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"SUB-FIELD NORMALIZATION IN THE MULTIPLICATIVE CASE: HIGH- AND LOW-IMPACT CITATION INDICATORS"

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Abstract

This paper uses high- and low-impact citation indicators for the evaluation of the citation performance of research units at different aggregate levels. To solve the problem of the assignment of individual articles to multiple sub-fields, it follows a multiplicative strategy according to which each paper is wholly counted as many times as necessary in the several categories to which it is assigned at each aggregation level. To control for wide differences in citation practices at the lowest level of aggregation, we apply a novel sub-field normalization procedure in the multiplicative case. The methodology is applied to a partition of the world into three geographical areas: the U.S., the European Union (EU), and the Rest of the World. The main findings are the following two. (i) Although normalization does not systematically bias the results against any area, it reduces the U.S./EU high-impact gap in the all-sciences case by a non-negligible 14.4%. (ii) The dominance of the U.S. over the EU in the basic and applied research published in the periodical literature is almost universal at all aggregation levels. From the high-impact perspective, for example, the U.S. is ahead of the EU in 77 out of 80 disciplines, and all of 20 fields. For all sciences as a whole, the U.S. high-impact indicator is 61% greater than that of the EU.

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I. INTRODUCTION

Assume that we are given a hierarchical Map of Science that distinguishes between several aggregation levels, say between scientific sub-fields, disciplines, and fields from the lowest to the highest aggregation level. Each category at any aggregate level is assumed to belong to only one item at the next level, so that each sub-field belongs to a single discipline, and each discipline to a single field. This paper uses high- and low-impact citation indicators for the evaluation of the citation performance of research units at different aggregate levels in a special case, namely, when the available dataset includes individual publications that are assigned to several categories at the lowest aggregation level. Our motivation is threefold.

In the first place, it is well known that citation distributions are highly skewed in the sense that a large proportion of articles get none or few citations while a small percentage of them account for a disproportionate amount of all citations.[1] Since in this situation average-based indicators may not adequately summarize these distributions, Albarrán *et al.* (2011b) introduced a novel methodology for the evaluation of research units of a certain size that begins with the observation that, due to their skewness, the upper and lower parts of citation distributions are typically very different. Consequently, it seems useful to describe a citation distribution by means of two real valued functions defined over the subsets of articles with citations above or below a *critical citation line* (CCL hereafter). These are referred to as a *high-* and a *low-impact indicator*, respectively.[2]

In the second place, papers in the periodical literature are often assigned to sub-fields via the journal in which they have been published. Many journals are assigned to a single sub-field, but many others are assigned to two, three, or more sub-fields. This is an important problem. For example, in the dataset used in this paper, where sub-fields are identified with the 219 Web of Science (WoS hereafter) categories distinguished by Thomson Scientific, 42% of the 3.6 million articles published in 1998-2002

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[1] See *inter alia* Seglen (1992), Shubert *et al.* (1987) for evidence concerning scientific articles published in 1981-85 in 114 sub-fields, Glänzel (2007) for articles published in 1980 in 12 broad fields and 60 middle-sized disciplines, Albarrán and Ruiz-Castillo (2011) for articles published in 1998-2002 in the 22 fields distinguished by Thomson Scientific, and Albarrán *et al.* (2011a) for these same articles classified in 219 Web of Science categories and a number of intermediate disciplines and broad scientific fields according to three aggregation schemes.

[2] Economists will surely recognize that the key to this approach is the identification of a citation distribution with an income distribution. Once this step is taken, the measurement of low-impact coincides with the measurement of economic poverty, which starts with the definition of the poor as those individuals with income below the poverty line. In turn, it is equally natural to identify the measurement of high-impact with the measurement of a certain notion of economic affluence.

are assigned to two or more, up to a maximum of six sub-fields. There are two ways to deal with this situation. The first follows a *fractional* strategy, according to which each publication is fractioned into as many equal pieces as necessary, with each piece assigned to a corresponding sub-field. The second follows a *multiplicative* strategy, according to which each paper is wholly counted as many times as necessary in the several categories to which it is assigned at each aggregation level. In this way, the space of articles is expanded as much as necessary beyond the initial size. As advocated by Herranz and Ruiz-Castillo (2011a), in this paper we follow a multiplicative strategy (see also Albarrán *et al.*, 2011a, and Herranz and Ruiz-Castillo, 2011b, c).

In the third place, it is generally accepted that for evaluations at the level of broad, aggregate scientific categories it is crucial that one carefully controls for wide differences in citation practices at the lowest level of aggregation. When publications are assigned to several sub-fields, the usual way to compile sub-field normalized citation indicators follows a fractional strategy (see *inter alia* Waltman *et al.*, 2011a, for sub-field normalization with average-based indicators). In this paper, we apply for the first time the ideas of Herranz and Ruiz-Castillo (2011a) about sub-field normalization in the multiplicative case to the evaluation of research units using high- and low-impact indicators.

The empirical case we study is a partition of the world into three large geographical areas: the U.S., the EU, namely, the 15 countries forming the European Union before the 2004 accession, and any other country of the rest of the world (RW hereafter). The comparison of the relative performance of the U.S. and the EU is an important empirical issue in view of the so-called "European Paradox", popularized in the *First European Report on Science and Technology Indicators* (EC, 1994), according to which Europe plays a leading world role in terms of scientific excellence but lacks the entrepreneurial capacity of the U.S. to transform it into innovation, growth, and jobs. This paradox is exclusively based on a mere counting of the number of publications. As soon as one takes into account the citation impact that these publications achieve, Albarrán *et al.* (2010, 2011c, d) *inter alia* provide ample evidence against this view, and in favor of a dramatic dominance of the U.S. over the EU (and the RW). However, these papers work at the level of 22 broad, heterogeneous fields also distinguished by Thomson Scientific. Herranz and Ruiz-Castillo (2011b) study this issue for the 219 sub-fields identified with the WoS categories. The present paper studies this important issue for 80 disciplines and 20 fields using high- and low-impact indicators.

The empirical issues analyzed are the following two. Firstly, we study for the first time the impact of sub-field normalization in the multiplicative case using high- and low-impact indicators. In particular, we investigate whether normalization systematically favors any geographical area. Secondly, we focus on the US/EU gap at different aggregation levels in the multiplicative case, and compare the results using high- and low-impact indicators with those obtained in Herranz and Ruiz-Castillo (2011c) using average-based indicators.

The rest of the paper is organized into three Sections and a statistical Appendix. Section II introduces the multiplicative strategy, the normalization procedure, and the high- and low-impact indicators. Section III presents some descriptive statistics for citation distributions at all aggregate levels, as well as the empirical results and some robustness checks. Other individual information is relegated to the Appendix. Section IV offers some concluding comments and suggestions for extensions.

II. METHODS

II.1. The Original Dataset and the Geographical Extended Count

Since we wish to address a homogeneous population, in this paper only research articles or, simply, articles are studied. We begin with a large sample acquired from Thomson Scientific, consisting of more than 3,600,000 articles published in 1998-2002, as well as the more than 28 million citations these fields receive using a five-year citation window for each one. Thus, the original dataset is a citation distribution $\mathbf{c} = \{c_l\}$ consisting of N distinct articles, indexed by $l = 1,\ldots, N$, where c_l is the number of citations received by article l.

