

The Effect of University Mergers on the Shanghai Ranking

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Received: date / Accepted: date

Abstract The growing influence of the idea of world-class universities and the associated phenomenon of international academic rankings are intriguing issues for contemporary comparative analyses of higher education. Although the Academic Ranking of World Universities (ARWU or the Shanghai ranking) was originally devised to assess the gap between Chinese universities and world-class universities, it has since been credited with roles in stimulating higher education change on many scales, from increasing the labor value of individual high-performing scholars to wholesale renovation of national university systems including mergers. This paper exhibits the response of the ARWU indicators and rankings to institutional mergers in general, and specifically analyses the universities of France that are engaged in a major amalgamation process motivated in part by a desire for higher international rankings.

Keywords Academic rankings · Shanghai · ARWU · mergers · French universities · French Higher Education System

1 Introduction

The Academic Ranking of World Universities (ARWU or the Shanghai Ranking) was developed “to assess the gap between Chinese universities and world-class universities” (Liu and Cheng, 2005). It scores and ranks the world’s leading research universities

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using numerical measures related to the research achievements of some associated individuals and to the amount of institutional research output. ARWU claims that its raw data are accessible, it releases annual revisions to scores and rankings, and it generates a hierarchy roughly aligned with perceptions of elite research universities (Docampo and Cram, 2014). A first-hand account of the data sources as well as the conceptual drivers of the ranking can be found in Liu and Cheng (2005). An account of the arithmetic ranking procedures can be found in Docampo and Cram (2014). The work of Florian (2007) suggests that around eight or nine annual ARWU rankings were published before its arithmetic procedures were discovered and disclosed by Docampo (2013).

In *Rankings and the Reshaping of Higher Education* Hazelkorn (2011) reports that the “annual publication of university rankings has perpetrated a feeding-frenzy that sends shock waves throughout the higher education system worldwide”. While designed to establish benchmarks for world-class universities, ARWU has acquired the dynamic role of indicating advancement or decline against those benchmarks. The international standing of universities and university systems *symbolize* socio-economic and cultural considerations of importance in many parts of the World. As Salmi (2009) points out many governments aim to “make sure that their top universities are actually operating at the cutting edge of intellectual and scientific development.” Salmi counsels that nations also need universities that “emphasize the diverse learning and training needs of the domestic student population and economy.” Nevertheless, in a process explained by the institutional economics of status (Podolny, 2005) nations and regions signal their importance in the global knowledge economy through efforts to drive up the international ranking of their top universities.

It is not easy to create a world-class university. Salmi (2009) points to the importance of a concentration of talent, abundance of resources and appropriate governance: these are elusive and often expensive characteristics. Recognizing that there are limited opportunities for any country to give birth to a new university with these features (King Abdullah University of Science and Technology is one counter example - see Shih, 2012), attention turns to cooperative relationships between pre-existing institutions that can enhance the concentration of talent and abundance of resources, and establish good governance. As Harman and Harman (2008) explain there is a continuum of available cooperative structures, from informal collaborations through joint ventures, consortia, affiliations, shared institutes and federations to formal mergers. Reasons for combining include survival of a financially non-viable institution, the quest for enhanced utility to stakeholders and the pursuit of international competitive advantage (Aula and Tienari, 2011; McBain, 2012). This paper considers mergers between “strong” institutions (universities and similar organizations) where the separate components bring significant research-related contributions (Harman and Harman, 2008).

Labi (2011), Staley (2014) and HERB (2014) provide overviews of university reorganizations and mergers “sweeping” Europe, India and Russia. Historically, university mergers are not uncommon (McBain, 2012; Tight, 2013) but a high level of merger activity among universities that are *strong institutions* in their national contexts seems unprecedented. Politicians’ public justifications of university reforms frequently list the expectation of improved international “visibility” through improved rankings and other indicators of status and reputation. While the real reasons for reforms are unlikely to be so simple, the political call for “visibility” motivates a study of the adjustments to ARWU indicators that may occur in response to institutional amalgamations. The

purpose of this study is to explore in detail the effects of mergers on ARWU indicators and rankings.

The paper is structured as follows. First, we explain how ARWU methods raise issues about the treatment of institutional mergers. We then turn to the university system of France which is undergoing extensive mergers. We present a robust baseline for the current French universities, adjusting the nomenclature of a few institutions and adopting improved values of the full-time equivalent (FTE) counts of academic staff numbers. We then forecast ARWU raw scores, indicator scores and ranks for the institutions that may result from reforms unfolding in France since the “electroshock” of the 2003 Shanghai ranking (Hoareau, 2011). We then discuss the findings, analyze the arithmetic context of “before-and-after” properties of merging institutions, outline some of the pros and cons of mergers as a device to alter university rankings and offer some conjectures about mergers in other settings. Our conclusions follow.

2 ARWU ranking methodology in the presence of a merger

ARWU scores and ranks universities (individually or into bands) by first gathering separate raw data elements for each institution as exhibited in Table 1. The raw data values are then scaled and transformed as explained by Docampo (2013). The indicator scores are combined producing a total score used to allocate the institution’s rank or band. The ARWU process cycle completes when ARWU published its annual revisions of scores and ranks. If a merger has occurred between one ARWU annual publication and the next, ARWU faces a number of decisions that will, ultimately, determine the implications of that merger in forthcoming ARWU publications. ARWU is free to establish its own approach to particular circumstances and we can only indicate in a tentative way the options and reasonable responses that might be made.

