Should you believe in the Shanghai ranking?
An MCDM view [1]

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Abstract

This paper proposes a critical analysis of the "Academic Ranking of World Universities", published every year by the Institute of Higher Education of the Jiao Tong University in Shanghai and more commonly known as the *Shanghai ranking.* After having recalled how the ranking is built, we first discuss the relevance of the criteria and then analyze the proposed aggregation method. Our analysis uses tools and concepts from Multiple Criteria Decision Making (MCDM). Our main conclusions are that the criteria that are used are not relevant, that the aggregation methodology is plagued by a number of major problems and that the whole exercise suffers from an insufficient attention paid to fundamental structuring issues. Hence, our view is that the Shanghai ranking, in spite of the media coverage it receives, does not qualify as a useful and pertinent tool to discuss the "quality" of academic institutions, let alone to guide the choice of students and family or to promote reforms of higher education systems. We outline the type of work that should be undertaken to offer sound alternatives to the Shanghai ranking.

Keywords: Shanghai ranking, multiple criteria decision analysis, evaluation models, higher education.

Contents

1 Introduction

A strange thing happened back in 2003. A group of people belonging to the *Institute of Higher Education* from the *Jiao Tong University* in Shanghai published on their web site their first "Academic Ranking of World Universities" (Shanghai Jiao Tong University, Institute of Higher Education, 2003–09), henceforth the *Shanghai ranking*[1]. This ranking consisted in an ordered list of 500 universities in the whole world. Since then, the same group publishes each year an updated version of the ranking. A description of the ranking can be found in Liu and Cheng (2005), whereas the story behind its creation is detailed in Liu (2009).

This ranking was almost immediately the subject of an extraordinary media coverage. Not only political decision makers used the results of the ranking so as to promote reforms of higher education systems but many academic institutions began to use their position in this ranking in their institutional communication. Apparently, this looks like a true success story.

Yet, almost immediately after the release of the first ranking, this enterprize has been the subject of fierce attacks. One of the earlier one was due to van Raan (2005a), which started a vigorous exchange with the authors of the ranking (Liu, Cheng, and Liu, 2005, van Raan, 2005b). Since then the attacks have been numerous and vigorous both in the academic literature (Buela-Casal, Gutiérez-Martínez, Bermúdez-Sánchez, and Vadillo-Muñoz, 2007, Dill and Soo, 2005, Gingras, 2008, Ioannidis, Patsopoulos, Kavvoura, Tatsioni, Evangelou, Kouri, Contapoulos Ioannidis, and Liberopoulos, 2007, van Raan, 2006, Vincke, 2009, Zitt and Filliatreau, 2006) and in various reports and position papers (Bourdin, 2008, Brooks, 2005, Dalsheimer and Despréaux, 2008, Desbois, 2007, HEFCE, 2008, Kävelmark, 2007, Kivinen and Hedman, 2008, Marginson, 2007, Saisana and D'Hombres, 2008, Stella and Woodhouse, 2006). Moreover, several special issues of the journal *Higher Education in Europe* (published by the OECD) have been devoted to the debate around university rankings (HEE 2002, HEE 2005, HEE 2007, HEE 2008). In views of such attacks, one could have expected a sharp decrease in the popularity of the Shanghai ranking. It could even have triggered the authors to stop publishing it. Quite the contrary happened. Each year, a new version of the ranking is released and each year the media coverage of the ranking seems to increase. Moreover, projects of transformation of higher education systems often appeal to the results of the Shanghai ranking. For instance, the present Minister of Re-

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[1] Since then, the authors of the Shanghai ranking have also produced, starting in 2007, a ranking of institutions distinguishing 5 different fields within Science (Natural Sciences and Mathematics, Engineering / Technology and Computer Sciences, Life and Agriculture Sciences, Clinical Medicine and Pharmacy, and Social Sciences), see `http://www.arwu.org/ARWU-FIELD2008.htm`. Since the methodology for these "field rankings" is quite similar to the one used for the "global ranking" analyzed in this paper, we will not further analyze them here.

search and Higher Education was given by the French President the mission "to have two institutions among the world top 20 and ten among the world top 100" (letter dated 5 July 2007, source `http://www.elysee.fr/elysee/elysee.fr/francais/interventions/2007/juillet/lettre_de_mission_adressee_a_mme_valerie_pecresse_ministre_de_l_enseignement_superieur_et_de_la_recherche.79114.html`, last accessed 30 March 2009, our translation from French).

This paper wishes to be a contribution to the analysis of the strengths and weaknesses of the Shanghai ranking. Our point of view will be that of Operational Researchers having worked in the field of evaluation and decision models with multiple criteria (Bouyssou, Marchant, Pirlot, Perny, Tsoukiàs, and Vincke, 2000, Bouyssou, Marchant, Pirlot, Tsoukiàs, and Vincke, 2006, T'kindt and Billaut, 2006), while most of the previous analyses of the Shanghai ranking have concentrated on bibliometric aspects, starting with the important contribution of van Raan (2005a).

The Shanghai ranking apparently aims at answering the following question: "What is the best university in the world?". To some of our readers, this very question may indeed seem rather childish and without much interest. We agree. Nevertheless, these readers are reminded that there may be lazy political decision-makers around that may want to use the results of a ranking that simply "is there". More importantly, there may also be strategic decision-makers that may try to use these results in order to promote their own views on how to reorganize a higher education system. Moreover, as happens with all management tools, the mere existence of a ranking will contribute to modify the behavior of the agents involved, creating changes that are sometimes unwanted. Hence, we think that it may be worth spending some time on the question. This is the purpose of this paper. It is organized as follows. In Section 2, we will briefly describe how the authors of the Shanghai ranking operate. Section 3 will discuss the various criteria that are used. Section 4 will present a Multiple Criteria Decision Making (MCDM) view on the Shanghai ranking. A final section will discuss our findings.

2   How the Shanghai ranking is built?

This section describes how the Shanghai ranking is built, based upon Shanghai Jiao Tong University, Institute of Higher Education (2003–09) and Liu and Cheng (2005). We concentrate on the last edition of the ranking published in 2008 [2] although the methodology has varied over time.

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[2] See `http://www.arwu.org/rank2008/ARWU2008Methodology(EN).htm`, last accessed 30 March 2009

2.1 Who are the authors of the ranking?

The Institute of Higher Eduction of the Jiao Tong University in Shanghai is a small group of people headed by Professor Nian Cai Liu. The authors of the ranking admit that they have no particular knowledge in bibliometry (e.g., Nian Cai Liu is a chemist specialized in polymers). Our analysis below shows that it is likely that they have no particular knowledge in MCDM and in the development of evaluation systems either.

The authors insist upon the fact that they receive no particular funding for producing the ranking and that they are guided mainly by academic considerations. This is at variance with the situation for rankings such as the one produced by the Times Higher Education Supplement (Times Higher Education Supplement, 2008).

2.2 What are their objectives?

Somewhere at the turn of the last century, the question of the renovation of the higher education system in continental China became important. This should be no surprise in view of the political situation in China and its growing economic strength.

The announced objective of the authors of the ranking is to have a tool allowing them understand the gap between Chinese universities and "world-class universities", with the obvious and legitimate aim of reducing this gap. Note that the authors do not give a precise definition of what they mean by a "world-class university". Because of the difficulty to obtain "internationally comparable data", they decided to rank order universities based on "academic or research performance" (Shanghai Jiao Tong University, Institute of Higher Education, 2003–09).

2.3 How were the universities selected?

The authors claim to have analyzed around 2000 institutions worldwide. This is supposed to include all institutions having Nobel prize and Fields medal laureates, a significant number of papers published in *Nature* or *Science*, of highly cited researchers as given by Thomson Scientific (formerly ISI), and a significant amount of publications indexed in the Thomson Scientific databases. The authors of the ranking claim that this includes all major universities in each country. The published ranking includes only 500 institutions. The first 100 are ranked ordered. The remaining ones are rank by groups of 50 (till the 201th position) and then 100.

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2.4 The criteria

The authors use six criteria belonging to four distinct domains. They are presented below.

2.4.1 Quality of Education

This domain uses a single criterion: the number of alumni of the institution having received a Nobel prize (Peace and Literature are excluded, the Bank of Sweden prize in Economics included) or a Fields medal. An alumni is defined as a person having obtained a Bachelor, a Master or a Doctorate in the institution. If a laureate has obtained a degree from several institutions, each one receives a share. Remember that Nobel prizes are attributed (on an annual basis) since 1901 and Fields medal (every four years) since 1936. All prizes and medals do not have the same weight: they are "discounted" using a simple linear scheme (an award received after 1991 counts for 100 %, an award received between 1981 and 1990 counts for 90 %, . . .). When several persons are awarded the prize or the medal, each institution receives a share. This defines the first criterion labeled ALU.

2.4.2 Quality of Faculty

This domain has two criteria. The first one counts the number of academic staff from the institution having received a Nobel prize (with the same definition as above) or a Fields medal. The conventions for declaring that someone is a member of the "academic staff" of an institution remain fuzzy. The following discounting scheme is applied: 100% for winners in after 2001, 90% for winners in 1991–2000, 80% for winners in 1981–1990, . . . , 10% for winners in 1911–1920. The case of multiple winners is treated as with criterion ALU. When a person has several affiliations, each institution receives a share. This defines criterion AWA

The second criterion in this domain is the number of highly cited researchers in each of the 21 areas of Science identified by Thomson Scientific. These highly cited researchers, in each of the 21 domains, consist in a list of 250 persons who have received the largest number of citations in the domain according to the Thomson Scientific databases (source `http://hcr3.isiknowledge.com/popup.cgi?name=hccom`, last accessed 30 March 2009. In some categories, Thomson Scientific lists more than 250 names; we suspect that this is due to ties). This is computed over a period of 20 years. This defines criterion HiCi.

