articles, we are applying a sliding scale weight adjustment in Arts & Humanities and Social Sciences & Management based on mean productivity levels in those areas for the country where the institution is based.

$$NTCC \equiv \frac{n}{n_{fa}} \sum_{f=1}^{5} C_f w_f a_f$$

n = total citation count prior to normalization

n_{fa} = sum of total citation count across the five faculty areas (typically greater than n since some articles are classified in more than one faculty area)

C_f = count of citations for the given faculty area for the subject institution

w_f = weighting factor for the given faculty area

a_f = weighting adjustment for given faculty area

f = current faculty area, which can be one of ah = Arts & Humanities; et = Engineering & Technology; ls = Life Sciences & Medicine; ns = Natural Sciences; ss = Social Sciences & Management

$$w_f \equiv \frac{n_{fa}}{5x_f}$$

$$a_{ah,ss} \equiv min\left\{\frac{p_f}{p_{f\,max}} \middle| 1\right\}^{\dagger}$$

$$a_{et,ls,ns} \equiv \frac{5 - (a_{ah} + a_{ss})}{3}$$

x_f = global count of citations for the given faculty area

p_f = mean proportion of papers from the faculty area for the institution's home country (e.g. in the US 3.69% of papers are attributable to Arts & Humanities and 12.14% to Social Sciences; by contrast, in China, 0.52% are attributable to Arts & Humanities and 4.45% to Social Sciences)

$p_{f\,max}$= the maximum value of p_f where the paper count in that faculty area for the given country exceeds the global average (e.g. for Arts & Humanities in 2015 this is South Africa, where p_f = 6.04%

† This weighting needs to accommodate specialised institutions in the faculty area to avoid the circumstance where a specialist institution in Economics, in a country where the broader community has lower Scopus counts for Social Sciences, is not disadvantaged. For example, output in Russia is low in Arts & Humanities and Social Sciences and as a result the adjustments in those areas for a typical Russian university will be substantial, but MGIMO, which is an institution focused in those areas will be exempt from the sliding scale adjustment.

and where the paper count is in the region of 5,400 against a global average of 3,400; for Social Sciences $p_{f\ max}$ is also South Africa where p_f = 21.58.76%)

For clarity, QS bibliometric analysis excludes self-citations and, from 2015, excludes publications carrying more than ten institutional affiliations (at time of introduction this represents approximately 0.34% of publications in Scopus). Affiliated hospitals are included.

Appendix E

SUSTAINABILITY REPORT

Sustainability report assesses the master thesis project in three aspects: **project into production, lifespan, and risk**. Project into production evaluates from 0 to 10 the project from its conception, planning and design until it is done. Lifespan evaluates from 0 to 20 the life of the project once it is done. Risk evaluates from -20 to 0 the risk in both project into production and lifespan faces. All of these aspects are evaluated in three dimensions: **environmental, economic and social**; and each dimension is evaluated in two stages: **initial stage**, when the project was design, and **final stage**, when the project was done.

	Project Into Production	Lifespan	Risk
Environment	Design Cost	Footprint	Environmental Risk
	9	18	-1
Economic	Cost	Viability Plan	Economic Risk
	9	18	-1
Social	Personal impact	Social Impact	Social Risk
	8	15	-1
Sustainability Range	26	51	-3
	74		

Table E.1: Sustainability Matrix

As a result, this master thesis gets the score of 74 on the scale of -60:90. The justification of each assessment is explained in the following sections.

E.1 Project Into Production

Project Into Production (PIP) evaluates the project **planning, development, and its implementation**.

E.1.1 Environmental Dimension

Initial Stage

The resources forecast and footprint evaluation were made and taken into account for this thesis planning and dissing.

To carry out the master thesis only a computer is needed. According to Megan Bray's review[1] a laptop needs 12~22W in running mode, 1.5~6W in safe mode and 1.5~2W off mode with a full charge; a personal computer needs 70W in running mode, 25W in safe mode and 1.5W in off mode.

[1]Review of Computer Energy Consumption and Potential Savings, author: Megan Bray. Retrieved April 19, 2017, from: `https://www.dssw.co.uk/research/computer_energy_consumption.html`

Assuming an intensive usage (running mode) of 4 hours, 1 hours of safe mode and 19 hours off mode:

$$\textit{Laptop: } 4h \times 22W + 1h \times 6W + 19h \times 2W = 132Wh$$

$$\textit{Personal Computer: } 4h \times 70W + 1h \times 25W + 19h \times 1.5W = 333.5Wh$$

According to the results above, the best option to perform the master thesis and safe energy is the laptop.

The cost of searching at the Internet is not considered, because there is not enough precision to determine which is the cost, and there are many different factors that can make it change.