Consider a merger forming a “merged university” from “former institutions” or “antecedents.” The antecedents may not all be universities. Assume that all parts of each antecedent participate. A merger potentially influences four dimensions of ARWU raw scores: (1) the assembly of the historical antecedent institutions of the merged university; (2) the former and new concordances of names, aliases and abbreviations (and their potentially multi-lingual homonyms) appearing in affiliation lists of the merged university and its antecedents; (3) the affiliations of a particular researcher with the merged institution and with its antecedents in the light of the ARWU principle that “institutions or research organizations affiliated to a university are treated according to the information in author affiliations” (Liu and Cheng, 2005) and (4) changes in the fore-mentioned dimensions over the time windows relevant to each category and relationship.

The first dimension raises issues if legal aspects are ambiguous and/or if some of the antecedents are not universities. For example, if a merger leads to a multi-campus university system like the University of California or the University of London, ARWU is likely to rank the constituent members and not the system. If the merger is legally a “federation” or a “joint venture” neither the Thompson Reuters index lists nor ARWU may choose to assemble the component affiliations into a single organization. ARWU does not include organizations such as the Chinese Academy of Sciences nor university hospitals, although researchers employed by such organizations may provide affiliations that do accrue to a university. Some mergers may require ARWU to extend the policies that guide these situations.

Table 1 ARWU indicator definitions relating to institutional changes

Alu	Alumni of an institution winning Nobel Prizes and Fields Medals, derived from biographical information. Bachelor, master and doctor degrees are counted, but only one per institution. Shared awards are weighted according to the award weights, and a “decadal aging” process is applied.
Awd	Staff of an institution winning Nobel Prizes (except Literature and Peace) and Fields Medals, derived from biographical information. Shared prizes and shared affiliations are established as the state of affairs at the time the prize was awarded. A “decadal aging” process is applied.
old HiCi	Highly cited researchers listed in the so-called 2001 version of Thompson Reuters Highly Cited Researchers form 50% of the HiCi score in ARWU 2014. For ARWU 2014 the score for this indicator was the ARWU 2013 score.
new HiCi	Highly cited researchers in the so-called 2014 version of Thompson Reuters Highly Cited Researchers form 50% of the ARWU 2014 score. The high-lycited.com web site indicates that highly cited researchers may change their affiliations monthly by changing their ResearcherID affiliation list.
N&S	Articles published in Nature and Science over the previous five years, weighted according to the status of the author in the author list and traced using authors’ affiliations listed in the article.
PUB	Articles indexed in Thompson Reuters Science Citation Index-expanded and Social Science Citation Index, traced using authors’ affiliations in the article.
FTE	The number of full-time equivalent academic staff at a level approximating Assistant Professor and above, obtained from national agencies. Where there is no suitable national agency data a placeholder value is adopted.
PCP	Per capita academic performance of an institution, obtained from the indicators listed above by the methods described in the text.

The second dimension reflects the well-known challenge of disambiguation and concordance in bibliographic studies (Van Raan, 2005). The challenge is reduced by tools such as the OG (organizations-enhanced) concordance presented in the Thompson Reuters Web of Science (WoS). According to the release notes (Thomson Reuters, 2013), OG names “precisely identify research published from a specific organization using the organization - enhanced searching to quantify an organization’s output including naming variants”. While authors’ affiliations on publications will not be retrospectively changed by publishers, WoS may ultimately adjust membership of OG, OO (organizations) and AD (addresses) descriptors in the event of a merger. It is unknown when or how this will be done. While ARWU does not explain how it uses WoS data, there is evidence that ARWU uses several WoS affiliation concordances in an effort to be fair to institutions where the OG list is questionable.

Counts of recipients of prizes and medals share credit between recipients and between the relevant institutions for *alma mater* and affiliations at the time of the award. The distribution may change if two antecedents were formerly credited with partial counts. Counts of highly cited researchers (HCR) must also pay attention to shared affiliations and to affiliation adjustments made by researchers and potentially re-adjusted by ARWU. Difficult questions arise for N&S and PUB indicators where an article has authors from more than one of the antecedent institutions. The N&S indicator identifies authors’ status (corresponding author, first author, next author, and so forth) and a merged university should receive the highest available weight. For indexed publications care is required to ensure that multiple authorship across antecedent institutions translates to the correct article count for the merged university. It is possible that ARWU may decide not to undertake these adjustments but rather will wait for a merger to propagate into authors’ own affiliations and/or into the OG list. Counts of

FTE academic staff are in principle easily accumulated, but an inconsistency arises where ARWU is obliged to use a “dummy” FTE value. Then the FTE for the merger will be the same as the FTE for the antecedent, the PCP indicator not reflect the larger size and the merged institution will rank too high. The effect occurs in the 2014 ARWU ranking of two merged universities in Lisbon: Universidade de Lisboa and Universidade Técnica de Lisboa.

In relation to the fourth dimension, the decadal “aging” procedure for prizes may be applied separately from the merging procedure, and few additional problems should arise. A single year is used for counts of highly cited researchers, authors of indexed articles, and FTE academic staff, avoiding questions of a moving time window. The five-year window for co-authored articles in *Science* and *Nature* raises particularly difficult questions because the merger potentially influences weighted counts for institutions that are *not* involved in the merger. Perhaps it will turn out that the large total number of articles and authors in this category implies that the consequences of a merger for other institutions’ raw data values are small enough to ignore.