2.4.3 Research output

This domain has two criteria. The first one is the number of papers published in *Nature* and *Science* by the members of the academic staff of an institution during

the last 5 years. This raises the problem of processing papers having multiple authors. The rule here is to give a weight of 100% to the 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 author affiliations. This defines criterion N&S. Since this criterion is little relevant for institutions specialized in Social and Human Sciences, it is "neutralized" for them.

The second criterion counts the number of papers published by the members of the academic staff of an institution. This count is performed using Thomson Scientific databases over a period of one year. Since it is well known that the coverage of the Thomson Scientific databases is not satisfactory for Social and Human Sciences, a coefficient of 2 is allocated to each publication indexed in the Social Science Citation Index. This defines criterion PUB.

2.4.4 Productivity

This domain has a single criterion. It consists in the "total score of the above five indicators divided by the number of Full Time Equivalent (FTE) academic staff" (Liu and Cheng, 2005). This criterion is "ignored" when the number of FTE academic staff could not be obtained. This defines criterion Py.

2.5 Data collection

Except for the number of FTE academic staff of each institution, data are collected on the web. This involves the official site of the Nobel Prizes (`http://nobelprize.org/nobel_prizes/`), the official site of the International Mathematical Union (`http://www.mathunion.org/general/prizes`, and various Thomson Scientific sites (`http://www.isihighlycited.com` and `http://www.isiknowledge.com`). The data used by the authors of the ranking are not made publicly available.

2.6 Normalization and aggregation

Each of the above six criteria is measured by a positive number. Each criterion is then normalized as follows. A score of 100 is given to the best scoring institution and all other scores are normalized accordingly. This leads to a score between 0 and 100 for each institution.

The authors say that "adjustments are made" when the statistical analyses reveal "distorting effects". The nature and the scope of these adjustments are not made public (Florian, 2007, shows that these adjustments are nevertheless important).

The authors use a weighted sum to aggregate these normalized scores. The weights of the six criteria are ALU: 10%, AWA: 20%, N&S: 20%, HiCi: 20%, PUB: 20%, and Py: 10%. Hence each institution receives a score between 0 and 100. The final scores are then normalized again so that the best institution receives a score of 100. This final normalized score is used to rank order the institutions.

2.7 The 2008 results

Table 1 gives the list of the best 20 universities in the world according to the 2008 edition of the Shanghai ranking. Table 2 does the same for European universities.

A cursory look at Table 1 reveals the domination of US universities in the ranking. Only 3 among the top 20 are not from the US. This may explain why so many European decision makers have strongly reacted to the Shanghai ranking. Within Europe, the domination of the UK is striking. Relatively small countries like Switzerland, Norway, Sweden, or The Netherlands seem to perform well, whereas larger countries like Italy or Spain are altogether absent from the top 20 in Europe.

Figure 1 shows the distribution of the global normalized score for the 500 institutions included in the Shanghai ranking. The curve becomes very flat as soon as one leaves the top 100 institutions.

We would like to conclude this brief presentation of the Shanghai ranking by giving three quotes taken from Liu and Cheng (2005). The Shanghai ranking uses "carefully selected objective criteria", is "based on internationally comparable data that everyone can check", and is such that "no subjective measures were taken".

3 An analysis of the criteria

We start our analysis of the Shanghai ranking by an examination of the six criteria that it uses.

3.1 Criteria linked to Nobel prizes and Fields medals

Two criteria (ALU and AWA) are linked to a counting of Nobel prizes and of Fields medals. These two criteria are especially problematic.

Let us first observe that, for criterion AWA, the prize and medals are attributed to the hosting institution *at the time of the announcement.* This may not be too much of problem for Fields medals (they are only granted to people under 40). This is however a major problem for Nobel prizes. Indeed, a close examination of the list of these prizes reveals that the general rule is that the prize is awarded long after the research leading to it has been conducted. A classic example of such

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Rank	Institution	Country	ALU	AWA	HiCi	N&S	PUB	Py	Score
1	Harvard	USA	100.0	100.0	100.0	100.0	100.0	74.1	100.0
2	Stanford	USA	40.0	78.7	86.6	68.9	71.6	66.9	73.7
3	UC Berkeley	USA	69.0	77.1	68.8	70.6	70.0	53.0	71.4
4	Cambridge	UK	90.3	91.5	53.6	56.0	64.1	65.0	70.4
5	MIT	USA	71.0	80.6	65.6	68.7	61.6	53.9	69.6
6	CalTech	USA	52.8	69.1	57.4	66.1	49.7	100.0	65.4
7	Columbia	USA	72.4	65.7	56.5	52.3	70.5	46.6	62.5
8	Princeton	USA	59.3	80.4	61.9	40.5	44.8	59.3	58.9
9	Chicago	USA	67.4	81.9	50.5	39.5	51.9	41.3	57.1
10	Oxford	UK	59.0	57.9	48.4	52.0	66.0	45.7	56.8
11	Yale	USA	48.5	43.6	57.0	55.7	62.4	48.7	54.9
12	Cornell	USA	41.5	51.3	54.1	52.3	64.7	40.4	54.1
13	UC Los Angeles	USA	24.4	42.8	57.4	48.9	75.7	36.0	52.4
14	UC San Diego	USA	15.8	34.0	59.7	53.0	66.7	47.4	50.3
15	U Pennsylvania	USA	31.7	34.4	58.3	41.3	69.0	39.2	49.0
16	U Wash Seattle	USA	25.7	31.8	53.1	49.5	74.1	28.0	48.3
17	U Wisc Madison	USA	38.4	35.5	52.6	41.2	68.1	28.8	47.4
18	UC San Francisco	USA	0.0	36.8	54.1	51.5	60.8	47.5	46.6
19	Tokyo Univ	Japan	32.2	14.1	43.1	51.9	83.3	35.0	46.4
20	Johns Hopkins	USA	45.8	27.8	41.3	48.7	68.5	24.8	45.5

Table 1: The best 20 universities in the world in the Shanghai ranking (2008). Source: Shanghai Jiao Tong University, Institute of Higher Education (2003–09).

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Rank	Institution	Country	ALU	AWA	HiCi	N&S	PUB	Py	Score
4	Cambridge	UK	90.3	91.5	53.6	56.0	64.1	65.0	70.4
10	Oxford	UK	59.0	57.9	48.4	52.0	66.0	45.7	56.8
22	U Coll London	UK	31.2	32.2	38.6	44.3	65.8	35.4	44.0
24	Swiss Fed Inst Tech Zurich	Switzerland	35.9	36.3	36.1	38.1	53.6	56.0	43.1
27	Imperial Coll	UK	18.6	37.4	39.9	38.2	61.8	39.4	42.4
40	U Manchester	UK	24.4	18.9	28.2	28.3	60.5	30.4	33.6
42	U Paris 06	France	36.6	23.6	23.1	27.3	58.2	21.3	33.1
45	U Copenhagen	Denmark	27.4	24.2	26.3	25.4	54.5	33.4	33.0
47	U Utrecht	Netherlands	27.4	20.9	28.2	28.8	53.3	26.0	32.4
49	U Paris 11	France	33.3	46.2	14.6	20.4	47.0	23.1	32.1
51	Karolinska Inst Stockholm	Sweden	27.4	27.3	31.8	18.3	50.1	25.7	31.6
53	U Zurich	Switzerland	11.2	26.8	24.7	27.5	50.2	32.4	31.0
55	U Edinburgh	UK	20.2	16.7	26.3	32.3	49.7	30.0	30.8
55	U Munich	Germany	33.1	22.9	16.3	25.6	52.7	31.8	30.8
57	TU Munich	Germany	41.1	23.6	25.3	18.9	44.8	30.6	30.5
61	U Bristol	UK	9.7	17.9	28.2	28.1	47.8	33.5	29.5
64	U Oslo	Norway	23.1	33.4	17.9	17.0	46.7	29.8	29.0
67	U Heidelberg	Germany	17.7	27.2	17.9	20.4	49.2	29.3	28.4
68	U Helsinki	Finland	16.8	17.9	21.9	20.8	53.8	30.1	28.3
70	Moscow State U	Russia	49.1	34.2	0.0	8.3	53.2	33.4	28.1