In this paper, the world is partitioned into three geographical areas, indexed by k = US, EU, RW. Articles are assigned to geographical areas according to the institutional affiliation of their authors on the basis of what had been indicated in the by-line of the publications. We must confront the possibility of international cooperation, namely, of articles written by authors belonging to two or more geographical areas. Although this old problem admits different solutions (see *inter alia* Anderson *et al.*, 1988, for a discussion in the international case), we side with many other authors in recommending a multiplicative strategy at all aggregation levels (see the influential contributions by May, 1997, and King, 2004, as well as the references in Section II in Albarrán *et al.*, 2010). Thus, in every internationally co-authored article a whole count is credited to each contributing area.

For every article l, let g^l be the number of geographical areas with authors in the byline of the publication. Only domestic articles, or articles exclusively authored by one or more scientists affiliated to research centers either in the U.S., the EU or the RW alone, are counted once, in which case $g^l = 1$. Otherwise, g^l can be equal to 2 or 3. In this way we arrive at what we call the *geographical extended count*, whose total number of articles is equal to $G = \Sigma_l g^l$. As long as $g^l > 1$ for some l, we have that $G > N$. In our dataset, the number of distinct articles in the original dataset is $N = 3{,}648{,}524$, while the number of articles in the geographically extended count is $G = 4{,}142{,}281$, a total which is 13.5% larger than N.

II. 2. Reasons for The Multiplicative Strategy

As indicated in the Introduction, in the original dataset there are only about two million articles assigned to a single sub-field, while the multiple assigned articles represent about 42% of the total. As advocated in Herranz and Ruiz-Castillo (2011a), there are two reasons why the multiplicative strategy might be preferable to deal with this problem.

Firstly, assume that there are two articles assigned to a certain discipline. The first article is only assigned to this discipline, while the second is also assigned to other disciplines. Why should the weights associated to both articles in computing any statistic be entirely different as implied by the fractional strategy? It can be argued that in the study of any discipline all articles should count equally regardless of the role some of them may play on other disciplines. Of course, this leads to an artificially large number of articles. However, this is not that worrisome in the sense that, since this strategy does not create any interdependencies among the disciplines involved, it is still possible to investigate separately every discipline in isolation, independently of what takes place in any other discipline. A similar argument can be offered for higher aggregate levels.

Secondly, assume that we want to evaluate the citation impact of different research units in a certain discipline. In the computation of any citation impact indicator a fractional strategy reduces the role of articles published in journals assigned to several disciplines. Therefore, this strategy would hurt relatively more those research units with highly cited articles of this type. It can be argued that, from a normative point of view, this implication distorts the evaluation of research units in a given discipline. A similar argument can be offered again for higher aggregate levels.

II. 3. The Multiplicative Strategy in the Geographical Extended Count

To describe the multiplicative strategy it suffices to consider two aggregate levels: sub-fields and disciplines. Therefore, assume that there are S sub-fields, indexed by $s = 1, \ldots, S$, D disciplines with $D < S$, indexed by $d = 1, \ldots, D$, as well as a rule that indicates the unique discipline to which each sub-field belongs. Each article l in the geographical extended count is written by one or more authors that work in one or more geographical areas. Thus, for any area k with one or more authors writing article l, let X^k_l be the non-empty set of sub-fields to which article l is assigned. The cardinal of this set, $x^k_l = |X^k_l|$, is the number of elements in the set. Since in our dataset articles can be assigned to at most six sub-fields, we have that $x^k_l \in [1, 6]$ for all l.

In the first step in the multiplicative strategy each article is wholly counted as many times as necessary in the several sub-fields to which it is assigned. Thus, if an article l is assigned to three sub-fields, so that $x^k_l = 3$ for some k, it should be independently counted three times, once in each of the sub-fields in question, without altering the original number of citations in each case. Consequently, as long as $x^k_l > 1$ for some article l and some area k, the total number of articles in what we call the *double extended sub-field count*, N_{SF}, is greater than G.

Formally, let N^k_s be the number of distinct articles, indexed by $i = 1, \ldots, N^k_s$, which are assigned to sub-field s and have at least one author working in area k. Then, $\boldsymbol{c}^k_s = \{c^k_{si}\}$ is the citation distribution of area k in sub-field s, where c^k_{si} is the number of citations received by article i, and $c^k_{si} = c_l$ for some article l in the original distribution. The citation distribution in sub-field s, $\boldsymbol{c}_s$, is the union of these distributions over all geographical areas, namely, $\boldsymbol{c}_s = \cup_k \boldsymbol{c}^k_s$. The double extended sub-field count, ***SF-count***, is the union of all sub-field distributions, namely, ***SF-count*** $= \cup_s \boldsymbol{c}_s$. If we denote by $N_s = \Sigma_k N^k_s$

the total number of articles in sub-field s, then $N_{SF} = \Sigma_s N_s$. For later reference, the MCR of area k in sub-field s, M^k_s, and the MCR of sub-field s, M_s, are defined by

$$M^k_s = \Sigma_i c^k_{si}/N^k_s, \tag{1}$$

$$M_s = (\Sigma_k \Sigma_i c^k_{si})/N_s = \Sigma_k (N^k_s/N_s)\, M^k_s. \tag{2}$$

According to the multiplicative strategy, at the next aggregate level each article is wholly counted as many times as necessary in the several disciplines to which it is assigned. In order to describe how to do that, we need to introduce some more notations. For any area k with one or more authors writing article l, let Y^k_l be the non-empty set of disciplines to which article l is assigned, and let $y^k_l = |Y^k_l|$ be the cardinal of this set. At the discipline level, article l is counted y^k_l times with c_l citations each time. Of course, $y^k_l \leq x^k_l$ for all l. As long as $y^k_l > 1$ for some article l and some area k, the total number of articles in what we call the *double extended sub-field count*, N_D, is greater than G.

Let N^k_d be the number of distinct articles in discipline d that have at least one author working in area k, and denote by $\boldsymbol{c}^k_d = \{c^k_{dj}\}$ the citation distribution of area k in discipline d, where c^k_{dj} is the number of citations received by article $j = 1,\ldots, N^k_d$. Thus, there must exist at least one sub-field s belonging to d, some $i = 1,\ldots, N^k_s$, and some article l in the original distribution such that $c^k_{dj} = c^k_{si} = c_l$. The citation distribution in discipline d, $\boldsymbol{c}_d$, is the union of these distributions over all geographical areas, namely, $\boldsymbol{c}_d = \cup_k \boldsymbol{c}^k_d$. The double extended discipline count, ***D-count***, is the union of all discipline distributions, namely, ***D-count*** $= \cup_d \boldsymbol{c}_d$, where $N_D = \Sigma_d N_d$ is the number of articles in the double extended discipline count. Since $D < S$, there must be some l, some d and some k for which $y^k_l < x^k_l$, so that $N^k_d < \Sigma_{s\in d} N^k_s$ and $N_D < N_{SF}$. For later reference, the MCRs of distributions $\boldsymbol{c}^k_d$ and $\boldsymbol{c}_d$, M^k_d and M_d, are defined by

$$M^k_d = \gamma^k_d/N^k_d,$$

$$M_d = \gamma_d/N_d,$$

where $\gamma^k_d = \Sigma_j c^k_{dj}$, $\gamma_d = \Sigma_k \gamma^k_d$, and $N_d = \Sigma_k N^k_d$.