2.1 Computation of ARWU indicator scores when institutions merge

Following Docampo (2013) we now explain how the ARWU indicator score, Y , of a merged institution is related to the indicator scores Y_1, Y_2, \dots, Y_n of the n antecedents. Prior to adding the various indicators with their respective weightings, ARWU “normalizes” each indicator raw score to the raw score of the best performing institution. For five of the indicators (Alumni, Award, HiCi¹, N&S and PUB) Harvard University achieves the maximum raw score in ARWU 2014. Harvard’s (approximate) raw scores are exhibited in Table 2.

Table 2 Harvard University raw scores in 2014

Alu	Awd	old HiCi	new HiCi	N&S	PUB
36.10	33.875	191	100	422.40	15860

Let the raw score of the best performer on any of these indicators be h and the corresponding raw score of any other institution be x . Then the ARWU score², X , is obtained by scaling x by h and compressing by the square root:

$$X = 100\sqrt{\frac{x}{h}} \quad (1)$$

The ARWU indicator PCP is derived by first computing the auxiliary quantity WSSX, the weighted sum of the squares of the five aforementioned scores³ where

$$\text{WSSX} = 0.1 (\text{Alu}^2 + \text{old HiCi}^2 + \text{new HiCi}^2) + 0.2 (\text{Awd}^2 + \text{N\&S}^2 + \text{PUB}^2) \quad (2)$$

¹ In 2014 ARWU made use of the old and new Thomson Reuters’ lists of Highly Cited Researchers to compute two HiCi sub-scores, old HiCi and new HiCi.

² In the case of the HiCi indicator the equation applies to both the old and new HCR counting separately.

³ There are slight differences for universities specializing in social sciences and humanities where N&S is not included

Denoting WSSX for the best scorer Caltech as WSSCT and FTE for Caltech as FTECT the indicator PCP for university X with WSSX and FTEX is

$$\text{PCP} = 100 \sqrt{\frac{\text{FTECT} \cdot \text{WSSX}}{\text{WSSCT} \cdot \text{FTEX}}} \quad (3)$$

Specifically, $\text{WSSCT} = 2734.3$ and $\text{FTECT} = 278$ for ARWU 2014 so that

$$\sqrt{\frac{\text{FTECT}}{\text{WSSCT}}} = 0.31886 \Rightarrow \text{PCP} = 31.886 \sqrt{\frac{\text{WSSX}}{\text{FTEX}}} \quad (4)$$

Where ARWU 2014 has been unable to source a reliable FTE value the “dummy” FTE count inferred from the 2014 ARWU list is $\text{FTE} = 940$.

In the year when a merger is first taken into account the raw scores for Alu, Awd and the two HiCi counts are expected to be the sum of the antecedents’ raw scores, except where such scores have been hitherto shared between antecedents. The raw scores for the indicators PUB and N&S for the merged institution are bounded above by the sum of the raw scores of the antecedents, but may be smaller owing to the loss of the separate counts for articles that are co-published between the antecedents. We expect that the comprehensive nature of research at strong antecedents (Harman and Harman, 2008) will imply co-publication of only a modest proportion of the articles counted for the indicator PUB. Thus, the upper bound for PUB may be close to the actual PUB value. For the indicator N&S the difference between the upper bound and the actual value may be large or small depending on the cooperative practices of a small number of researchers affiliated with the antecedents. The FTE value used to calculate the PCP indicator will be the sum of the antecedents’ FTEs except where the FTE has been estimated and remains at the estimated value after the merger.

The scaling and compressing entailed in equation (1) carries through in the calculation of the ARWU indicator scores which we estimate as actual values for Alu, Awd and the two HiCi counts and upper bounds for N&S and PUB. Thus, the value of the upper bound, Y , of an ARWU indicator score for the merged institution expressed in terms of the ARWU indicator scores Y_i for the n antecedents is given by the “Pythagorean” rule

$$Y = \sqrt{\sum_{i=1}^n Y_i^2} \quad (5)$$

Equation 5 must be applied to both the counts of old and new HiCi before combining them in the HiCi score.

The ARWU indicator score PCP is calculated as the ratio given by equation (4). The numerator is bounded above by the weighted sum of squares defined in equation (2). For countries where values of the divisor FTE are available, the value for the merged institution is the sum of the FTE values for the antecedents. The ARWU indicator score PCP for a merged institution is a weighted average of the PCPs of the antecedents and will be smaller than the largest PCP of the antecedents. This is consistent with the design of PCP (Liu and Cheng, 2005) which compensates for the correlation between large size and high rank by normalising to FTE.

3 The French Higher Education System

The *contestation* of May 1968 and afterwards was a protest against “prominent inadequacies” in French universities (Samuelson, 1968). While earlier influences contributed to the current architecture of the French higher education system, these events had a significant influence on the present double duality of (a) research and teaching organizations (between large publicly funded research agencies [PFRAs] such as CNRS and INSERM and higher education institutions) and (b) higher education institutions and programs (universities and grandes écoles) (Chevaillier, 2013; Aghion and Cohen, 2004). Lichtenberger et al (2007) present a comprehensive overview of the current structure of the French higher education system, while Fridenson (2010) reviews the evolution of the French higher education policy since 1968. These references explain the existence of more than 80 universities and approximately 250 grandes écoles in France at the turn of the century (Baron, 2010), intermixed with separately identified but embedded PFRAs.