Table 2: The best 20 universities in Europe in the Shanghai ranking (2008). Source: Shanghai Jiao Tong University, Institute of Higher Education (2003–09).
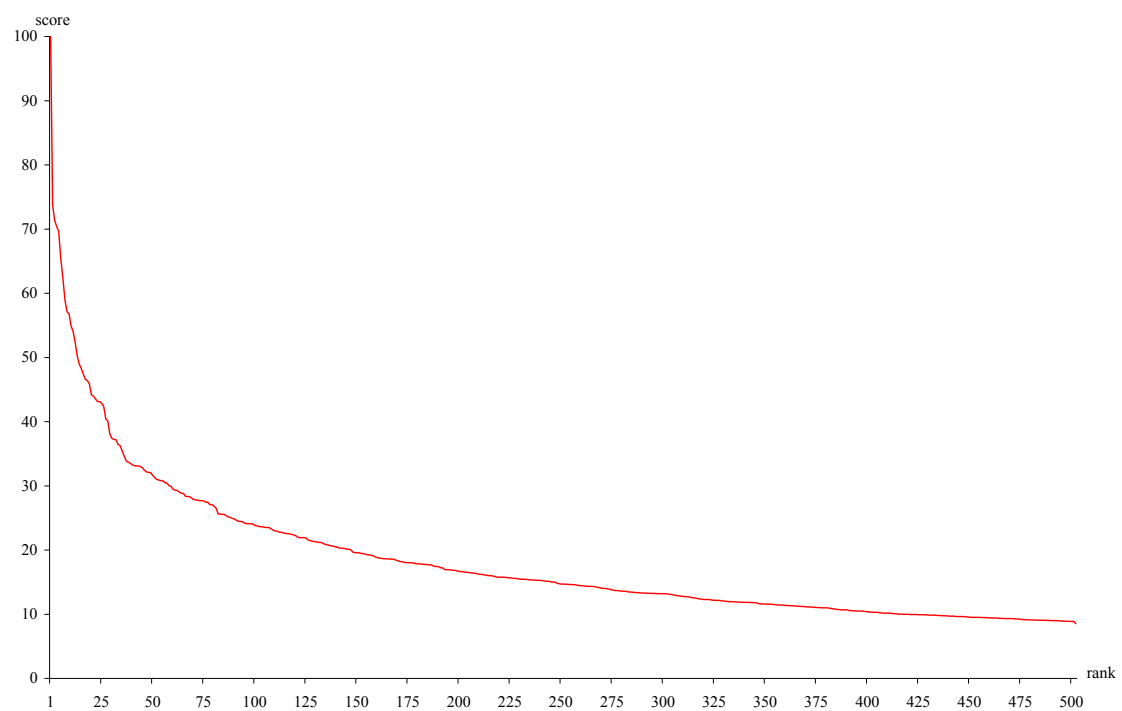
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Figure 1: Distribution of normalized scores for the 500 universities in the Shanghai ranking (2008). Source: Shanghai Jiao Tong University, Institute of Higher Education (2003–09).

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a situation is Albert Einstein. He conducted his research while he was employed by the Swiss Patent Office in Zurich. He received the Nobel Prize long after, while he was affiliated to the University of Berlin (we will say more on the case of Albert Einstein below). Therefore, it does not seem unfair to say that the link between AWA and the quality of research conducted in an institution is, at best, extremely approximative. Even when the winner of a Nobel prize has not moved, the lag between the time at which the research was conducted and the time at which the award was announced is such that the criterion captures more the past qualities of an institution than its present research potential. The same is clearly true for criterion ALU since the time lag is here even longer. At best, this criterion might give some indication on the ability an institution had several decades ago to give extremely bright people a stimulating environment. It has almost nothing to do with the present ability of an institution to provide an excellent education to its students.

One may also wonder why prizes attributed long ago (before World War II and even before World War I) have anything to do with the present quality of an institution. Although the discounting scheme adopted by the authors of the Shanghai ranking tends to limit the impact of these very old prizes and medals, they still have some effect. It should also be stressed that the discounting scheme that is adopted is completely arbitrary (e.g., why use a linear and not an exponential scheme?)

The options taken by the authors of the ranking on these two criteria involve many other biases. A bias in favor of countries having known few radical political changes since 1901. A bias towards institutions having been created long ago and having kept the same name throughout their history. This is not the case for most institutions in continental Europe (think of the many wars and radical political changes that have happened in Europe since 1901). This has led to really absurd situations. For instance the two universities (Free university of Berlin and Humboldt University, using their names in English) created in Berlin after the partition of Germany and, therefore, the splitting of the University of Berlin, quarrelled over which one should get the Nobel Prize of Albert Einstein (see Enserink, 2007, on this astonishing case). It turned out that depending on the arbitrary choice of the university getting this prize, these two institutions had markedly different positions in the ranking.

Unfortunately, Germany is not an isolated example. Table 3 lists some French Nobel prize winners together with their affiliation as indicated by the official Nobel prize web site (`http://nobelprize.org/nobel_prizes/`). A careful examination of this table reveals many interesting facts. First there are, in this list, institutions that have *never* existed (except maybe, in medieval times). Sorbonne University, whether or not translated into French, has never existed as such and surely does not

Institution	Name	Prize	Date
Sorbonne University	Henri Moissan	Chemistry	1906
Sorbonne University	Gabriel Lippmann	Physics	1908
Sorbonne University	Marie Curie	Chemistry	1911
Sorbonne University	Charles Richet	Medicine	1913
Sorbonne University	Jean Perrin	Physics	1925
Sorbonne University & Institut Henri Poincaré	Louis de Broglie	Physics	1929
Strasbourg University	Karl Braun	Physics	1909
École municipale de physique et de chimie industrielle	Pierre Curie	Physics	1903
Nancy University	Victor Grignard	Chemistry	1912
Toulouse University	Paul Sabatier	Chemistry	1912
University of Grenoble	Louis Néel	Physics	1970
Université de Paris	Jean Dausset	Medicine	1980
Université Louis Pasteur & Collège de France	Jean-Marie Lehn	Chemistry	1987
ESPC & CERN	Georges Charpak	Physics	1992
Collège de France	Pierre-Gilles de Gennes	Physics	1991
Collège de France & École Normale Supérieure	Claude Cohen-Tannoudji	Physics	1997

Table 3: Some French Nobel prize winners (source: `http://nobelprize.org/nobel_prizes/`, last accessed 30 March 2009)

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presently exist (although a building called Sorbonne does exist in Paris). A second problem lies in multiple affiliations. To which institution should go the Nobel Prize of Louis de Broglie. It should go either to Sorbonne University (but we have just seen there is no such institution) or to the Institut Henri Poincaré that, for sure, is not a university. There are also many cases in which the Nobel prize is attributed to the right institution, but that institution does not exist any more (Strasbourg University, Nancy University, Toulouse University, *Université de Paris*, University of Grenoble, *École municipale de physique et de chimie industrielle*). Another intriguing case is the Nobel prize of Georges Charpak who has two affiliations ESPC and CERN. Since CERN is not a university, should all the prize go the ESPC or only half of it? (note that ESPC is the new name of the *École municipale de physique et de chimie industrielle*). This shows, for the case of France, that the correct attribution of each prize requires a very good knowledge of the institutional landscape in each country and to take many "micro-decisions". Since the authors of the Shanghai ranking do not document any of these micro-decisions, the least that can be said is that these two counting criteria are at best, orders of magnitudes.

We would like to conclude here with a sad note. The last French Physics Nobel Prize winner, Albert Fert, is a Professor at the *Université de Paris Sud*. He happens to work in a joint research center (CNRS & *Université de Paris Sud*). It seems that because of this only fact, only half his Nobel Prize will go to his university (Fert, 2007). We really wonder why.

Summarizing, the two criteria ALU and AWA are only very loosely connected with what they are trying to capture. Their evaluation furthermore involves arbitrary parameters and raises many difficult counting problems. Hence, these criteria are plagued by a significant imprecision and inaccurate determination (Bouyssou, 1989, Roy, 1988).

3.2   Highly cited researchers

The most striking fact here is the complete reliance of the authors of the ranking on choices made by Thomson Scientific. Is the division of Science into 21 domains relevant? In view of Table 4, it is apparent that the choice of these 21 domains seems to favor medicine and biology. This may be a reasonable option for a commercial firm like Thomson Scientific, since theses fields generate many "hot" papers. The fact that this choice is appropriate in order to evaluate universities would need to be justified and, unfortunately, the authors of the ranking remain silent on this point.

Finally, as already stressed in van Raan (2005a), these 21 categories do not have the same size. Speaking only in terms of the number of journals involved in each categories (but keep in mind that journals may have quite different sizes) they are indeed quite different. Space Science involves 57 journals, Immunology

21 categories used by Thomson Scientific	
Agricultural Sciences	Materials Science
Engineering	Plant & Animal Science
Neuroscience	Computer Science
Biology & Biochemistry	Mathematics
Geosciences	Psychology / Psychiatry
Pharmacology	Ecology / Environment
Chemistry	Microbiology
Immunology	Social Sciences, General
Physics	Economics & Business
Clinical Medicine	Molecular Biology & Genetics
Space Sciences	

Table 4: The 21 categories used by Thomson Scientific (source: `http://www.isihighlycited.com/isi_copy/Comm_newse04.htm#ENGINEERING`, last accessed 30 March 2009).

120, ..., Plant & Animal Science 887, Engineering 977, Social Science General 1299, and Clinical Medicine 1305 (source: `http://www.isihighlycited.com/isi_copy/Comm_newse04.htm#ENGINEERING`, last accessed 30 March 2009).

As observed in van Raan (2005a), this criterion clearly uses Thomson Scientific citation counts. Bibliometricians have often stressed that these citation counts are somewhat imprecise. Indeed, the matching of cited papers involves "losses" (e.g., due to incorrect spelling or wrong page numbers). Van Raan (2005a) evaluates the average loss of citations to 7%, while it may be as high as 30% in certain fields. Bizarrely, Liu et al. (2005) answering these comments, simply did not acknowledge that criterion HiCi uses citation counts.

Finally, let us observe that Thomson Scientific uses a period of 20 years to determine the names of highly cited researchers in each category. Hence, in most categories, the persons in these lists are not particularly young and have often changed institutions several times during their careers.

Summarizing, combining the exclusive reliance on a division of Science into 21 categories suggested by Thomson Scientific, the use of rather long period of reference, and the difficulties inherent to a precise counting of citations reveals that this criterion is only extremely loosely connected to the present ability of an institution to presently produce research with high impact.

3.3 Papers in *Nature* and *Science*

Probably the most surprising fact with this criterion is the weighting scheme for multiple authors (remember that this is the usual rule in the "hard sciences"). With 100% for the corresponding author, 50% for the first author, 25% for the next author affiliation, and 10% for other author affiliations, one quickly sees that all papers published in *Nature* and *Science* do not have the same weight. A paper signed by *many* co-authors will have a greater weight than a paper signed by a single person (therefore it is in the interest of an institution that any paper published in *Nature* and *Science* is co-signed by *many* co-authors from the same institution). We have to say that this seems highly counter-intuitive and even paradoxical. We should also mention that the problems of affiliation that we examine below are also present for this criterion.