Next, for any $d \in Y^k{}_l$, let $X^k{}_{ld} \subseteq X^k{}_l$ be the non-empty set of sub-fields in $X^k{}_l$ that belong to discipline d, and let $x^k{}_{ld} = |X^k{}_{ld}|$ be the number of sub-fields in $X^k{}_{ld}$. Finally, for any s, let $\mathbf{c}^{k}{}'_s = \{v^k{}_{si}\, c^k{}_{si}\}$ be a new sub-field distribution for area k where

$$v^k{}_{si} = 1/x^k{}_{ld} \text{ for all } s \in X^k{}_{ld}.$$

Similarly, the new sub-field distribution $\mathbf{c}'_s$ is the union of these distributions over all geographical areas, namely, $\mathbf{c}'_s = \cup_k\, \mathbf{c}^{k}{}'_s$. Let $N^{k'}{}_s = \Sigma_i\, v^k{}_{si}$ be the possibly fractional number of articles in the new sub-field distribution $\mathbf{c}^{k'}{}_s$, let $N'_s = \Sigma_k\, N^{k'}{}_s$ be the number of articles in the new sub-field s, and define the new MCRs, $M^{k}{}'_s$ and M'_s, by

$$M^{k}{}'_s = (\Sigma_i\, v^k{}_{si}\, c^k{}_{si})/(\Sigma_i\, v^k{}_{si}). \tag{3}$$

$$M'_s = (\Sigma_k\, \Sigma_i\, v^k{}_{si}\, c^k{}_{si})/N'_s = \Sigma_k\, (N^{k'}{}_s/N'_s)\, M^{k'}{}_s. \tag{4}$$

As in Herranz and Ruiz-Castillo (2011a), it can be shown that the number of articles and citations in the union of the new sub-field distributions, $\cup_{s\in d}\, \mathbf{c}^{k'}{}_s$, coincides with $N^k{}_d$ and $\gamma^k{}_d$, respectively. That is to say, $N^k{}_d = \Sigma_{s\in d} N^{k'}{}_s$, and $\gamma^k{}_d = \Sigma_{s\in d} \Sigma_i\, v^k{}_{si}\, c^k{}_{si}$. Therefore, we have:

$$M^k{}_d = (\Sigma_{s\in d}\, \Sigma_i\, v^k{}_{si}\, c^k{}_{si})/(\Sigma_{s\in d}\, \Sigma_i\, {}^k v_{si}) = (\Sigma_{s\in d} \left[N^{k}{}'_s\, [\Sigma_i\, v^k{}_{si}\, c^k{}_{si}/N^{k}{}'_s]\right]/(\Sigma_{s\in d}\, \Sigma_i\, v^k{}_{si})$$

$$= \Sigma_{s\in d}\, (N^{k}{}'_s/N^k{}_d)\, M^{k}{}'_s. \tag{5}$$

At the aggregate level,

$$M_d = \gamma^k{}_d/N_d = (\Sigma_k\, \gamma^k{}_d)/(\Sigma_k\, N^k{}_d) = (\Sigma_k\, \Sigma_{s\in d}\, \Sigma_i\, v^k{}_{si}\, c^k{}_{si})/N_d = \Sigma_k\, (N^k{}_d/N_d)\, M^k{}_d$$

$$= \Sigma_k\, (N^k{}_d/N_d)\, \Sigma_{s\in d}\, (N^{k}{}'_s/N^k{}_d)\, M^{k}{}'_s = \Sigma_{s\in d}\, \Sigma_k\, (N^{k}{}'_s/N_d)\, M^{k}{}'_s$$

$$= \Sigma_{s\in d}\, (N'_s/N_d)\, \Sigma_k\, (N^{k}{}'_s/N'_s)\, M^{k}{}'_s = \Sigma_{s\in d}\, (N'_s/N_d)\, M'_s. \tag{6}$$

By comparing expressions (1) and (3), and (2) and (4), it should be clear that the difference between the multiplicative strategy at the sub-field and the discipline level amounts to a question of weighting. In the first case, the $N^k{}_s$ distinct articles of area k in sub-field s receive a weight equal to one, while in the second case an article l in the original distribution belonging to a new sub-field s and discipline d is weighted by the inverse of the number of sub-fields belonging to discipline d, namely, by $v^k{}_{si} = (1/x^k{}_{ld})$. Then, the MCRs at the discipline level are seen in expressions (5) and (6) to be equal to the weighted sum of the new sub-fields MCRs, with weights equal to the proportion that the number of articles in each new sub-field represents in the total number of articles in the discipline.

II. 4. Normalization Procedure

As indicated in the Introduction, whenever possible we must normalize aggregate distributions, say at the discipline level, taking into account differences in citation practices across their sub-fields. Discipline *d*'s normalized distribution in area *k* in the multiplicative case is $\mathfrak{z}^k_d = \{\mathfrak{z}^k_{dj}\}$, where

$$\mathfrak{z}^k_{dj} = c^k_{dj}\,\Sigma_{s\in X^k_{ld}}(v^k_{si}/M'_s) = (c_l/x^k_{ld})\Sigma_{s\in X^k_{ld}}(1/M'_s),$$

and M'_s is defined in expression (3). Discipline *d*'s normalized distribution, $\mathfrak{z}_d$, is the union of these distributions over all geographical areas, namely, $\mathfrak{z}_d = \cup_k\, \mathfrak{z}^k_d$. For each *s* belonging to *d*, let $\mathfrak{z}^{k}{}'_s = \{c^{k}{}'_s/M'_s\} = \{(v^k_{si}\; c^k_{si})/M'_s\}$ be area *k*'s new sub-field normalized distribution, while the union of distributions $\mathfrak{z}^{k}{}'_s$ over all geographical areas, $\mathfrak{z}'_s = \cup_k\, \mathfrak{z}^{k'}_s$, is the new sub-field *s* normalized distribution. As before, the MCR of distribution $\mathfrak{z}^k_d$ is equal to the MCR of the union $\cup_{s\in d}\, \mathfrak{z}^{k'}_s$. Therefore, the MCR of distribution $\mathfrak{z}_d$ is equal to the MCR of the union $\cup_{s\in d}\, \mathfrak{z}'_s$. Of course, the MCRs of distributions $\mathfrak{z}'_s$ and $\mathfrak{z}_d$ for all *s* and all *d* are equal to one.