When ARWU’s ranking first touched French universities in 2003 the “message” was stark. The top-ranked French university was Pierre and Marie Curie University (Paris 6) at rank 65, and only the University of Paris Sud (Paris 11) joined it in the top 100. In ARWU 2004, four French universities were entered in the top 100 and Paris 6 ranked at 41. The changes in rank over one year obviously reflect ARWU’s difficulties in obtaining stable indicator values for French universities, but even so the message of ARWU was still seen by many influential actors in France as further evidence that French higher education arrangements left much to be improved relative to other national systems (Bourdin, 2008). Indeed, Hoareau (2011) suggests that the combination of the early Shanghai rankings and the contemporaneous literature on the relationships between universities and economic growth (Aghion and Cohen, 2004) prompted a cognitive shift towards greater university autonomy, competition and governance by indicators.

The past decade has witnessed gradual adjustments to French higher education that now show significant consequences. The adoption in 2007 of the law LRU (*Libertés et Responsabilités des Universités*) together with with the promise of increased funding accelerated the *regroupement* process of reform that had been unfolding in France over the past few years. In combination with legislation relating to PFRAs, these changes enabled the establishment of “poles” of research and higher education (PRES) that were designed with the objective of gaining international visibility, critical mass, coherent education and research strategies, and in some cases merged services to create economies of scale (SIRIS, 2011).

An early merger was the University of Strasbourg in 2009 – a decision already taken in 2001–2003, well before the rankings and political agenda mentioned above (Merindol, 2007; Musselin and Dif-Pradalier, 2014). More recently, a major governmental decision was the selection in 2011–2012 of eight research and higher education centers as part of the excellence initiative program (IdEx)⁴ aiming to create the French “Ivy League” (SIRIS, 2011).

Even more recently a law voted in July 2013 asks for the creation of one community of universities per region (several in Paris) in charge of the coordination of research and higher education. Typically one of two models is available in the communities and regions in question:

⁴ <http://www.enseignementsup-recherche.gouv.fr/cid51351/initiatives-d-excellence.html>

- the COMUE (Communauté d’Universités et d’Etablissements): a statutory new university coordinating several member universities, schools and research institutions; or
- the Association: a group composed of a lead university (frequently a merged university, e.g. Strasbourg, Marseille, Lorraine) and several associated universities and schools.

As a result of the application of the law, a new map of the higher education landscape in France is currently being drawn, with the constitution of some 25 COMUEs made public in July 2014⁵, as shown in Table 3. Generally launched within the past year these structures are too new to appear in international rankings. However, because an important incentive for their creation has been the pursuit of increased international visibility, including visibility in world rankings, it is important to address the issue of the potential impact of these structures in the Shanghai ranking by estimating their potential scores on the ARWU indicators. Before we address this question, it is useful to establish a baseline for the ARWU indicators of the antecedent institutions.

4 French institutions in ARWU 2014 and beyond

To obtain data for a large number of French universities we have checked the electronic sources used by ARWU and consulted data provided by official sources in France. We have conducted electronic searches using the organizations-enhanced (OG) term of the Web of Science. To the best of our knowledge all disambiguation problems with affiliations have been corrected. We also have made a considerable effort through a number of reliable official sources to estimate the FTE numbers of academic staff of French institutions whether or not they are included in the 2014 ARWU list. The figures correspond to the number of Full Time Equivalent academic staff at the level of Assistant Professor (or the equivalent category within the French university system) and higher, which is the rule of thumb of the ARWU counting for the countries with available FTE numbers⁶. Some discrepancies have been encountered in the case of institutions present in the ARWU-2014 500 list; we leave that for discussion among the institutions and the ARWU rankers.

4.1 French institutions listed in ARWU 2014

The 2014 edition of the Shanghai ranking included 21 French Higher Education institutions in the 500 world-class universities (Table 4). There were 20 French institutions listed in ARWU 2013. The University of Auvergne entered in 2014 due to its score in the indicator HiCi which rose as ARWU used the new list of highly cited researchers released by Thomson Reuters in June 2014. In reconstructing ARWU 2014 for French universities we have been led to understand that ARWU has assigned to the University of Auvergne the publications with affiliation Univ Clermont Ferrand that do not have affiliations with the lists defined either by OG = University of Auvergne or OG = Blaise Pascal University.

⁵ http://cache.media.enseignementsup-recherche.gouv.fr/file/Loi_pour_L_ESR/23/4/MESR-lan-loi_341234.pdf

⁶ More explicitly: the rule is to count *enseignants-chercheurs* excluding research staff from e.g. CNRS or INSERM.

Table 3 New French mergers (COMUE and associations) and their antecedent constituent institutions. Following ARWU practice only institutions with a significant number of publications indexed in WoS are listed. The list corresponds to data publicly available in July 2014. No association data were available at that time for University of Picardie.