3.4 Articles indexed by Thomson Scientific

As stressed in van Raan (2005a), the authors of the ranking entirely rely for the evaluation of this criterion on the Thomson Scientific databases. This raises a number of important problems.

First, the attribution of the papers to the right institution is far from being an easy task. The authors of the ranking solve it saying that "institutions or research organizations affiliated to a university are treated according to their own expression in the author affiliation of an article" (Liu et al., 2005). This is likely to lead to many problems. First, it is well known that authors do not always pay much attention to the standardization of their affiliation when they publish a paper. The problem is especially serious when it comes to papers published by university hospitals (they often have a specific name that is distinct from the name of the university and have a distinct address, see van Raan, 2005a, Vincke, 2009) A similar phenomenon occurs when university has an official name that is not in English. Some authors will use the official name (which is likely to cause problems if it contains diacritical signs or, even worse, if it is a transliteration). Some might try to translate it into English, causing even more confusion. A famous example is the difficulty to distinguish the *Université Libre de Bruxelles* from the *Vrije Universiteit Brussel*. Both are located in Brussels and have the same postal code. Both names are the same in English (Free University of Brussels). Hence this first problem is likely to cause much imprecision on the evaluation of criterion PUB [3].

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[3] Let us mention here that even expert bibliometricians may not be aware of some of the potential problems. Van Raan (2005a) mentions that a paper that has the affiliation "CNRS, Illkirsh" should go to the *Université Louis Pasteur*. We want to stress that although this may be possible, this is not automatically correct since the above affiliation could well mean that we have a paper coming from an employee of the CNRS working a joint research unit managed

Attaching to each author a correct affiliation is a difficult task requiring a deep knowledge of the peculiarities of the institutional arrangements in each country.

Second, it is well known that the coverage of the Thomson Scientific database is in no way perfect (Adam, 2002). The newly created SCOPUS database launched by Elsevier, has a vastly different coverage, although clearly, the intersection between the two databases is not empty. Counting using Thomson Scientific instead of SCOPUS is a perfectly legitimate choice, provided that the impact of this choice on the results is carefully analyzed. This is not the case in the Shanghai ranking.

Third, it is also well known that the coverage of most citation database has a strong slant towards publications in English (see van Leeuwen, Moed, Tijssen, Visser, and van Rann, 2001, van Raan, 2005a, for an analysis of the impact of this bias on the evaluation of German universities). Yet, there are disciplines (think of Law) in which publications in a language that is not the language of the country make very little sense. Moreover, there are whole parts of Science that do not use articles in peer-reviewed journals as the main media for the diffusion of research. In many parts of Social Science, books are still a central media, whereas in Engineering or Computer Science, conference proceedings dominate. The authors of the ranking have tried to correct for this bias against Social Sciences by multiplying by a factor 2 all papers indexed in the Social Science Citation Index. This surely goes in the right direction. But it is also quite clear that this coefficient is arbitrary and that the impact of varying it should be carefully analyzed.

Finally, we may also wonder why the authors of the ranking have chosen to count indexed papers instead of trying to measure the impact of the papers. Browsing through the Thomson Scientific databases quickly reveals that most of indexed papers are almost never cited and that a few of them concentrate most citations, this being true independently of the impact of the journal.

Summarizing, criterion PUB raises several important problems and involves many arbitrary choices.

3.5 Productivity

Criterion Py consists in the "total score of the above five indicators divided by the number of Full Time Equivalent (FTE) academic staff". It is ignored when this last number could not be obtained. Two main things have to be stressed here.

First this criterion is clearly affected by all the elements of imprecision and inaccurate determination analyzed above for the first five criteria. Moreover, the authors of the ranking do not detail which sources they use to collect information on the number of Full Time Equivalent (FTE) academic staff. We have no reason

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by the CNRS and the *Université Louis Pasteur* (now merged with the two other universities in Strasbourg).

to believe that these sources of information are more "reliable" than the ones used by the authors of the ranking to evaluate the first five criteria. If this information is collected through the institutions themselves, there is a risk of potential serious problems, since the notion of "member of academic staff" is not precisely defined and may be interpreted in several quite distinct ways (e.g., how to count invited or emeritus professors, teaching assistants, research engineers, pure researchers?).

Second, it is not 100% clear what is meant by the authors when they refer to the "total score of the above five indicators". Are these scores first normalized? Are these scores weighted? (we suspect that this is the case). Using which weights? (we suspect that these weight are simply the weights of the first five indicators normalized to add up to 1).

3.6 A varying number of criteria

Institutions are evaluated in the Shanghai ranking using six criteria. . . but not all of them. In fact we have seen that there are several possible cases:

- institutions not specialized in Social Sciences and for which FTE academic staff data could be obtained are evaluated on 6 criteria: ALU, AWA, HiCi, N&S, PUB, and Py.

- institutions not specialized in Social Sciences and for which FTE academic staff data could not be obtained are evaluated on 5 criteria: ALU, AWA, HiCi, N&S, and PUB.

- institutions specialized in Social Sciences and for which FTE academic staff data could be obtained are evaluated on 5 criteria: ALU, AWA, HiCi, PUB, and Py.

- institutions specialized in Social Sciences and for which FTE academic staff data could not be obtained are evaluated on 4 criteria: ALU, AWA, HiCi, and PUB.

This raises many questions. First MCDM has rarely tackled the situation in which alternatives are not evaluated on the same family of criteria. This raises many interesting questions. For instance the right way to meaningfully "neutralize" a criterion does not seem to be entirely obvious. Second, the authors of the Shanghai ranking do not make publicly available the list of institutions that they consider to be specialized in Social and Human Sciences. They neither give the list of institutions for which criterion Py could be computed. Hence not only the family of criteria varies but it is impossible to know which family is used to evaluated what. This is extremely surprising and most uncommon.

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3.7 A brief summary on criteria

We have seen that all criteria used by authors of the ranking are only loosely connected with what they intended to capture. The evaluation furthermore involves several arbitrary parameters and many micro-decisions that are not documented. In view of Figure 1, we surely expect all these elements to quite severely impact the robustness of the results of the ranking. Quite unfortunately, since the authors of the Shanghai ranking do not make "raw data" publicly available (a practice which does not seem to be fully in line with their announced academic motives), it is impossible to analyze the robustness of the final ranking with respect to these elements.

We have seen above that the authors claim that the ranking: uses "carefully selected objective criteria", is "based on internationally comparable data that everyone can check", and is such that "no subjective measures were taken".

It seems now clear that the criteria have been chosen mainly based on availability, that each one of them is only loosely connected with what should be captured and that their evaluation involves the use of arbitrary parameters and arbitrary micro-decisions. The impact of these elements on the final result is not examined. The raw data that are used are not made publicly available so that they cannot be checked.

We take this occasion to remind the reader that there is a sizeable literature on the question of structuring objectives, associating criteria or attributes to objective, discussing the adequateness and consistency of a family of criteria. This literature has two main sources. The first one originates in the psychological literature (Ebel and Frisbie, 1991, Ghiselli, 1981, Green, Tull, and Albaum, 1988, Kerlinger and Lee, 1999, Kline, 2000, Nunally, 1967, Popham, 1981) has concentrated on the question of the validity and reliability and has permeated the bulk of empirical research in Social Sciences. The second originates from MCDM (Bouyssou, 1990, Fryback and Keeney, 1983, Keeney, 1981, 1988a,b, 1992, Keeney and McDaniel, 1999, Keeney and Raiffa, 1976, Keeney, Hammond, and Raiffa, 1999, Roy, 1996, Roy and Bouyssou, 1993, von Winterfeldt and Edwards, 1986) has concentrated on the question of the elicitation of objectives and the question of the construction of attributes or criteria to measure the attainment of these objectives. It seems to have been mostly ignored by the authors of the ranking.

3.8 Final comments on criteria

We would like to conclude this analysis of the criteria used in the Shanghai ranking with two sets of remarks.

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3.8.1 Time effects

The authors have chosen to publish their ranking on an annual basis. This is probably a good choice if what is thought is media coverage. However, given the pace of most research programs, we cannot find any serious justification for such a periodicity. As observed in Gingras (2008), the ability of a university to produce excellent research, is not likely to change much from one year to another. Therefore, changes from one edition of the ranking to the next one are more likely to reflect random fluctuations than real changes (empirical psychological research has amply shown that decision makers are not very efficient in realizing that random variations are much more likely than structural changes, see, e.g., Bazerman, 1990, Dawes, 1988, Hogarth, 1987, Kahneman, Slovic, and Tversky, 1981, Poulton, 1994, Russo and Schoemaker, 1989). This is all the more true that several important points in the methodology and the criteria have changed over the years (Saisana and D'Hombres, 2008, offer an overview of these changes).

The second point is linked to the choice of an adequate period of reference to assess the "academic performance" of an institution. This is a difficult question. It has been implicitly answered by the authors of the ranking in a rather strange way. Lacking any clear analysis of the problem, they mix up in the model several very different time periods: one century for criteria ALU and AWA, 20 years for criterion HiCi, 5 years for criterion N&S, and 1 year for criterion PUB[4]. There may be a rationale behind these choices. It is not made explicit by the authors of the ranking. As observed in van Raan (2005a), "academic performance" can mean two very different things: the prestige of an institution based on its past performances and its present capacity to attract excellent researchers. These two elements should not be confused.