An example should be useful. Assume that an article *l* in the original distribution is assigned to four sub-fields, three of which belong to a certain discipline d_1, while the fourth belongs to discipline d_2. Thus, the article in question is wholly counted twice in the double extended discipline count. In each of the new sub-fields article *l* appears weighted by the inverse of the number of sub-fields belonging to each of the two disciplines: by 1/3 in the three sub-fields belonging to d_1, and by one in the fourth sub-field belonging to d_2. To control for wide differences in citation practices at the sub-field level, the procedure takes as the normalization factor the MCR of the new sub-fields thus constructed. Consider the c_l citations in discipline d_1. One third of them are normalized by each of the three new sub-fields' MCRs. Instead, the c_l citations of this same article in discipline d_2 are normalized by the MCR of the fourth new sub-field.

Consider the situation for higher aggregate levels, say for F fields with $F < D$, indexed by $f = 1,\ldots, F$. Let N^k_f be the number of distinct articles in field f that have at least one author working in area k, and denote by $\mathbf{c}^k_f$ the citation distribution of area k in field f. The MCR of distribution $\mathbf{c}^k_f$, M^k_f, is defined by $M^k_f = \gamma^k_f/N^k_f$, where γ^k_f is the number of citatioons in distribution $\mathbf{c}^k_f$. Field f's citation distribution, $\mathbf{c}_f$, is the union of the areas' citation distributions, namely, $\mathbf{c}_f = \cup_k \mathbf{c}^k_f$. The MCR of distribution $\mathbf{c}_f$, M_f, is defined by $M_f = \gamma_d/N_f$, where $N_f = \Sigma_k N^k_f$, and $\gamma_f = \Sigma_k \gamma^k_f$. The *double extended field count*, ***F-count***, is the union of all field distributions, namely, ***F-count*** $= \cup_f \mathbf{c}_f$. If we denote by $N_f = \Sigma_k N^k_f$ the total number of distinct articles in field f, then $N_F = \Sigma_f N_f$ is the number of articles in the double extended field count.

To understand the procedure at this level, it suffices to redefine Y^k_l as the non-empty set of fields to which article l is assigned, and X^k_{lf} as the non-empty set of sub-fields in X^k_l that belong to field f in Y^k_l. As before, if $x^k_{lf} = |X^k_{lf}|$ is the number of sub-fields in X^k_{lf}, then for any s let $\mathbf{c}^{k}{}''_s = \{u^k_{si}\, c^k_{si}\}$ be a new sub-field distribution where $u^k_{si} = 1/x^k_{lf}$ for all $s \in X^k_{lf}$, so that $\Sigma_{s \in X^k_{lf}} u^k_{si} = 1$. The new fractional number of articles in sub-field s is equal to $N^{k}{}''_s = \Sigma_i u^k_{si}$, and the new MCR of distribution $\mathbf{c}^{k}{}''_s$ is denoted by $M^{k}{}''_s$. It can be shown that the number of articles and citations in the union of the new sub-field distributions, $\cup_{s \in f} \mathbf{c}^{k}{}''_s$, coincides with N^k_f and γ^k_f, respectively. Consequently, the MCR of $\mathbf{c}^k_f$, M^k_f, is equal to the weighted sum of its new sub-fields MCRs, with weights equal to the proportion that the number of articles in each new sub-field represents in the total number of articles in the field:

$$M^k_f = \Sigma_{s \in f} \, (N^{k}{}''_s/N^k_f) \, M^{k}{}''_s.$$

Similarly,

$$M_f = \Sigma_{s \in f} \, (N''_s/N_f) \, M''_s,$$

where $M''_s = \Sigma_k \, (N^{k}{}''_s/N''_s) \, M^{k}{}''_s$, and $N''_s = \Sigma_k N^{k}{}''_s$. From this point, normalization proceeds as in the discipline case. Eventually, when we reach the maximum aggregation level the weighting system in the multiplicative strategy coincides with the one in the fractional strategy.

II. 5. The FGT Family of High- and Low-impact Indicators

Consider a discrete citation distribution of papers published in a given year, that is, consider an ordered, non-negative vector $\boldsymbol{c} = (c_1, \ldots, c_i, \ldots, c_n)$ where $c_1 \leq c_2 \leq \ldots \leq c_n$, and $c_i \geq 0$ is the number of citations received by the i-th article. Given a distribution $\boldsymbol{c}$ and a positive CCL, classify as low- or high-impact articles all papers with citation $c_i \leq$ CCL, or $c_i >$ CCL. To simplify the notation, we will omit in the sequel a reference for such fixed CCL. Thus, denote by $n(\boldsymbol{c})$ the total number of articles in the distribution, and by $l(\boldsymbol{c})$ and $h(\boldsymbol{c}) = n(\boldsymbol{c}) - l(\boldsymbol{c})$ the number of low- and high-impact articles. A *low-impact index* is a real valued function L whose typical value $L(\boldsymbol{c})$ indicates the low-impact level associated with distribution $\boldsymbol{c}$, while a *high-impact index* is a real valued function H whose typical value $H(\boldsymbol{c})$ indicates the high-impact level associated with that distribution.

Given a citation distribution $\boldsymbol{c}$ and a CCL, the Foster, Greer, and Thorbeke (FGT hereafter) family of low-impact indicators, originally introduced in Foster *et al.* (1984) for the measurement of economic poverty, is defined by:

$$L_\beta(\boldsymbol{c}) = [1/n(\boldsymbol{c})] \, \Sigma_{i=1}^{l(c)} (\boldsymbol{\Gamma}_i)^\beta, \; 0 \leq \beta,$$

where β is a parameter identifying the members of the family, and $\boldsymbol{\Gamma}_i = \max\{(\text{CCL} - c_i)/\text{CCL}, 0\}$ is the *normalized low-impact gap* for any article with c_i citations. Note that $\boldsymbol{\Gamma}_i \geq 0$ for low-impact articles, while $\boldsymbol{\Gamma}_i = 0$ for high-impact articles. The class of FGT high-impact indicators is defined by

$$H_\beta(\boldsymbol{c}) = [1/n(\boldsymbol{c})] \, \Sigma_{i=l(c)+1}^{n(c)} (\boldsymbol{\Gamma}^*_i)^\beta, \; 0 \leq \beta,$$

where β is again a parameter identifying the members of the family, and $\boldsymbol{\Gamma}^*_i = \max\{(c_i - \text{CCL})/\text{CCL}, 0\}$ is the *normalized high-impact gap*. Now $\boldsymbol{\Gamma}^*_i > 0$ for high-impact articles, while $\boldsymbol{\Gamma}^*_i = 0$ for low-impact articles. As explained in Albarrán *et al.* (2011b), both families are size- and scale-invariant. In view of the sub-field differences in size and MCR that will be reviewed in Section III.1 this is a very convenient property to have.