New University Mergers	Antecedent Institutions
Sorbonne Universités	UPMC, Paris 4, MNHN, INSEAD BS, UTC Compiègne
Paris-Saclay	Univ. Paris Sud, UVSQ, Ecole Polytechnique, HEC Paris, ENS Cachan, Agro ParisTech, Ecole Centrale Paris, TELECOM ParisTech, Supélec, ENSTA ParisTech
PSL	ENS Paris, ESPCI ParisTech, Mines ParisTech, Chimie ParisTech, Univ. Paris Dauphine, Institut Curie, Collège de France, Observatoire de Paris
Sorbonne Paris Cité	Paris Diderot, Paris Descartes, Paris 13, Paris 3, IPGP
Université Grenoble Alpes	Joseph Fourier, INP Grenoble, Savoie, Pierre Mendès France, Stendhal
Université de Strasbourg	Strasbourg, Haute-Alsace
Aix-Marseille Université	Aix-Marseille, Avignon, E. Centrale Marseille
Université de la Côte d'Azur	Nice Sophia Antipolis, Toulon, Corse
Université fédérale de Toulouse	Paul Sabatier, Toulouse 1, INP Toulouse, Toulouse 2, CUFR Albi
Université d'Aquitaine	Univ. Bordeaux, Michel de Montaigne, Pau
Languedoc-Roussillon Universités	Montpellier 2, Montpellier 1, Montpellier 3, Perpignan, Chimie Montpellier, Mines Alès, Nimes
Université de Lyon Saint-Etienne	Claude Bernard, ENS Lyon, INSA Lyon, Jean Monnet , E. Centrale Lyon, Lyon 2, Lyon 3, Mines St Etienne
Université de Lorraine	Lorraine
Centre Limousin Poitou-Charentes	Limoges, Orléans, François Rabelais Tours, Poitiers, La Rochelle
Université de Bretagne-Loire	Brest, Rennes 1, Rennes 2, Bretagne-Sud, Chimie Rennes, Nantes, Angers, E. Centrale Nantes, Maine Le Mans, Mines Nantes
Clermont Université	Auvergne, Blaise Pascal
Bourgogne Franche-Comté	Bourgogne Dijon, Franche Comté, Belfort-Montbeliard
Lille Nord de France	Lille 1, Lille 2, Valenciennes, Littoral, E. Centrale Lille, Lille 3, Artois, Mines Douai, ENSCL Lille
HESAM	Panthéon Sorbonne, EHESS, Arts et Métiers ParisTech, CNAM, EPHE
Université de Champagne	Reims, Tech Troyes
Université Paris-Est	Paris-Est Créteil, Paris-Est Marne-la-Vallée, ENPC Paris-Tech
Université Paris-Seine	Cergy Pontoise, ESSEC Business School
Université Paris Lumières	Paris 10, Paris 8
Normandie Université	Caen, Rouen, Le Havre, ENSI CAEN

To check our reverse engineering Table 4 compares actual ARWU scores with our estimates for the French universities in ARWU 2014. There are no errors on the first three indicators, apart from the case of the University of Bordeaux where we believe that there are three researchers in the new HiCi list with affiliation to the University of Bordeaux, rather than the two acknowledged by ARWU. The errors of estimation on the indicator N&S may be due to rounding operations to the first decimal place and are barely noticeable. Errors in the estimation of the indicator PUB are generally small and presumably due to minor differences in the use of the Web of Science. There is a large discrepancy with ARWU for Mines ParisTech. We believe that the error arises in ARWU's application of its own methodology perhaps as the consequence of a misunderstanding about the nature or structure of the institution.

Table 4 Published ARWU scores compared with our reverse engineered results for the 21 French universities and institutions listed in ARWU 2014

Indicators	HiCi				HICI	N&S	PUB	PCP	Score	FTE
	Alu	Awd	new	old						
<i>Université Pierre et Marie Curie</i>										
ARWU	34.5	27.4	26.5	25.1	25.8	30.2	60.0	23.8	35.4	2333
ESTIMATED	34.5	27.4	26.5	25.1	25.8	30.1	60.4	27.5	35.8	1755
<i>Université Paris 11 - Paris Sud</i>										
ARWU	31.1	54.3	17.3	16.2	16.8	18.5	48.4	26.5	34.2	1846
ESTIMATED	31.1	53.6	17.3	16.2	16.8	18.5	48.3	31.1	34.5	1321
<i>École Normale Supérieure ENS Paris</i>										
ARWU	50.2	28.0	10.0	12.4	11.2	16.8	26.8	59.8	28.3	180
ESTIMATED	50.2	28.0	10.0	12.4	11.2	16.8	26.8	63.4	28.6	160
<i>Université de Strasbourg</i>										
ARWU	25.8	28.8	10.0	17.7	13.9	17.7	35.5	21.2	24.5	1320
ESTIMATED	25.8	28.8	10.0	17.7	13.9	17.7	35.6	19.4	24.3	1583
<i>Université Paris 7 - Diderot</i>										
ARWU	11.8	9.4	17.3	12.5	14.9	32.2	44.5	19.4	23.9	1829
ESTIMATED	11.8	9.4	17.3	12.5	14.9	32.1	45.2	23.0	24.4	1320
<i>Aix-Marseille Université</i>										
ARWU	13.9	0	17.3	16.2	16.8	19.5	50.0	26.5	21.8	940
ESTIMATED	13.9	0	17.3	16.2	16.8	19.4	48.9	16.2	20.5	2442
<i>Université Grenoble 1 - Joseph Fourier</i>										
ARWU	0	14.9	24.5	10.2	17.4	22.4	39.6	20.2	21.4	1288
ESTIMATED	0	14.9	24.5	10.2	17.3	22.4	39.8	23.3	21.7	996
<i>Université Paris 5 - Descartes</i>										
ARWU	11.8	9.4	14.1	10.2	12.2	16.2	42.0	16.3	19.2	1779
ESTIMATED	11.8	9.4	14.1	10.2	12.2	16.2	41.7	20.2	19.6	1149
<i>Université Bordeaux 1 - Sciences technologies</i>										
ARWU	0	0	17.3	14.5	14.3	16.6	40.0	15.4	16.1	1777
ESTIMATED	0	0	17.3	14.5	15.9	16.6	40.0	15.0	16.4	1911
<i>Université Toulouse 3 - Paul Sabatier</i>										
ARWU	0	0	17.3	7.2	12.3	20.6	38.1	14.3	16.0	2009
ESTIMATED	0	0	17.3	7.2	12.3	20.7	38.2	16.9	16.3	1466
<i>Université de Lorraine</i>										
ARWU	11.8	16.3	0	0	0	7.9	33.7	18.2	14.9	940
ESTIMATED	11.8	16.3	0	0	0	7.9	34.0	12.1	14.4	2153
<i>Université Lyon 1 - Claude Bernard</i>										
ARWU	10.5	0	0	0	0	17.4	41.0	14.5	14.5	1965
ESTIMATED	10.5	0	0	0	0	17.4	41.6	17.5	15.0	1379
<i>École Normale Supérieure ENS Lyon</i>										
ARWU	0	20.0	0	7.2	3.6	11.7	21.0	28.4	14.5	249
ESTIMATED	0	20.0	0	7.2	3.6	11.7	21.0	34.6	15.1	170
<i>Université Montpellier 2 - Sciences et techniques</i>										
ARWU	10.5	0	0	12.5	6.3	15.0	31.1	17.3	13.6	871
ESTIMATED	10.5	0	0	12.5	6.3	15.1	31.2	19.3	13.8	728
<i>Université Paris 9 - Dauphine</i>										
ARWU	15.8	26.6	0	7.2	3.6	0	13.6	23.1	13.0	391
ESTIMATED	15.8	26.6	0	7.2	3.6	0	13.6	26.9	13.4	293
<i>ESPCI ParisTech</i>										
ARWU	7.4	18.8	0	0	0	9.5	15.5	28.9	12.7	173
ESTIMATED	7.4	18.8	0	0	0	9.7	15.4	28.8	12.7	174
<i>École Polytechnique</i>										
ARWU	17.5	0	0	10.2	5.1	9.7	27.0	21.3	12.5	448
ESTIMATED	17.5	0	0	10.2	5.1	9.7	27.2	21.4	12.6	459
<i>Université Clermont-Ferrand 1 - Auvergne</i>										
ARWU	0	0	14.1	0	7.1	10.9	25.6	16.2	10.6	637
ESTIMATED	0	0	14.1	0	7.1	10.8	25.8	20.6	11.1	421
<i>Université Nice - Sophia-Antipolis</i>										
ARWU	0	0	0	7.2	3.6	14.9	25.8	12.1	10.3	1246
ESTIMATED	0	0	0	7.2	3.6	14.8	25.8	14.1	10.5	922
<i>Mines ParisTech</i>										
ARWU	13.9	24.9	0	0	0	3.8	8.1	13.1	10.3	940
ESTIMATED	13.9	24.9	0	0	0	3.8	14.5	25.8	12.9	286
<i>Université Rennes 1</i>										
ARWU	0	0	0	7.2	3.6	9.2	28.2	11.1	9.6	1468
ESTIMATED	0	0	0	7.2	3.6	9.2	28.1	13.5	9.8	996