3.8.2 Size effects

Five of the six criteria used by the authors of the ranking are counting criteria (prizes and medals, highly cited researchers, papers in N&S, papers indexed by Thomson Scientific). Hence, it should be no surprise that all these criteria are strongly linked to the size of the institution. As Zitt and Filliatreau (2006) have forcefully shown, using so many criteria linked to the size of the institution is the sign that *big is made beautiful*. Hence, the fact that criteria are highly correlated should not be a surprise. Although the authors of the Shanghai ranking view this fact as a strong point of their approach, it is more likely to simply reflect the

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[4] Let us note that this period of 1 year seems especially short. The computation of the Impact Factors of journals by Thomson Scientific uses a period of 2 years, see `http://admin-apps.isiknowledge.com.gate6.inist.fr/JCR/help/h_impfact.htm#impact_factor`, last accessed 30 March 2009, and Impact Factors over a period of 5 years are also computed

impact of size effects.

Moreover since the criteria used by the authors of the ranking are linked with "academic excellence", we should expect that they are poorly discriminatory between institutions that are not ranked among the top ones. A simple statistical analysis reveals that this is indeed the case. Table 5 gives the mean value for the first five criteria used by the authors of the ranking according to the rank of the institutions (this is based in the 2008 edition of the ranking; similar figures would be obtained with previous editions).

It is apparent that criteria ALU and AWA contribute almost to nothing in the ranking of institutions that are not in the top 100. Furthermore, criteria HiCi and N&S have very small values at the bottom of the list. Hence, for these institutions, criteria PUB mostly explains what is going on. This is at much variance with the presentation of the ranking as using multiple criteria.

4   An MCDM view on the Shanghai ranking

In the previous section, we have proposed a critical analysis of the criteria used by the authors of the Shanghai ranking. This analysis is well in line with the observations in van Raan (2005a) and Ioannidis et al. (2007). We now turn to questions linked with the methodology used by the authors to aggregate these criteria.

4.1   A rhetorical introduction

Suppose that you are giving a Master course on MCDM. The evaluation of students is based on an assignment consisting in proposing and justifying a particular MCDM technique on an applied problem. The subject given to your students this year consists in devising a technique that would allow to "rank order countries according to their 'wealth'". Consider now the case of three different students.

The first student has proposed a rather complex technique that has the following feature. The fact that country a is rank before or after country b does not only depend on the data collected on countries a and b but also with what happens with a third country c. Although we might imagine situations in which such a phenomenon could be admitted (see Luce and Raiffa, 1957, Sen, 1993), our guess is that you will find that this student is *completely out of her mind.*

Consider a second student that has proposed a simple technique that works as follows. For each country she has collected the GNP (Gross national Product) and the GNPpc (Gross national Product per capita) of this country. She then suggests to rank order the countries using a weighted average of the GNP and the GNPpc of each country. Our guess is that you will find that this student is *completely*

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Rank	ALU	AWA	HiCi	N&S	PUB
0–97	26.32 (10%)	26.15 (17%)	35.57 (1%,16.2)	31.96 (0%,15.1)	54.56 (12.4)
101–200	8.03 (52%)	5.18 (69%)	18.02 (1%, 6.4)	16.87 (0%, 5.3)	41.62 (8.0)
201–302	5.01 (65%)	1.08 (92%)	10.84 (16%, 5.9)	12.24 (1%, 3.6)	35.52 (7.1)
303–401	3.05 (82%)	1.55 (91%)	8.04 (23%, 5.3)	8.06 (1%, 3.6)	29.13 (6.8)
402–503	0.71 (94%)	0.45 (96%)	5.25 (37%, 4.3)	6.50 (7%, 3.0)	26.70 (5.8)

Table 5: Mean values of criteria according to ranks (source: 2008 ARWU ranking). For criteria ALU and AWA, we indicate in parenthesis the percentage of institutions having a null score. For criteria HiCi and N&S, we indicate in parenthesis the percentage of institutions having a null score and the standard deviation of the score. For criteria PUB, we indicate in parenthesis the standard deviation of the score. The apparent irregularity of ranks is due to ties, as reported in the 2008 ARWU ranking.

out of her mind. Either you want to measure the "total wealth" of a country and you should use the GNP or you want to measure the "average richness" of its inhabitants and you should use the GNPpc. Combining theses two measures using a weighted average makes no sense: the first is a "production" measure, the second is a "productivity" measure. Taking α times production plus $(1 - \alpha)$ times productivity is something that you can compute but that has absolutely no meaning, unless, of course, if α is 0 or 1. The reader who is not fully convinced that this does not make sense is invited to test the idea using statistics on GNP and GNPpc that are widely available on the web.

Consider now a third student who has proposed a complex model but that has:

- not questioned the relevance of the task,

- not reflected on what "wealth" is and how it should be measured,

- not investigated the potential impacts of her work,

- only used readily available information on the web without questioning its relevance and precision,

- has mixed this information with highly subjective parameters without investigating their influence of the results.

Clearly you will find that this student is *completely out of her mind.* She has missed the entire difficulty of the subject reducing it to a mere number-crunching exercise.

We are sorry to say that the authors of the ranking do not seem to be in a much better position than any of our three students. We explain below why we think that they have, in their work, combined all what we have found to be completely unacceptable in the work of these three students.

4.2 The aggregation technique used is flawed

One of the first thing that is invariably taught in any basic course on MCDM is the following. If you aggregate several criteria using a weighted sum, the weights that are used should *not* be interpreted as reflecting the "importance" of the criteria. This may seem strange but is in fact very intuitive. Weights, or rather *scaling constants* as we call them in MCDM, are indeed linked to the normalization of the criteria. If normalization changes, weights should change. A simple example should help the reader not familiar with MCDM understand this point. Suppose that one of your criterion is a measure of length. You may choose to measure this criterion in meters, but you may also choose to measure it in kilometers. If you

use the same weight for this criterion in both cases, you will clearly end up with *absurd results.*

This has two main consequences. First, weights in a weighted sum cannot be assessed on the basis of a vague notion of "importance". The comparison of weights do not reflect a comparison of importance. Indeed, if the weight of a criterion measured in meters is 0.3 this weight should be multiplied by 1 000 if you decide to measure it in kilometers. Therefore the comparison of this weight with the weights of other criteria does not reflect a comparison of importance (it may well happen that the weight of criterion length, when this criterion is measured in meters, is smaller than the weight of another criterion, while the opposite comparison will prevail when this criterion is measured in kilometers). This has many important consequences on the correct way to assess weights in a weighted sum (see Bouyssou et al., 2006, Keeney and Raiffa, 1976). In any case, it does not make sense to ask someone directly for weights (as the authors of the ranking do on their web site). This also raises the problem on how the authors of the Shanghai have chosen their set of weights. They offer no clue on this point. It seems safe to consider that the weights have been chosen arbitrarily. The only rationale we can imagine for this choice is that, in the first version of the ranking, the authors used only five criteria with equal weights. Although the use of equal weights may be justified under certain circumstances (see Einhorn and Hogarth, 1975), we have no reason to believe that they apply here.

A more devastating consequence is the following. If you change the normalization of the criteria, you should absolutely change the weights to reflect this change. If you do not do so, this amounts to changing the weights... and you will end up with nonsensical results. Since, each year, the authors of the ranking normalize their criteria giving the score of 100 to the best scoring institution on each criterion, and, since each year the non-normalized score of the best scoring institution on this criterion is likely to change, the weights should change each year so as to cope with this new normalization. But the authors of the ranking do not change the weights to reflect this change of normalization[5]. Because of the change of normalization, this amounts to using each year a different set of weights!

Let us illustrate what can happen with a simple example using two criteria. Let us consider the data in Table 6. In this table, eight alternatives (or institutions) a, b, c, d, e, f, g and h are evaluated on two criteria g_1 and g_2 (the average values that are used in this example roughly correspond to the average values for criteria PUB and $10 \times$ HiCi). These criteria are normalized so as to give a score of 100 to the best scoring alternative on each criterion (here, h on both criteria). This defines the two normalized criteria g_1^n and g_2^n. For instance we have $g_2^n(f) = 35 = (175 \times 100)/500$. Let us aggregate these two criteria with a weighted

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[5] Keeney (1992, p. 147) calls this the "most common critical mistake".

alternatives	g_1	g_2	g_1^n	g_2^n	Score	Rank
h	2 000	500	100.00	100.00	100.0	1
a	160	435	8.00	87.00	47.5	2
b	400	370	20.00	74.00	47.0	3
c	640	305	32.00	61.00	46.5	4
d	880	240	44.00	48.00	46.0	5
e	1 120	175	56.00	35.00	45.5	6
f	1 360	110	68.00	22.00	45.0	7
g	1 600	45	80.00	9.00	44.5	8

Table 6: Weighted sum: example with equal weights

sum using equal weights. This defines the 'Score' column in Table 6 (it is not necessary to normalize again the global score, since the score of h is already 100). If we use this global score to rank order the alternatives, we obtain the following ranking ($a \succ b$ means that a is preferred to b):

$$h \succ a \succ b \succ c \succ d \succ e \succ f \succ g.$$

Consider now a similar situation in which everything remains unchanged except that the performance of h on g_2 increases: it is now 700 instead of 500. This leads to the data in Table 7. The two criteria are again normalized so as to give a score of 100 to the best scoring alternative on each criterion (here again, h on both criteria). But because the score of h on g_2 has changed, this impacts *all* normalized scores on g_2^n. If you decide to aggregate the two normalized criteria using the same weights as before, you end up with the following ranking:

$$h \succ g \succ f \succ e \succ d \succ c \succ b \succ a.$$

Observe that the modification of the score of h on g_2 has inverted the ranking of all other alternatives! The intuition behind this "paradox" should be clear. Since the score of h on g_2 has changed, we have changed the normalization of criterion g_2^n. Because the normalization has changed, the weight of this criterion should change if we want to be consistent: instead of using weights equal to 0.5 and to 0.5, we should now use different weights so as to reflect this change of normalization.