It will be sufficient to understand the differences involved in these indicators for parameter values $\beta = 0$, 1, and 2. Firstly, note that the high- and low-impact indices obtained when $\beta = 0$ coincide with the proportion of high- and low-impact papers: $H_0(\boldsymbol{c}) = h(\boldsymbol{c})/n(\boldsymbol{c})$, and $L_0(\boldsymbol{c}) = l(\boldsymbol{c})/n(\boldsymbol{c})$. It should be noted that the mere percentage of articles satisfying some interesting condition only captures what can be referred to as the *incidence* aspect of the phenomenon in question. In this sense, it can be said that H_0 and L_0 only capture the incidence aspect of the high- and low-impact phenomenon. Secondly, denote by $\mu_H(c)$ and $\mu_L(c)$ the MCR of high- and low-impact articles. It can be shown that

$$H_1(c) = [1/n(c)]\, \Sigma_{i = l(c) + 1}^{n(c)}\, \Gamma^*_I = H_0(c)H_I(c),$$

and

$$L_1(c) = [1/n(c)]\, [\Sigma_{i = 1}^{l(c)}\, \Gamma_i] = L_0(c)L_I(c),$$

where

$$H_I(c) = [1/h(c)]\, \Sigma_{i = l(c) + 1}^{n(c)}\, \Gamma^*_i = [\mu_H(c) - CCL]/CCL,$$

and

$$L_I(c) = [1/l(c)]\, \Sigma_{i = 1}^{l(c)}\, \Gamma_i = [CCL - \mu_L(c)]/CCL.$$

The indices H_I and L_I are said to be monotonic in the sense that one more citation among high-impact articles increases H_I and L_I. Therefore, it can be said that H_1 and L_1 capture both the incidence and the intensity of these phenomena. Thirdly, the high- and low-impact members of the FGT families obtained when $\beta = 2$ can be expressed as:

$$H_2(c) = H_0(c)\{[(H_I(c)]^2 + [1 + H_1(c)]^2\, (C_H)^2]\}, \qquad (2)$$

$$L_2(c) = L_0(c)\{[(L_I(c)]^2 + [1 - L_I(c)]^2\, (C_L)^2]\}, \qquad (3)$$

where C_H and C_L are the coefficients of variation (that is, the ratio of the standard deviation over the mean) among the high- and low-impact articles, respectively. Average-based measures are silent about the distributive characteristics on either side of the mean. Instead, in so far as the coefficient of variation is a measure of citation inequality, the FGT indicators H_2 and L_2 defined in equations (2) and (3) simultaneously capture the incidence, the intensity, and the *citation inequality* aspects of the high- and low-impact phenomenon they measure (see Albarrán *et al.*, 2011b, for a full discussion of the properties possessed by the above indicators).

Since in this paper only indicators for parameter value $\beta = 2$ will be computed, we will omit any further subscript in what follows; the corresponding high- and low-impact indicators are simply denoted as H and L, respectively. The CCL is fixed equal to the 80th percentile of each sub-field distribution.

III. EMPIRICAL RESULTS

III.1. Aggregation Scheme and Descriptive Statistics

As indicated in the Introduction, in this paper sub-fields are identified with the 219 WoS categories. As is well known, there is no generally agreed-upon Map of Science or aggregation scheme that allows us to climb from the sub-field up to other aggregate levels. Among the many alternatives, Albarrán *et al.* (2011a) borrow from the schemes recommended by Tijssen and van Leeuwen (2003) and Glänzel and Schubert (2003) with the aim of maximizing the possibility that a power law represents the upper tail of each of the corresponding citation distributions. The resulting scheme consists of 80 disciplines, and 19 fields (The existence of a power law cannot be rejected in 59 of 80 disciplines and 16 of 19 fields, accounting for 71.8% and 75.5% of all articles in the respective extended samples). For our purposes, we separate Computer Sciences from Engineering to work with a total of 20 fields.[3] Table A in the Appendix presents the information about the number of articles, and the MCR in the multiplicative strategy, namely, in the double extended discipline and field counts. Moreover, columns 4 and 8 contain the value of the CCL when it is fixed at the 80th percentile of each sub-field distribution. For convenience, sub-fields, disciplines, and fields are grouped into four very broad grand-fields that include Life Sciences, Physical Sciences, Other Natural Sciences, and Social Sciences. Five points should be noted.

Firstly, as expected, the total number of articles in the double extended counts decrease as we move upwards in the aggregation scale: the number of articles for sub-fields, disciplines, and fields are N_{SF} = 6,512,031, N_D = 6,107,509, and N_F = 5,538,760, totals which are 57.7%, 47.4%, and 33.7% greater than the total number of articles in the geographical extended count, *G*. Secondly, publication practices across sub-fields are known to be very different. In some research areas, authors publishing one article per year would be among the most productive, while in other instances authors –either alone or as members of a research team– are expected to publish several papers per year. On the other hand, since the WoS categories are not designed at all to equalize the number of articles published in a given period of time, distribution sizes are expected to differ greatly. In particular, in our dataset mean sizes (and standard deviations) are 29,735 (33,826) for sub-fields, 76,344 (51,021) for disciplines, and 276,938

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[3] It is not claimed that this scheme provides an accurate representation of the structure of science. It is rather a convenient simplification for the discussion of aggregation issues in this paper.

(185,742) for fields. Thirdly, the correlation coefficients between the publication effort across disciplines for every pair of geographical areas are the following: between the U.S and the EU it is 0.86, while between the RW and the U.S. and the RW and the EU they are 0.67 and 0.90. This means, of course, that all areas' publication efforts are rather similar. Fourthly, given the differences in citation practices across sub-fields, MCRs vary widely. The mean (and standard deviation) is 7 (3.9) for disciplines, and 7 (3.6) for fields. At the field level, for example, the maximum MCR is reached in Biosciences and Clinical Medicine I (Internal Medicine) with 15.4 and 13.2 citations, respectively, while the minimum is in Mathematics and Social Sciences, General with three citations each. Fifthly, as can be observed in columns 4 and 8 in Table A in the Appendix, CCL values are always greater than the MCRs, but the difference is relatively small. On average, the 80th percentile is reached at 8.8 citations while the MCR is equal to 6.1. The reason is that the percentage of articles that receive citations less than or equal to the MCR at every aggregation level is on average approximately 70% (see Glänzel, 2007, 2010, and Albarrán *et al.*, 2011a).

On the other hand, Table B in the Appendix includes the geographical areas' publication shares for disciplines and fields. It should be noted that the share of all articles is approximately 29%, 33% and 38% for the U.S., the EU, and the RW, respectively. The U.S. publishes considerably more in the Social Sciences, Clinical Medicine III (Health and other sciences), and Neurosciences & Behavioral, and considerably less in Chemistry, Physics, Materials Science, and the Residual Sub-fields[4] where the RW increases its share. More importantly for the discussion of the European Paradox in Section IV, the EU publishes more articles than the U.S. in 54 out of 80 disciplines, and 15 out of 20 fields. These 54 disciplines are allocated as follows over grand-fields: 17 out of 28 in Life Sciences, 17 out of 17 in Physical Sciences, 20 out of 26 in Other Natural Sciences, including three out of four Residual Sub-fields, and none out of nine Social Sciences. In 16 disciplines and three fields –Clinical Medicine I and II (Internal and Non-internal Medicine), and Space Science– the EU is the world leader.