A direct search through the WoS OG list is only possible in roughly 50% of the institutions under analysis. While the OG search occasionally does not recover as many articles as counted by ARWU, it frequently recovers more implying that WoS acknowledges associated affiliations that ARWU does not acknowledge. For instance, papers with primary affiliation to a university hospital may be assigned by the WoS to the university through the OG list but they are usually not counted by ARWU. This is consistent with the view (Liu and Cheng, 2005) that affiliations used by researchers are the affiliations ARWU will use, and affiliations to university hospitals are not affiliations to the university. Disentangling uncounted papers from an OG search is a difficult task, but the estimation of the PUB indicator does not induce a noticeable error in the final score and we are comfortable with the results.

Significant discrepancies are observed in the FTE counts, which we source from official files obtained from the Ministry of Higher Education in France. For institutions that have not previously merged there is generally a higher count in ARWU than in our sources. The Universities of Strasbourg and Bordeaux ARWU figures are similar in both data sets. For Lorraine and Aix-Marseille the ARWU count is smaller. There is a suggestion that ARWU may adopt the dummy FTE value for some French universities, including Aix-Marseille and Mines ParisTech. Mines ParisTech is a French *grande école* and its FTE should be comparable with similar institutions (i.e. ESPCI ParisTech, Ecole Polytechnique), much smaller than the adopted ARWU figure. Together with the under-counting of Mines ParisTech publications mentioned above, the ARWU 2014 score lies 2.5 points below the score we estimate. If adjusted, Mines ParisTech would rank in the 300-400 band of ARWU 2014.

4.2 French mergers and forecasts of ARWU indicators

The policy intent of French reformation in higher education is to form approximately 5–10 multidisciplinary world-class universities (see e.g. Pisani-Ferry, 2014) and a network of regional comprehensive universities. One intended outcome is increased visibility which among other measures would be revealed by improved ARWU rankings for the leading French universities. To explore the effects of mergers in the ARWU, we have analyzed the announced mergers of French universities described in Section 3, referenced to ARWU 2014. We have followed the methodology described in Section 2 with the new institutions described in Table 3.

The application of the ARWU 2014 criteria yields *estimates* of the indicator scores for the new French mergers as shown in Table 5. The ranking indicates where the score of the merged institution lies in the ARWU 2014 list. Forecast changes in the ranking profile of French universities are presented in Table 6. To place these results in context, note that former French President Sarkozy was reported in a *Nature* editorial (The ratings game, 2010) as seeming “obsessed with the poor showing of his country’s universities in international rankings” and “ordering” France’s science and higher education ministry to set the objective of having two French establishments in the top 20, and 10 in the top 100.