This "paradox" can be made even stronger by using the following example. Start with Table 6 and suppose now that everything remains unchanged except that h increases its performance on g_2 and that a, being in second position, increases its performance on both g_1 and g_2. Intuitively we would expect that since h and a were ranked in the first two positions and since they have both improved, they should clearly remain ranked on top. But this is not so. This is detailed in

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alternatives	g_1	g_2	g_1^n	g_2^n	Score	Rank
h	2 000	**700**	100.00	100.00	100.00	1
a	160	435	8.00	62.14	35.07	8
b	400	370	20.00	52.86	36.43	7
c	640	305	32.00	43.57	37.79	6
d	880	240	44.00	34.29	39.14	5
e	1 120	175	56.00	25.00	40.50	4
f	1 360	110	68.00	15.71	41.86	3
g	1 600	45	80.00	6.43	43.21	2

Table 7: Weighted sum with equal weights: h increases on g_2

Table 8. The final ranking is now:

$$h \succ g \succ f \succ e \succ d \succ c \succ b \succ a.$$

Again, a counterintuitive situation occurs: institution a, the only one besides h having progressed, is now ranked last!

alternatives	g_1	g_2	g_1^n	g_2^n	Score	Rank
h	2 000	**700**	100.00	100.00	100.00	1
a	**165**	**450**	8.25	64.29	36.27	8
b	400	370	20.00	52.86	36.43	7
c	640	305	32.00	43.57	37.79	6
d	880	240	44.00	34.29	39.14	5
e	1 120	175	56.00	25.00	40.50	4
f	1 360	110	68.00	15.71	41.86	3
g	1 600	45	80.00	6.43	43.21	2

Table 8: Weighted sum: h increases on g_2 and a increases on both g_1 and g_2

Observe that the failure to change weights when normalization changes has very strange effects besides the ones just mentioned. If an institution is weak on some criterion, so that a competitor is ranked just before it, its interest is that the best scoring alternative on this particular criterion improves its performance: if the weights are kept unchanged, this will mechanically decrease the importance of this criterion and will eventually allow it to be ranked before its competitor. Therefore if an institution is weak on some criterion, its interest is that difference between its performance and the performance of the best scoring criterion on this criterion increases!

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	g_1	g_2
a	5	19
b	20	4
c	11	11
d	3	3

Table 9: Weighted sum: unsupported efficient alternatives

Because the authors of the ranking felt into this elementary trap, it seems safe to conclude that their results are absolutely of no value. A rather tortuous argument could be put forward in order to try to salvage the results of the Shanghai ranking saying that the data is such that, whatever the weights, the results are always the same. In view of Figure 1, it seems clear that such an argument does not apply here [6].

Let us conclude with a final remark on the aggregation technique that is used. Even if the authors of the ranking had not fallen in the trap explained above (and, clearly, there are very simple steps that could be taken to correct this point), the weighted sum would remain a poor way to aggregate criteria. Almost all of Bouyssou et al. (2000) is devoted to examples explaining why this is so. Let us simply recall here the classical problem of the existence of *unsupported efficient alternatives*, in the parlance of MCDM. An alternative is said to be dominated if there is an alternative that has better evaluations on all criteria and a strictly better one on some criterion. An alternative is *efficient* if it not dominated. Clearly, all efficient alternatives appear as reasonable candidates: all of them should be in position to be ranked first with an appropriate choice of weights. Yet, with a weighted sum, there are efficient alternatives that cannot be ranked first, whatever the choice of weights.

Table 9 gives an example (taken from Bouyssou et al., 2000) of such a situation, using two criteria to be maximized. Observe that there are three efficient alternatives in this example: a, b, and c (alternative d is clearly dominated by all other alternatives). Intuitively, alternative c appears to be a good candidate to be ranked first: it performs reasonably well on all criteria, while a (resp. b) is excellent on criterion 1 (resp. 2) but seems poor on criterion 2 (resp. 2). However, if the two criteria are aggregated using a weighted sum, it is impossible to find weights that would rank c on top. Indeed, suppose that they are weights α and $1 - \alpha$ that would allow to do so. Ranking c before a implies $11\alpha + 11(1 - \alpha) > 5\alpha + 19(1 - \alpha)$, i.e., $\alpha > 8/15 \approx 0.53$. Ranking c before b implies $11\alpha + 11(1 - \alpha) > 20\alpha + 4(1 - \alpha)$,

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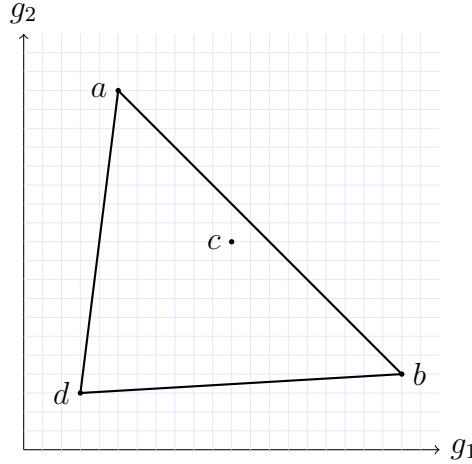[6] The reader may want to check what is the final ranking based on Table 6 using the weights 0.6 and 0.4.

Figure 2: Unsupported efficient alternatives

i.e., $\alpha < 7/16 \approx 0.44$. Figure 2 shows that this impossibility is due to the fact that c is dominated by a convex combination of a and b (this convex combination of a and b dominating c is not unique).

Recent research in MCDM have exhibited a wealth of aggregation techniques that do not have such a major deficiency (Belton and Stewart, 2001, Bouyssou et al., 2000).

4.3 The aggregation technique that is used is nonsensical

Criteria ALU, AWA, HiCi, N&S, and PUB are *counting* criteria. It is therefore rather clear that they are globally linked to the ability of an institution to produce a large amount of good papers and good researchers. They capture, up to the remarks made in Section 3, the research potential of an institution. This is semantically consistent. However, criterion Py is quite different. If the first five criteria capture "production" the last one captures "productivity". But common sense and elementary economic analysis strongly suggest that taking a weighted average of production and productivity, although admissible from a purely arithmetic point of view, leads to a composite index that is meaningless (we use the word here in its ordinary sense and not in its measurement-theoretic sense, see Roberts, 1979). The only argument that we can think of in favor of such a measure is that the weight of the last criterion is rather small (although, we have seen above that weights in a weighted sum should be interpreted with great care). Nevertheless, the very fact that production is mixed up with productivity seems to us highly problematic and indicates a poor reflection on the very meaning of what an adequate composite index should be. The projects of the authors of the ranking, as announced in Liu

et al. (2005, p. 108), to build a ranking with a weight of 50% for the criterion Py, are a clear sign that this semantic problem has not been fully understood by the authors of the ranking. This severely undermines the confidence one can have in the results of the ranking.

4.4 Neglected structuring issues

When trying to build an evaluation model, good practice suggests (Bouyssou et al., 2000, JRC/OECD, 2008) that the reflection should start with a number of simple but crucial questions:

1. What is the definition of the objects to be evaluated?

2. What is the purpose of the model? Who will use it?

3. How to structure objectives?

4. How to achieve a "consistent family of criteria"?

5. How to take uncertainty, imprecision, and inaccurate definition into account?

Concerning the last three questions, we have seen in Section 3 that the work of the authors of the Shanghai ranking could be subjected to severe criticisms. This is especially true for the last question: since raw data are not made publicly available and the many micro-decisions that led to these data are not documented, it is virtually impossible to analyze the robustness of the proposed ranking. The partial analyses conducted in Saisana and D'Hombres (2008) show that this robustness is likely to extremely weak.

Let us concentrate here on the first two questions keeping in mind a number of good practices for the construction of an evaluation model.

4.4.1 What is a "university"?

This question might sound silly to most our readers coming from the US and the UK. However for a reader coming from continental Europe this question is not always an easy one. Let us take here the example of France, which is, admittedly, a particularly complex example. In France co-exit:

- Public universities (usually named *Universités*). What should be observed here is that the history of most of these universities has been long and somewhat erratic. After 1968, most of them were split into several smaller ones (which explains why most of French universities carry numbers in their names). Moreover, there are many newly created universities in France that

are rather small and do not offer programs in all areas of Science and/or do not offer programmes at all levels of the Bachelor-Master-Doctorate scale. Finally, when analyzing the French system, it should be kept in mind that these universities rarely attract the best students. They rather choose to enter the *Grandes Écoles* system. Tuition fees in these universities are generally small.

- *Grandes Écoles* (mainly in Engineering, Management and Political Science) are very particular institutions. They are usually quite small and most of them only grant Master degrees. They are highly selective institutions that are recruiting students after a nationwide competitive exam. They have a long tradition and a very active network of alumni. Only very few of them are actively involved in Doctoral programs. Tuition fees in *Grandes Écoles* vary a lot. Some of them are quite expensive (mostly management schools) while in some others, the fees are comparable to that of a public university. Finally, in some of them, (e.g., the *Écoles Normales Supérieures*), students are paid.

- Large public and private research institutes that may have common research centers, among them or with universities or *Grandes Écoles*. Among the public research centers we should mention: CNRS, INSERM (specialized in biomedical research), INRA (specialized in agricultural sciences) and INRIA (specialized in Computer Science). A very significant part of research in France is conducted in such institutes, although they have no student and grant no diploma. Moreover, there are large and renowned private research centers, the most famous one being *Institut Pasteur* (many of the French Nobel prizes in Medicine are linked to it).

With such a complex institutional landscape, what should count as a university is far from being obvious. It seems that this was not obvious to the authors of the ranking, that included in their 2003 edition the *Collège de France*, an institution that has no student and grants no diploma: if such an institution can count as a university then almost all organizations can. The French situation is especially complex but is far from being exceptional. Germany and Italy have strong Public Research centers, besides their universities, too.