III.2. The Impact of Normalization

Tables C and D in the Appendix present the normalized and un-normalized high- and low-impact indicators at all aggregation levels when the CCL is equal to the 80th percentile of the corresponding

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[4] These are sub-fields whose presence distorts the appearance of a power law among the group of sub-fields to which they in principle belong. See Albarrán *et al.* (2011a) for details.

distribution. One way to assess the impact of normalization is to look at the changes introduced in the measurement of the ratio of high- and low-impact measures for a pair of geographical areas. In the sequel, we focus on the US/EU gaps.

Consider the possibility of aggregating in a single discipline two sub-fields *s* and *t* with rather different MCRs, and hence, rather large different un-normalized CCLs. Without loss of generality, assume that both sub-fields have the same size, and that sub-field *s* is the one with larger MCR. Consider the set of high-impact articles at the discipline level. Since the un-normalized CCL for the discipline is the mean of both CCLs, the percentage of articles in this set belonging to sub-field *s* will be considerably greater than the one belonging to sub-field *t*. However, after normalization the distribution of high-impact articles at the discipline level by sub-field will become considerably more equal. Therefore, it is very likely that the normalized and the un-normalized US/EU gaps are different. The question that should be investigated is whether these differences are important, and whether normalization systematically favors any geographical area.

Columns 1 to 6 in Table E in the Appendix compare the normalized and the un-normalized results about the US/EU gaps measured by the corresponding high- and low-impact ratios at all aggregate levels. Since there are 21 disciplines consisting of a single sub-field, only the remaining 59 disciplines can be affected by normalization. Similarly, since the Space Sciences and the Multidisciplinary category also consists of a single sub-field, normalization may affect 18 fields at a maximum.

Starting with the high-impact gap, the first finding is that normalization reduces the US/EU gap in 32 out of 59 disciplines, 14 out of 18 fields, and the important all-sciences case. On the other hand, quite apart from the Residual Sub-fields case where normalization reduces the US/EU gap by 37.5%, there are only five other fields with reductions that are greater than 10% reductions (Agricultural & Environment; Materials Science; Mathematics; Economics & Business, and Chemistry). In the Neurosciences & Behavioral Sciences the gap increases by 25% after normalization. For all sciences as a whole, there is a 14.4% gap reduction. Thus, we may conclude that normalization reduces the US/EU high-impact gap by a non-negligible but not a dramatic amount. Nevertheless, changes induced by normalization in 37 out 59 disciplines and seven out of 18 fields are of a small order of magnitude, and in 27 disciplines and four fields normalization increases rather than reduces the U.S./EU gap.

The low-impact gap is much less affected: in 53 out of 59 disciplines and 16 out of 18 fields the U.S./EU gap changes in either direction by less than 2%. There is no case in which normalization changes the low-impact gap by more than 10%, and in the all-sciences case the gap is reduced by 1.8%. At any rate, whenever possible normalization should be recommended on methodological grounds. Consequently, the rest of the paper only focuses on normalized estimates.

III.3. Substantive Results about the U.S./EU Gap

Information about the contribution of specific geographical areas to high- and low-impact worldwide levels in the normalized case at all aggregate levels, $H(\mathbf{x}^k)/H(\mathbf{x})$ and $L(\mathbf{x}^k)/L(\mathbf{x})$ for k = U.S., EU, can be deduced from Table C. Information on the U.S./EU high- and low-impact gaps measured through the ratios $H(\mathbf{x}^{US})/H(\mathbf{x}^{EU})$ and $L(\mathbf{x}^{US})/L(\mathbf{x}^{EU})$ are in columns 1 and 4 in Table D. A summary of results about observed contributions for the U.S. and the EU, as well as about the U.S./EU gaps in the high- and low-impact case for disciplines are in Tables 1 and 2. The corresponding information for higher aggregation levels is presented in Table 3.

Tables 1, 2, and 3 around here

Let us start with high-impact aspects. The contrast between the U.S. and the EU is phenomenal. The EU contribution to high-impact levels is below its publication share in 55 out of 80 disciplines, and by more than 50% above its publication share in a single occasion (Integrative & Complementary Medicine). These figures are one and 43, respectively, for the U.S. (see the last two rows in Table 1A). The dismal performance of the EU is particularly serious in the Life, Physical, and Social Sciences. The consequences for the US/EU gap are dramatic. The EU is ahead or at the same level in only two disciplines among the natural sciences (Integrative & Complementary Medicine, and Other Clinical Medicine), and in Geography, Planning, and Urban Studies among the social sciences. In turn, the U.S. dominates the EU by more than 100% in 27 out of 80 disciplines (see Table 1B). On the other hand, the U.S./EU high-impact gap is greater than one in all fields, and greater than two in eight of them. Finally, for all sciences as a whole the U.S. high-impact indicator is about 61% greater than that of the EU (see Table 3).

As far as low-impact is concerned, the EU performs somewhat better: its contribution to world levels is below what can be expected from its publication share in 55 disciplines. Even so, the U.S is in this same situation in 75 out of 80 cases (see Table 2A). Nevertheless, the EU is ahead (namely, its contribution to low-impact levels is smaller that that of the U.S.) in 14 disciplines. Moreover, the U.S. is ahead by more than 20% in only 14 disciplines (see Table 2B). Only in the field Clinical Medicine III (Health and Other Medical Sciences) the EU dominates the U.S. Nevertheless, in all sciences as a whole the U.S. is also ahead but only by 12.3% (see Table 3).

III. 4. Average-based *versus* High-impact Measurement of the US/EU Gap

Column 7 in Table E in the Appendix includes the results obtained in Herranz and Ruiz-Castillo (2011c) about the U.S./EU gap measured with the *MNCS* at all aggregation levels, while column 8 compares the measurement of the gap using our normalized high-impact indicator and the *MNCS* (the information for fields is also in columns 3 and 4 in Table 3). The situation for disciplines and fields is illustrated in Figure 1.

Figure 1 around here

From an ordinal point of view, there are few reversals: only in Integrative & Complementary Medicine the EU is behind according to the mean normalized citation score (*MNCS* hereafter) and ahead according to the *H* index, while in two instances the opposite is the case (Experimental & Laboratory Medicine, and Applied Chemistry & Chemical Engineering). It should be noted that in only five disciplines the US/EU gap is greater according to the *MNCS*. From a cardinal point of view, the differences between the results obtained with the two approaches are of a large order of magnitude: among the 77 disciplines for which the U.S./EU high-impact gap is greater than the gap according to the *MNCS*, in 29 cases the difference is between 20% and 50%, and in 35 additional cases the difference is greater than 50%.

III. 5. Robustness Checks

Two robustness checks on the US/EU high-impact gap have been performed: the effect of following a fractional rather than a multiplicative strategy, and the effect of raising the CCL in the multiplicative case.