Insofar as this refers to the ARWU ranking our findings show that no merger will attain the top 20, although PSL and Paris-Saclay rise to positions 26 and 27 and there are three mergers in the top 50, one more than the current number. All three arise from Paris-based institutions. Eight are forecast in the top 100, two more than at present. Some mergers bring a significantly higher ranking than that of any antecedent – Paris-Saclay, PSL, Sorbonne Paris Cité, Lyon Saint-Etienne, Languedoc-

Table 5 Computed ARWU 2014 scores for new French mergers (COMUE or association). RKG is the ranking in ARWU 2014 that would result from the computed score.

Institutions	Alu	Awd	HICI	N&S	PUB	PCP	score	FTE	RKG
PSL	52.9	61.6	12.2	30.2	47.2	35.5	40.1	1362	26–50
Paris-Saclay	35.7	54.3	21.4	22.9	66.0	23.7	39.8	3213	26–50
Sorbonne Univ.	34.5	27.4	25.8	30.2	61.8	22.5	35.6	2700	26–50
Sorbonne Paris Cité	16.7	13.3	19.2	36.1	61.9	18.0	30.3	3658	51–100
Strasbourg	29.3	28.8	13.9	17.7	36.5	18.1	24.7	1917	51–100
Grenoble Alpes	0.0	14.9	17.4	22.6	48.1	15.9	22.7	2720	101–150
Lyon Saint-Etienne	10.5	20.0	3.6	20.6	51.1	14.2	22.1	3515	101–150
Aix-Marseille	13.9	0.0	16.8	19.5	51.1	15.8	21.0	2738	101–150
Fed Toulouse	0.0	0.0	15.1	21.4	45.1	14.2	18.2	2753	151–200
Languedoc-Roussillon	18.2	0.0	7.2	15.4	42.6	14.7	16.8	2165	201–300
Aquitaine	0.0	0.0	14.3	16.6	43.1	13.1	16.5	2757	201–300
Centre-Limousin PC	11.8	0.0	8.6	15.7	37.9	10.8	15.1	3179	201–300
Bretagne-Loire	0.0	0.0	8.6	12.0	47.4	10.0	15.0	4979	201–300
Lorraine	11.8	16.3	0.0	7.9	33.9	18.2	14.9	2153	201–300
Clermont	0.0	0.0	7.1	12.3	27.0	13.5	10.9	1096	401–500
Côte d’Azur	0.0	0.0	3.6	14.9	28.1	12.4	10.8	1362	401–500
Bourgogne FC	10.5	0.0	0.0	7.2	30.6	10.9	9.9	1795	401–500
Lille Nord de France	0.0	0.0	3.6	5.6	34.7	8.6	9.9	3429	401–500
HESAM	0.0	0.0	8.6	4.9	23.2	8.5	8.4	1792	> 500
Normandie	0.0	0.0	0.0	7.6	28.1	9.1	8.3	2087	> 500
Paris-Est	4.6	3.8	0.0	1.5	24.5	10.2	7.6	1227	> 500
Picardie	0.0	0.0	3.6	3.1	15.5	8.6	5.4	762	> 500
Champagne	0.0	0.0	0.0	4.1	17.2	8.4	5.2	903	> 500
Paris Lumières	0.0	0.0	0.0	2.7	16.5	6.3	4.6	1456	> 500
Paris-Seine	0.0	0.0	0.0	1.5	15.7	9.4	4.5	570	> 500

Table 6 How mergers move the French university system in the ARWU

ARWU 2014	Current status	After mergers	Difference
1 to 25	0	0	0
1 to 50	2	3	1
1 to 100	4	5	1
1 to 150	7	8	1
1 to 200	8	10	2
1 to 300	14	14	0
1 to 400	17	14	-3
1 to 500	21	18	-3

Roussillon, and Bretagne-Loire. Other mergers elevate universities not present in the 2014 ranking – Centre Limousin Poitou-Charentes, Bourgogne Franche-Comté or Lille Nord de France. Some mergers dilute the ranking of the best-ranked antecedent – Sorbonne Universités, Grenoble Alpes and Aix-Marseille.

5 Discussion

Harman and Harman (2008), Stephenson (2011) and Tight (2013) outline the considerations that lead policy makers and governance boards to consider university mergers. In the context of the French higher education and research system, mergers are part of an armory of tools that can be adopted to address desires for reform and improvement. Aghion and Cohen (2004) identify a number of structural and functional features of the system that might be improved through a process of “la réforme incrémentale.” These include new approaches to financing education and research, selection of students, the

addition of money to bring France closer to OECD funding norms, modifications of the conditions of employment of university staff and the exploitation of competitive practices to test and drive quality.

The evolution of the French doubly-dual system of higher education and publicly funded research organizations over the past decade has entailed adjustment towards integration and enlargement. Alix and Andler (2013) have summarized stakeholder criticisms of the various mechanisms of this evolution. The formation of COMUEs represents an opportunity to build a number of French institutions with many of the characteristics of the universities found towards the top of the ARWU ranking. Unsurprisingly we forecast that these institutions may come to have ARWU indicator values that rank them alongside the world-class benchmarks, especially if publications arising from the research conducted by staff of CNRS, INRIA, INSERM and similar publicly funded research agencies are affiliated to the appropriate university/COMUE. On the other hand some French mergers will not improve the ranking, and are not intended to do so.