Any evaluation system should minimally start with a clear definition of the objects to be evaluated. Such a definition is altogether lacking in the Shanghai ranking.

4.4.2 What is a "good" university?

The authors of the ranking are interested in "world-class" universities. But, as they have not proposed a definition of what a university is, they do not offer a definition of what a "world class" university is. Nevertheless the criteria they use allow to implicitly define what they mean here. The only thing of importance is "excellence" in research. Moreover this excellence is captured using very particular criteria evaluated in a very particular way (see Section 3). Why ignore research outputs such as patents, books or PhD theses? Why count papers instead of trying to measure impact?, etc.

Perhaps the most perplexing thing in the implicit definition of a world class university used by the authors of the ranking is that it mostly ignores inputs and institutional constraints.

Some universities have a more-or-less complete freedom to organize their governance, to hire and fire academic and non-academic staff, to decide on salaries, to select students, to decide on tuition fees. Some others have almost no freedom in all these respects (this is mostly the case for French universities). They cannot select students, they cannot decide on tuition fees, they are not fully involved in the selection of their academic staff, and firing someone is difficult. Given such differences in institutional constraints, should we simply ignore them, as is implicitly done in the ranking? This is only reasonable if one admits that there is "one best model" of a world-class university. This hypothesis would need detailed empirical justification that is not offered by the authors of the Shanghai ranking.

Similarly the "inputs" consumed by institutions in their "scientific production process" are mostly ignored. The only input that is explicitly taken into account is the number of FTE academic staff, when it could be obtained. But there are many other important inputs that should be included, if one is to judge on the efficiency of a scientific production process. Let us simply mention here that tuition fees, funding (Harvard's annual budget is over 3×10^9 USD in 2007, Harvard University, 2007, p. 38; this is larger than the GDP of Laos), quality of campus, libraries (Harvard's libraries possess over 15×10^6 volumes, Harvard University, 2007), academic freedom to research and publish on any subject of interest, etc. are also very important ingredients in the success of a university. Ignoring all these inputs implies a shallow and narrow view on academic excellence[7].

The implicit definition that is used by the author of the Shanghai ranking should be clear at this point. It roughly consists in an institution:

1. that is old and has kept its name (preferably a simple English one without diacritical signs) throughout its history,

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[7]We disagree here with Principle 8 in International Ranking Expert Group (2006): a production process, whether it is or not scientific, cannot be analyzed without explicitly considering inputs *and* outputs.

2. coming from a country that has not experienced major political and social changes and that is peaceful democracy,

3. coming from a country in which the organization of the higher education system is simple (no dual system, no research centers around),

4. coming from an English speaking country,

5. having much freedom with respect to its governance,

6. having much freedom in hiring and firing staff and deciding on salaries,

7. being well funded.

We do not want to claim that such an implicit definition is nonsensical. We only want to point out that it more or less corresponds to the definition of the Ivy League (plus "Oxbridge") and, unsurprisingly, these institutions are quite well represented at the top of the Shanghai ranking.

4.4.3 What is the purpose of the model?

To us, the very interest of ranking "universities" is not obvious at all. Indeed, who can benefit from such a ranking?

Students and families looking for information are much more likely to be interested in a model that will evaluate programs. We are all aware of the fact that a good university may be especially strong in some areas and quite weak in others. Moreover, it seems clear that (although we realize that each family might want to consider its child as a future potential Nobel Prize winner) students and families are likely to be interested in rather trivial things such as tuition fees, quality of housing, sports facilities, quality of teaching, reputation of the program in firms, average salaries after graduation, strength of alumni association, campus life, etc. For an interesting system offering such details, we refer to Berghoff and Federkeil (2009) and Centre for Higher Education Development (2008).

Recruiters are likely to be little impressed by a few Nobel prizes granted long ago to members of a given department, if they consider recruiting some with a Master degree coming from a totally different department. Clearly, they will be mostly interested in the "employability" of students with a given degree. Besides the criteria mentioned above for students and families, things like the mastering of foreign languages, international experience, internships, etc. are likely be of central importance to them.

Likewise, a global ranking of universities is quite unlikely to be of much use to deans and rectors willing to work towards an increase in quality. Clearly, managers of a university will be primarily interested in the identification of weak and strong

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departments, the identification of the main competitors, and the indication of possible directions for improvement. Unless they have a contract explicitly specifying that they have to increase the position of their institution in the Shanghai ranking (as astonishing as it may sound, this has happened), we do not see how a ranking of an institution as whole can lead to a useful management tool.

Finally, political decision makers should be primarily interested in an evaluation system that would help them decide on the efficiency of the higher education system of a country. If a country has many good medium-sized institutions, it is unlikely that many of them will be standing high in the Shanghai ranking. But this does not mean that the system as a whole is inefficient. Asking for "large" and "visible" institutions in each country may involve quite an inefficient use of resources. Unless the authors of the ranking can produce clear empirical evidence that scientific potential is linked with size and that medium-sized institutions simply cannot produce valuable research, we do not understand why all this may interest political decision makers, except, of course, to support other strategic objectives.

4.4.4 Good evaluation practices

As detailed in Bouyssou et al. (2000) and Bouyssou et al. (2006), there are a number of good practices that should be followed when building an evaluation model. We want only to mention two of them here.

The first one is fairly obvious. If you evaluate a person or an organization, you should allow that person or organization to check the data that are collected on her/it. This seems quite obvious. Not doing so, inevitably leads to a bureaucratic nightmare in which each one is evaluated based on data that remain "behind the curtain". We have seen that this elementary good practice has been forgotten by the authors of the ranking.

The second good practice we would like to mention is less clear-cut, but is nevertheless crucial. When an evaluation system is conceived, its creators should not expect the persons or the organizations that are evaluated to react passively to the system. This is the baseline of any introductory management course. Persons and organizations will adapt their behavior, consciously or not, in reaction to the evaluation system. This feedback is inevitable and perverse effects due to such adaptations are inescapable (all this has been well documented in the management literature, Berry, 1983, Boudon, 1979, Dörner, 1996, Hatchuel and Molet, 1986, Mintzberg, 1979, Moisdon, 2005, Morel, 2002). A good practice is therefore the following. Try to anticipate the most obvious perverse effects that can be generated by your evaluation system. Try to conceive a system in which the impacts of the most undesirable perverse effects are reduced. It does not seem that the authors of the ranking have followed this quite wise advice. The only words of wisdom are here

that "Any ranking exercise is controversial, and no ranking is absolutely objective" and that "People should be cautious about any ranking and should not rely on any ranking either, including the 'Academic Ranking of World Universities'. Instead, people should use rankings simply as one kind of reference and read the ranking methodology carefully before looking at the ranking lists" (Shanghai Jiao Tong University, Institute of Higher Education, 2003–09). Sure enough. But beyond that, we surely expect the developers of an evaluation system to clearly analyze the potential limitations of what they have created in order to limit, as far as possible, its illegitimate uses and the authors of the ranking remain silent on this point.

Suppose that you manage a university and that you want to increase your position in the ranking. This is simple enough. There are vast areas in your university that do not contribute to your position in the ranking. We can think here of Law, Humanities and most Social Sciences. Drop all these fields. You will surely save much money. Use this money to buy up research groups that will contribute to your position in the ranking. Several indices provided by Thomson Scientific are quite useful for this purpose: after all, the list of the potential next five Nobel prizes in Medicine is not that long. And, anyway, if the group is not awarded the prize, it will publish much in journals that count in the ranking and are quite likely to be listed among the highly cited researchers. This tends to promote a view of Science that much resembles professional sports in which a few wealthy teams compete worldwide to attract the best players. We are not fully convinced that this is the best way to increase human knowledge, to say the least.

Manipulations are almost as simple and as potentially damaging for governments. Let us take for example the case of the French government, since we have briefly evoked above the complex organization of the French higher education system. Most French universities were split in several smaller part in the early seventies. The idea was then to create organizations that would be easier to manage. Indeed, the venerable *Université de Paris* gave rise to no less than 13 new universities. But we have seen that this is surely detrimental in the ranking. So you should give these universities strong incentives to merge again. Neglecting the rather marginal impact of the last criterion, a simple calculation shows that merging the universities in Paris that are mainly oriented towards hard sciences and medicine (there is clearly no interest to merge with people doing such futile things as Law, Social Sciences and Humanities), i.e., Paris 5, 6, 7 and 11 (these are not the official names but their most common names), would lead (using the data from the 2007 Shanghai ranking) to an institution that would roughly be at the level of Harvard University. Bingo! You are not spending one more Euro, you have surely not increased the scientific production and potential of your country, you have created a huge organization that will surely be rather difficult to man-

age. . . but you have impressively increased the position of France in the Shanghai ranking. Can you do even more? Sure, you can. Public research centers, although quite efficient, count for nothing in the ranking. You can surely suppress them and transfer all the money and persons to the huge organization you have just created. Then, you will surely end up much higher than Harvard University. . . No need to say that all these manipulations are likely to lead, in the long term, to disastrous results. But since they will only occur in the long term, we confess that French political decision makers seem to be no exception to the rule stating that political decision makers trade off short term and long term effects in rather strange ways. Indeed, as witnessed, for instance, by the recent merger of the three universities in Strasbourg (that has taken effect on 1 January 2009, see `http://demain.unistra.fr/`, last accessed 30 March 2009) and the new law on the organization and autonomy of public universities (numbered 2007-1199 and dated 10 August 2007), they have started working in this direction.

5   Where do we go from here?

Let us now summarize our observations on the Shanghai ranking and try to draw some conclusions based on our findings, both on a scientific and a more strategic level.