Final Stage

In order to determine the environmental impact and footprint of this master thesis, the energetic cost to carry out it became a good factor. To compute the total energetic cost, the 900 hours used to perform the thesis are used:

Energetic Cost:

$$(22W \times 0.8 + 6W \times 0.2) \times 900h + 273day \times 19h \times 2W = 27294Wh$$

To reduce the energetic cost, many different good practices have been taken, such as:

- Shutdown laptop instead of hibernating, to reduce the energy usage, while not working for long periods.
- GUIs with lower energetic cost was chosen, to reduce the screen energy usage.
- Screen brightness was optimised for the light conditions.
- Working without laptop battery, to extend the battery life and avoid charge it many times.
- Reduce the amount of paper used and use recycled paper.

The energetic impact of all these actions can not be measured in the global energetic cost. For that reason,1/5 of the usage time in the total energetic cost was assumed as safe mode. Moreover, the resource usage planning was done according to the requirements, in order to avoid waste more resource than needed. Due to that fact, if the thesis has to be reproduced or done again, it can not be done with less environmental resources and impact.

E.1.2 Economic Dimension

This thesis has two different actors directly involved: researcher (student) and supervisor (professor). Both actors have to be taken into account, in order to establish the economic cost of the research.

Initial Stage

The research process requires one researcher, one laptop, office material and a final printed edition, and additionally the supervisor time.

The researcher's time to do the master thesis is 900 hours, and its salary would be 16€/h:

Researcher cost:

$$900h \times 16€/h + 70€ \text{ PRLVMS} + (900h \times 16€/h) \times 32.2\%(\text{CESS})^2 = 19.106,8€$$

The supervisor's time is estimated by: one meeting for each week of researcher work, where supervisor use 1 hour for review the research and 2 hours for meeting. And his salary would be at least 20€/h.

Supervisor cost:

$$28weeks \times 3h/meeting \times 20€/h + 70€ \text{ PRLVMS} +$$

$$(28weeks \times 3h/meeting \times 20€/h) \times 32.2\%(\text{CESS}) = 2.290,96€$$

The total cost of the research project, would be:

Concept	**Cost**
Researcher Salary	19.106,8 €
Supervisor Salary	2.290,96 €
Laptop	750 €
Office material	10 €
Thesis printed edition	50 €
Total	**22.207,76 €**

Table E.2: Total Cost PIP - Initial Stage

Final Stage

This research project is done under the academical master thesis requirements, due to that fact the cost of researcher and supervisor can be avoided, and also the laptop cost. There are no unexpected costs because no unexpected costs appeared while doing the master thesis. For that reason, the final real cost of this research project is:

Concept	**Cost**
Office material	10 €
Thesis printed edition	50 €
Total	**60 €**

Table E.3: Total Cost PIP - Final Stage

E.1.3 Social Dimension

Initial Stage

The aim of this project is the learning of research techniques while doing a real research, and providing the necessary skills to start a PhD. Whereas the objective of this master thesis is to learn how works university rankings, which information is needed and managed, and their processes. At the same time, the researcher gains proficiency in the informational analysis.

[2]Cost Empresa Seguretat Social, source: Seguridad Social:Trabajadores. (n.d.). Retrieved April 19, 2017, from: http://www.seg-social.es/Internet_1/Trabajadores/CotizacionRecaudaci10777/Basesytiposdecotiza36537/index.htm

Final Stage

All the initial objectives were achieved with proficiency. Moreover, new learnings were acquired, such as:

- Rigour and documenting is essential in the research process to make them truthfully, and easy to follow and understand.
- Understand the propose of each ranking is important in order to have a clear view of them and use it to evaluate the universities.
- Current university rankings lack social, ethical and environmental indicators to assess how universities works and influence the society in these aspects.

E.2 Lifespan

This master thesis is a research project that produces knowledge that can be used to perform other projects with tangible results. Due to that fact, as knowledge is ethereal and infinite it is not suitable to talk about lifespan.

For that reason, both environmental and economic dimensions had been defined in the product into the production stage, and in during the lifespan, there are no environmental and economic costs. The only possible intrinsic cost could be the cost of knowledge maintenance and transmission.

Besides that, in the social dimension could be significant impacts. Thank this research, academic community can understand better how university rankings works and find ways to improve, monitor and assess their results. These improvements will benefit the society, providing better universities or finding ways to improve the university and academic system.

E.3 Risk

In the risk analysis only risk directly related with that research project have been taken into account.

E.3.1 Environmental Dimension

The environmental footprint of this project is very low. The only possible risk could be the increase of the planned work hours and office material, due that a bad previous planning or an expansion of the project's scope.

E.3.2 Economic Dimension

The real cost of this master thesis is significant, compared with the estimated cost that could have as a research. The only possible deviation in cost can be in the number of master thesis' printed editions and office material.

E.3.3 Social Dimension

There are not any social risk that can be anticipated or forecasted.

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