Through consideration of how a ranking body such as ARWU might address a merger we have identified intriguing features of the calculus of mergers. To illustrate, consider a fictitious “merger” created by adding an identical copy to one of the existing institutions in the ARWU list. Combining two identical copies of an institution will double the values of the raw data for Alu, Awd, HiCi, N&S and PUB. Because the FTE will also double, PCP will not change. The effect on the total score is given by the “Pythagorean” rule (5). For an institution with a relatively small contribution of PCP to the total score, the total will increase by an amount approaching $\sqrt{2}$ (around 40%). There are a few institutions where PCP contributes more than 20% of the total, and for these the total will increase by a smaller amount, significantly less than 30%. The *differential* increase in a world comprising doubled universities would lead to some radical readjustments of rank.

Some interesting and perhaps counter-intuitive consequences follow. Owing to the special status of Harvard, the ARWU score and rank of “double Harvard” are unchanged. Apart from “double Stanford” no other doubled institution rivals “undoubled Harvard.” Large ranking shifts would occur in a world of doubled universities. Among the universities in the top 100, those with relatively large PCP compared with other indicators are École Normale Supérieure ENS Paris, Caltech, Basel, Ghent, Rice, Leiden and Moscow State. These would have notably small relative increases in their scores and in a world of doubled institutions would fall in ARWU rank. On the other hand, a large number of universities in the top 100 have relatively small values of PCP compared with their other indicators. If doubled, their total score would rise substantially. Because PCP is relatively unimportant for all of them, their rank relative to others in this category would remain roughly unchanged. As discussed in Docampo and Cram (2015) it is highly debatable whether this is a desirable feature of the arithmetic behind the ARWU. The situation reflects its well-known ARWU emphasis on size-driven performance indicators rather than per-unit performance.

Finally, let us briefly note that some forecasts of ARWU indicator values following mergers have been based on (understandably) erroneous arithmetic. Hindsight shows that the forecast ranking of the merged University of Manchester (Hall, 2004) was over-estimated by adding indicator scores rather than following the procedures described above. The otherwise important critique of ARWU by Billaut et al (2010) wrongly reports that the ARWU score of a fictitious merger of Paris 5, 6, 7 and 11 would be roughly at the level of Harvard, apparently as a result of the same error. This error also

compromises the more detailed forecasts of the consequences of several proposed mergers of French universities undertaken by a French expert on international comparators, E. Mathieu, and reported by Siganos (2008). Strangely, this work was presented but remained uncorrected at the Second International Conference on World-Class Universities held in Shanghai, China (Siganos, 2007).

As we have mentioned, Salmi's (2009) study of world-class universities points to the value of concentration of talent, abundance of resources and appropriate governance. None of these components necessitates mergers, although mergers might assist in bringing them about. Mergers have a particular attraction in the French system which has been described by commentators as being dualized or fragmented. The French mergers may turn out to be particularly astute, as they bring together on the same campus the three key constituents of the French higher education and research system: multi-disciplinary university, selective *grandes écoles*, and publicly funded research agencies. Provided that the merged entities can (1) project strongly and globally their new status as a single entity, (2) achieve the expected benefits of improved coordination of research planning and resourcing, and (3) steer the allocation of output to a single affiliation, it appears likely that the French institutions will rise significantly over the long-term in the global university rankings.

While our study shows the modest capacity of mergers to improve ranking-related visibility on the short term, we note that mergers may offer a number of other immediate benefits, such as greater potential for inter-disciplinary education and research, and easier access by students to some of France's best researchers.

6 Conclusions

It is recognized that the ARWU ranking methodology favors universities that are large and excellent over those that are small and excellent. Whether or not this feature of the ARWU methodology is capturing an important attribute of world-class universities is, we feel, a question that has yet to be decided. Irrespectively, the merging of relatively strong universities will, according to ARWU, produce a more highly ranked institution. This is widely understood and while it seems inconceivable that something as important as a merger of great universities should be motivated by the quest for a higher ARWU ranking, there are many examples where merger proposals have been coupled politically to the claim that ranking or "visibility" would be enhanced. In some cases quantitative forecasts of higher rankings have been overly optimistic owing to erroneous arithmetic.

We have explored in this paper the manner in which university aggregations might improve ranking in the Shanghai ranking. We have described how to evaluate correctly the scores of potential conglomerates. The methods we have described have been applied to extend and to establish what we believe to be improved indicators for some current French universities, and also to forecast the ARWU total score for new mergers or groups of universities in France.

Our analysis demonstrates that higher ranking does not always eventuate, although of course there may well be other legitimate drivers for certain mergers. The ARWU scores of some new aggregates (Sorbonne Universités, Grenoble Alpes, Lyon) are not substantially raised above the score already obtained by the institutions that would be aggregated. On the other hand the analysis also shows that in three out of the four conglomerates proposed for the Paris region the gains in ranking are remarkable. This is also the case for some unions in which none of the members are ranked in the cur-

rent ARWU 500 list (Centre Limousin Poitou-Charentes, Bretagne-Loire, Bourgogne Franche-Comté and Lille Nord de France).

The results obtained in the paper could be replicated in other geographical scenarios. Accordingly the methodology could provide useful guidance for policy makers interested in the overall ranking of a national university system. The methods can be used to explore merging and partnering strategies to raise visibility in the global arena — not just through merging but also through careful attention to the ways that the affiliations of collaborating researchers are captured by indexing systems. The results for the French case clearly point to the need of treating proposed conglomerates and partnerships on a case by case to avoid being misled about what might be gained.

Acknowledgements The work of D. Docampo was supported by the European Regional Development Fund (ERDF) and the Galician Regional Government under agreement for funding the Atlantic Research Center for Information and Communication Technologies (AtlantTIC).

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