5.1   An assessment of the Shanghai ranking

In what was probably the first serious analysis of the Shanghai ranking, van Raan (2005a) stated that "From the above considerations we conclude that the Shanghai ranking should not be used for evaluation purposes, even not for benchmarking" and that "The most serious problem of these rankings is that they are considered as 'quasi-evaluations' of the universities considered. This is absolutely unacceptable". We surely agree. The rather radical conclusions of van Raan were mainly based on bibliometric considerations, to which the authors of the Shanghai ranking proved unable to convincingly answer (Liu et al., 2005, van Raan, 2005b).

Our own analysis adopted a point of view that reflects our slant towards MCDM. Adding an MCDM point of view to the bibliometric analysis of van Raan (2005a) inevitably leads to an even more radical conclusion. Indeed, we have seen all criteria used by authors of the ranking are only loosely connected with what they intended to capture. The evaluation of these criteria involves several arbitrary parameters and many micro-decisions that are not documented. Moreover, we have seen that the aggregation method that is used is flawed and nonsensical. Finally, the authors of the ranking have paid almost no attention to fundamental structuring issues.

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Therefore, it does not seem unfair to say that *the Shanghai ranking is a poorly conceived quick and dirty exercise with no value whatsoever.* Again any of our MCDM student that would have proposed such a methodology in her Master's Thesis would have surely failed according to our own standards.

Although we have concentrated here on the Shanghai ranking, it is clear that much the same analysis (and conclusions) could (and should) be applied to the Times higher Education Supplement ranking (Times Higher Education Supplement, 2008). We leave it up to the interested reader (for a vigorous critical analysis of the US News and World Report ranking, we refer to Ehrenberg, 2003).

5.2 What can be done?

An optimistic point of view would be that, after having read our paper, the authors of the ranking would decide to immediately stop their work, apologizing for having created so much confusion in the academic world, and that all political decision-makers would immediately stop using "well know international rankings" as means to promote their own strategic objectives. However, we live in the real world and our bet is that this will not happen. Since the authors of Shanghai ranking more or less decided to ignore the point of view of van Raan (2005a), we think much likely that they will ignore ours. Therefore, we expect that they will continue for a long time to produce an annual ranking. Also, we should not expect too much of the ability of political decision makers to abandon easy-to-use arguments that look striking enough in the general media. Therefore, we will have to live in a world in which extremely poor rankings are regularly published and used. What can be done then? Well, several things.

The first, and the more easy one, should be to stop being naive. "What is the best wine in the world?", "What is the best car in the world?", "Where is the most pleasant city in Europe?", etc. All these questions may be interesting if your objective is to sell many copies of a newspaper or a book. However, it is clear that all these questions are meaningless unless they are preceded by a long and difficult structuring work. Clearly the "best car in the world" is a meaningless concept unless you have identified stakeholders, structured their objectives, studied the various ways in which attributes can be conceived to measure the attainment of these objectives, applied meaningful procedures to aggregate this information and performed an extensive robustness analysis. Doing so, you might arrive at a model that can really help someone choose a car, or alternatively help a government to prepare new standards for greenhouse gas emissions. Without this work, the question is meaningless [8]. If the question is meaningless for cars, should we expect

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[8] The same is true for wines. Some "experts" have popularized the idea of "grading wines". This process has has undoubtedly made them rich but has also resulted in an incredible impov-

a miracle when we turn to incredibly more complex objects such as universities? Certainly not. There is no such thing as a "best university" in abstracto. Hence, a first immediate step is that we suggest is the following. Stop talking about these "all purpose rankings". They are meaningless. Lobby in our own institution so that these rankings are never mentioned in institutional communication. This is, of course, especially important for our readers "lucky" enough to belong to institutions that are well ranked. They should resist the temptation of saying or thinking "there is almost surely something there" and stop using the free publicity offered by these rankings.

Since the production of poor rankings is unlikely to stop, a more proactive way to fight them is to produce many alternative rankings that produce vastly different results. It is not of vital importance that these new rankings are much "better" in some sense that the Shanghai ranking. Their main usefulness will be to "dilute" its devastating effects. A very interesting step in the direction was taken in ENSMP (2007). The *École Nationale Supérieure des Mines de Paris* (ENSMP) is a French *Grande École*, being very prestigious in France. Its size is such that it is clear that it will never appear in good position in the Shanghai ranking. Hence, the ENSMP has decided to produce an alternative ranking. It can be very simply explained since it is based on a single criterion: the number of alumni of an institution having become the CEO of one of the top 500 leading companies as identified by Fortune (we refer to ENSMP, 2007, for details on how this number is computed). We do not regard this ranking as very attractive. Indeed, the performances of the various institutions are based on things that happened long ago (it is quite unusual to see someone young becoming the CEO of a very large company). Therefore this number has little relation with the present performance of the institution. Moreover, this criterion is vitally dependent upon the industrial structures of the various countries in the world (institutions coming from countries in which industry is highly concentrated have a clear advantage) and "network effects" will have a major impact on it (we know that these effects are of utmost importance to understand the French *Grandes Écoles* system). Yet, we do not consider that the ENSMP ranking is much worse than the Shanghai ranking. On the contrary, it quite clearly points out the arbitrariness of many of the criteria used by the authors of the Shanghai ranking. Finally and quite interestingly, the ENSMP ranking gives results that are *vastly different* from the Shanghai ranking. The top 10 institutions in this ranking have no less than 5 French institutions (École Polytechnique, HEC, Sciences Po, École Nationale d'Administration, and ENSMP). Among these five institutions, three are not even mentioned in the top 500 of the Shanghai ranking (HEC, Sciences Po, and École Nationale d'Administration). Diluting the effects of the Shanghai ranking clearly calls for *many more rankings* of this kind.

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erishment of the variety of wines that are produced in Europe.

5.3 Why don't you propose your own ranking?

We have been fairly negative on the Shanghai ranking (but fair, as far as we can judge). The reader, already exhausted at this point, may legitimately wonder why we do not now suggest another, better, ranking. We will refrain here of doing so for various reasons.

First, this is not our main field of research. We are not experts in education systems. We are not experts in bibliometry. Contrary to the authors of the ranking, we do think that a decent ranking should obviously be the product of a joint research team involving experts in evaluation, education systems and bibliometry.

Second, we do not underestimate the work involved. Although we think that the Shanghai ranking is of very poor quality, producing it is a huge task. A better ranking will inevitably involve even more work, based on the reasonable assumption that there is no free lunch.

Third, we are not at all convinced that this exercise can be of any use to any serious person. We have explained why we would tend to rank programs or national education systems instead universities. We have also given several clues on what should be done and what should absolutely not be done. We hope that these guidelines will be helpful for readers willing to take up to this task.

Let us finally observe that the combination of Operational Research (OR) with sophisticated bibliometric evaluation tools seem to offer good promises for evaluation systems that would really help improve the quality of Science, the only thing, after all, we are interested in. Because the issue of bibliometric techniques has been extensively dealt with elsewhere (Moed, De Bruin, and van Leeuwen, 1995, Moed, 2006, van Raan, 2005c, 2006, Zitt, Ramanana-Rahary, and Bassecoulard, 2005), we will concentrate here on a few potentially useful OR techniques.

We have already mentioned how the absence of a minimal knowledge of aggregation techniques and their properties, as studied in MCDM, may vitiate an evaluation technique. We would like here to add that OR has also developed quite sophisticated tools to help structuring problems (Checkland, 1981, Checkland and Scholes, 1990, Eden, 1988, Eden, Jones, and Sims, 1983, Friend and Hickling, 1987, Ostanello, 1990, Rosenhead, 1989) and to use this work together with sophisticated aggregation tools (Ackermann and Belton, 2006, Bana e Costa, Ensslin, Corrêa, and Vansnick, 1999, Belton, Ackermann, and Shepherd, 1997, Montibeller, Ackermann, Belton, and Ensslin, 2008, Phillips and Bana e Costa, 2007). A parallel development concerns methods designed to assess the efficiency of "decision making units" that transform several inputs into several outputs, known as Data Envelopment Analysis (DEA) (Banker, Charnes, and Cooper, 1984, Charnes, Cooper, and Rhodes, 1978, Cherchye, Moesen, Rogge, van Puyenbroeck, Saisana, Saltelli, Liska, and Tarantola, 2008, Cook and Zhu, 2008, Cooper, Seiford, and Tone, 1999, Norman and Stoker, 1991). The potential of such techniques for building evalua-

tion models in higher education systems has been already recognized (Bougnol and Dulá, 2006, Johnes, 2006, Leitner, Prikoszovits, Schaffhauser-Linzatti, Stowasser, and Wagner, 2007, Turner, 2005, 2008). We suspect that a wise combination of the above two approaches is quite likely to lead to interesting evaluation models. It could well be combined with the promising interactive approach developed by the Center for Higher Education in Germany (Berghoff and Federkeil, 2009, Centre for Higher Education Development, 2008).

5.4 The role of Europe

We would like to conclude with a word on Europe. Our view is that the European Union has a *huge* responsibility in the development of alternative evaluation tools. Europe has a long, complex, and unfortunately violent history. It is nevertheless rich of its political, cultural and linguistic diversity. But we have seen that such a diversity was rather detrimental in the Shanghai ranking. Hence, at this point, many things are in the hands of the Brussels officials. If they think that a ranking produced in China can be a sound basis to engage into major reforms of European higher education system, they are kindly invited not to do anything. If they think that Europe's cultural, linguistic, and political diversity is of any value, action is urgently needed. In the course of writing this text, we discovered that a call for tenders on this point was launched on 11 December 2008, see `http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/1942&format=HTML&aged=0&language=EN&guiLanguage=en`, last accessed 30 March 2009. We would like to conclude on this positive signal.

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