Columns 2 and 3 in Table F in the Appendix has the disciplines' information on the normalized U.S./EU high-impact gap in the fractional case, as well as the comparison with the same magnitude in the multiplicative approach. The same information for fields and the all-sciences case is in Table G in the Appendix. The two strategies, of course, differ in the way they treat articles coming from journals assigned to multiple sub-fields. One of the main findings in Herranz and Ruiz-Castillo (2011a) is that, in certain respects, the citation characteristics of these articles do not differ much from those of articles coming from journals assigned to a single sub-field. Thus, in spite of the wide differences in the mix between the two types of articles –which give rise to vast differences in the number of articles at every aggregate level–, the two strategies lead to citation distributions that have many important features in common. However, a second major finding in Herranz and Ruiz-Castillo (2011a) is that excellence is not equally structured in all citation distributions: in 63 out of 219 sub-fields, 16 out of 80 disciplines, and two out of 20 fields, differences in *H* values between the two strategies are greater than 20%.

In our case, there are 48 out of 80 disciplines and 10 out of 20 fields in which the US/EU high-impact gap increases when we take the fractional approach. However, in only 12 disciplines and none of the 10 fields this increase is greater than 10%. On the other hand, in seven disciplines and two fields the gap decreases by more than 10% in the fractional strategy, and in two instances (Crystallography, and Agricultural Science & Technology) the US/EU becomes less than one. It should be mentioned that the gap decreases by more than 100% in Crystallography and increases by 17.6% in Medicine, Research & Experimental, two disciplines consisting of a single sub-field that were detected as "residual" sub-fields in Albarrán et al (2011a), and as "extreme distributions" according to the multiplicative and the fractional strategies in Herranz and Ruiz-Castillo (2011a). Correspondingly, the gap decreases by 56.8% in the field consisting of all four Residual Sub-fields. Finally, the gap difference in the all-science case only represents 0.03%, while the correlation coefficient between the gap according to the two strategies at the discipline level is 0.96.

In brief, in line with our conclusion in Herranz and Ruiz-Castillo (2011a), although the similarity of citation characteristics of articles published in journals assigned to one or several sub-fields guarantees that choosing one of the two strategies may not lead to a radically different picture in practical applications, the US/EU high-impact gap differs by more than 10% in 19 out of 80 disciplines and two out of 20 fields depending on that choice. However, results are not biased in favor of any of the two geographical areas.

So far, in this paper the CCL has been set equal to the 80th percentile of all world citation distributions. It is interesting to investigate what the consequences are of considerably raising the CCL. Columns 4 and 5 in Table F in the Appendix have the information on the U.S./EU high-impact gap for the 95th percentile in the multiplicative approach, as well as the comparison with the same magnitude with the 80th percentile for disciplines. The same information for fields and the all-sciences case is in Table G in the Appendix.

Results vary at different aggregate levels. Firstly, in two disciplines (Aquatic Sciences, and Integrative & Complementary Medicine) the normalized US/EU high-impact gap goes up by more than 70% when the CCL is raised. In 26 other disciplines the gap increases by more than 20%. At the other extreme, there are two dramatic reversals in favor of the EU (Physiology, and Dentistry), and 18 other cases in which the gap decreases by more than 20%. A coefficient of correlation of 0.22 between the gaps for the two CCLs reveals important changes at this level. Secondly, these large changes tend to be reduced at the field level: raising the CCL from the 80th to the 95th percentile increases the gap in 17 out of 20 fields, but only in one case (Materials Science) by more than 20%, and in eight more cases by between 10% and 20%. The U.S./EU gap decreases by 6% in the Residual Sub-fields case, and by less than 3.5% in the two remaining cases. This is agreement with the findings in Albarrán *et al.* (2011c) for the 22 broad fields distinguished by Thomson Scientific. Thirdly, for all sciences as a whole the impact of CCL changes is entirely negligible. We may conclude that a drastic raise in the CCL tends to increase the dominance of the U.S. over the EU in a majority of cases. However, in 31 out of 80 disciplines and three out of 20 fields the relative situation of the EU improves. In 49 disciplines the change in either direction is greater than 20%. These large numbers drastically diminish as we move towards higher aggregate levels.

IV. CONCLUSIONS AND EXTENSIONS

This paper has used a pair of high- and low-impact indicators introduced in Albarrán *et al.* (2011b) to question the truth of the European Paradox according to which Europe plays a leading world role in terms of scientific excellence, measured in terms of the number of publications, but lacks the entrepreneurial capacity of the U.S. to transform it into innovation, growth, and jobs. The citation performance of the U.S., the EU, and the RW has been compared at different aggregation levels: the 80 disciplines and 20 fields suggested in Albarrán *et al.* (20011a), as well as the all-sciences as a whole. The dataset consists of 3.6 million articles published in 1998-2002 with a common five-year citation window. A multiplicative strategy has been followed to solve the problems posed by international co-authorship and the assignment of articles to multiple sub-fields.

The paper has applied a novel sub-field normalization procedure in the multiplicative case. This is done in two steps. Firstly, at each aggregate level a new set of sub-fields is defined where, for example, an article in the original distribution is weighted by the inverse of the number of sub-fields belonging to each discipline. Secondly, to control for wide differences in citation practices at the lowest level of aggregation, the procedure takes as a normalization factor the MCR of the new sub-field thus constructed. The main empirical results can be summarized as follows.

1. Normalization reduces the U.S./EU high-impact gap by a non-negligible 14.4% in the all-sciences case, but increases it in 27 out of 59 disciplines and four out of 18 fields. Hence, we may conclude that it does not systematically bias the results against any of the two areas. Moreover, in a world partitioned into only three large geographical areas, changes in either direction, particularly for the low-impact gap, are often relatively small. It remains to be seen whether this is also the case in the evaluation of smaller research units. Nevertheless, whenever possible, for the evaluation of the citation performance of research units of any type, normalization is always recommended.

2. From the substantive point of view, the European Paradox is definitely put to rest. It is true that the EU has more publications than the U.S. in 54 disciplines, and 15 fields. Overall, the EU has about 4% more publications than the U.S. However, judging from the high-impact perspective, the EU is ahead of the U.S. only in three out of 80 disciplines, and none out of 20 fields. The U.S. has a high-impact indicator at least twice as large as the EU in 21 out of 71 disciplines within the natural sciences, and in six out of nine social sciences. This is also the case for eight fields. For all sciences as a whole, the U.S. high-impact indicator is 61% greater than that of the EU. When we measure the U.S./EU gap by low-impact indicators the EU situation is somewhat more favorable. For example, the EU is ahead in 14

out of 80 disciplines, and one out of 20 fields. For all sciences as a whole the U.S. low-impact indicator is 12.2% smaller than that of the EU.

As is well known, the problem with the European Paradox is that it is exclusively based on the number of publications. This paper confirms that there is no connection at any aggregation level between publication shares and high- or low-impact levels. Instead, together with Herranz and Ruiz-Castillo (2011b), this paper has established that the European Paradox hides a truly *European Drama*: judging from citation impact, the dominance of the U.S. over the EU in the basic and applied research published in the periodical literature is almost universal at all aggregation levels.

3. The paper has compared the consequences of measuring the U.S./EU gap using our high-impact indicator or using the *MNCS*. The gap is greater according to the *MNCS* only in three disciplines, and one minor field (Clinical Medicine III). In the remaining 77 disciplines, 19 fields, as well as all sciences as a whole, the gap is considerably greater when measured by the high-impact indicator (in 35 disciplines and ten fields the difference is greater than 50%). As explored in detail in Herranz and Ruiz-Castillo (2011b), for all sciences as whole the U.S. *MNCS* indicator is 24.7% greater than that of the EU.

4. Two robustness tests have been performed. Firstly, as indicated in Herranz and Ruiz-Castillo (2011a), choosing the fractional rather than the multiplicative strategy does not lead to a radically different picture in practical applications. In our case, the U.S./EU high-impact gap changes by more than 10% when we take the fractional approach in only 17 disciplines and two fields. Secondly, a drastic raise in the CCL from the 80th to the 95th percentile of world citation distributions generally increases the intensity of the U.S. dominance over the EU. In 49 out of 80 disciplines the change in either direction is greater than 20%. These large numbers drastically diminish as we move towards higher aggregate levels.

As indicated in our companion paper Herranz and Ruiz-Castillo (2011b), the present analysis might be extended in rather obvious directions towards specific countries within the EU and the RW, and even individual research centers. It would be important to analyze domestic and internationally co-authored articles separately. In the European case, the latter should differentiate between intra-European cooperation and cooperation with the U.S. and the rest of the world.

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Table 1A. Geographical Areas' Observed Contribution (OC) To the Overall High-impact Level. Summary At the Discipline Level

	OC Below Its Publication Share	**OC Above Its Publication Share:**				
		0-50%	**51-100%**	**> 100**	**(5) = 2+3+4**	**Total = 1+5**
	(1)	**(2)**	**(3)**	**(4)**		
A. Life Sciences						
U.S.	**1**	16	11	0	**27**	28
EU	**24**	3	1	0	**4**	28
B. Physical Sciences						
U.S.	**0**	1	10	6	**17**	17
EU	**10**	7	0	0	**7**	17
C. Other Natural Sciences						
U.S.	**0**	10	12	4	**26**	26
EU	**13**	13	0	0	**13**	26
NATURAL SCIENCES = A + B + C						
U.S.	**1**	27	33	10	**70**	71
EU	**47**	23	1	0	**24**	71
D. Social Sciences						
U.S.	**0**	9	0	0	**9**	9
EU	**8**	1	0	0	**1**	9
TOTAL = A + B + C + D						
U.S.	**1**	**36**	**33**	**10**	**79**	80
EU	**55**	**24**	**1**	**0**	**25**	80

Table 1B. Summary of the U.S./EU High-impact Gap at the Discipline Level

Number of Disciplines in which:	**EU IS AHEAD**	**U.S. IS AHEAD:**				**TOTAL**
		0 - 50%	**51% - 100%**	**> 100%**	**Total**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
A. Life Sciences	**2**	5	14	7	**26**	28
B. Physical Sciences	**0**	6	3	8	**17**	17
C. Other Natural Sciences	**0**	12	8	6	**26**	26
NATURAL SCIENCES = A + B + C	**2**	23	25	21	**69**	71
D. Social Sciences	1	0	2	6	8	9
TOTAL = A + B + C + D	**3**	23	27	27	**77**	80

Table 2A. Geographical Areas' Observed Contribution (OC) To the Overall Low-impact Level. Summary At the Discipline Level

	OC Above Its Publication Share	**OC Below Its Publication Share:**			
	(1)	**≤ 20% (2)**	**> 20% (3)**	**(4) = (2) + (3)**	**(5) = (1) + (4)**
A. Life Sciences					
U.S.	**4**	20	4	**24**	28
EU	**18**	10	0	**10**	28
B. Physical Sciences					
U.S.	**0**	11	6	**17**	17
EU	**1**	16	0	**16**	17
C. Other Natural Sciences					
U.S.	**1**	23	2	**25**	26
EU	**0**	26	0	**26**	26
NATURAL SCIENCES = A + B + C					
U.S.	**5**	54	12	**62**	71
EU	**19**	52	0	**52**	71
D. Social Sciences					
U.S.	**0**	9	0	**9**	9
EU	**6**	3	0	**3**	9
TOTAL = A + B + C + D					
U.S.	**5**	**63**	**12**	**75**	80
EU	**25**	**55**	**0**	**55**	80

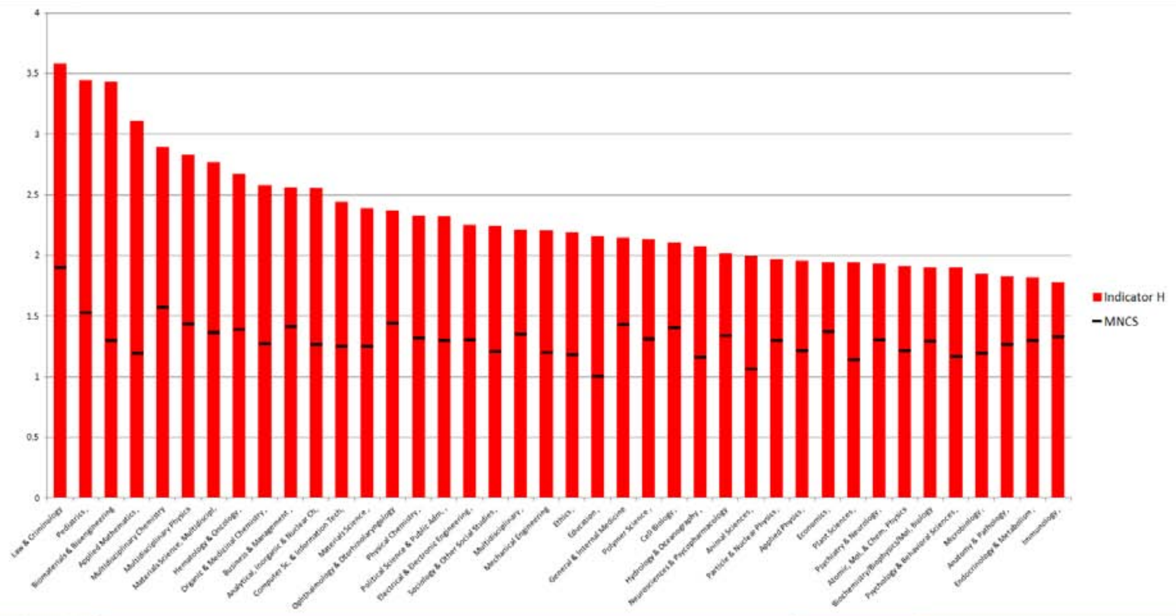
Table 2B. Summary of the U.S./EU Low-impact Gap at the Discipline Level

Number of Disciplines in which:	**EU AHEAD**	**U.S. AHEAD:**			**TOTAL**
		Difference:			
	(1)	**Small < 20% (2)**	**Large > 20% (3)**	**Total = (2)+(3) (4)**	**(5) = (1) + (4)**
A. Life Sciences	3	15	10	25	28
B. Physical Sciences	1	14	2	16	17
C. Other Natural Sciences	8	17	1	18	26
NATURAL SCIENCES = A+ B+ C	**12**	46	13	**59**	71
D. Social Sciences	2	6	1	7	9
TOTAL = A + B + C + D	**14**	52	14	**66**	80

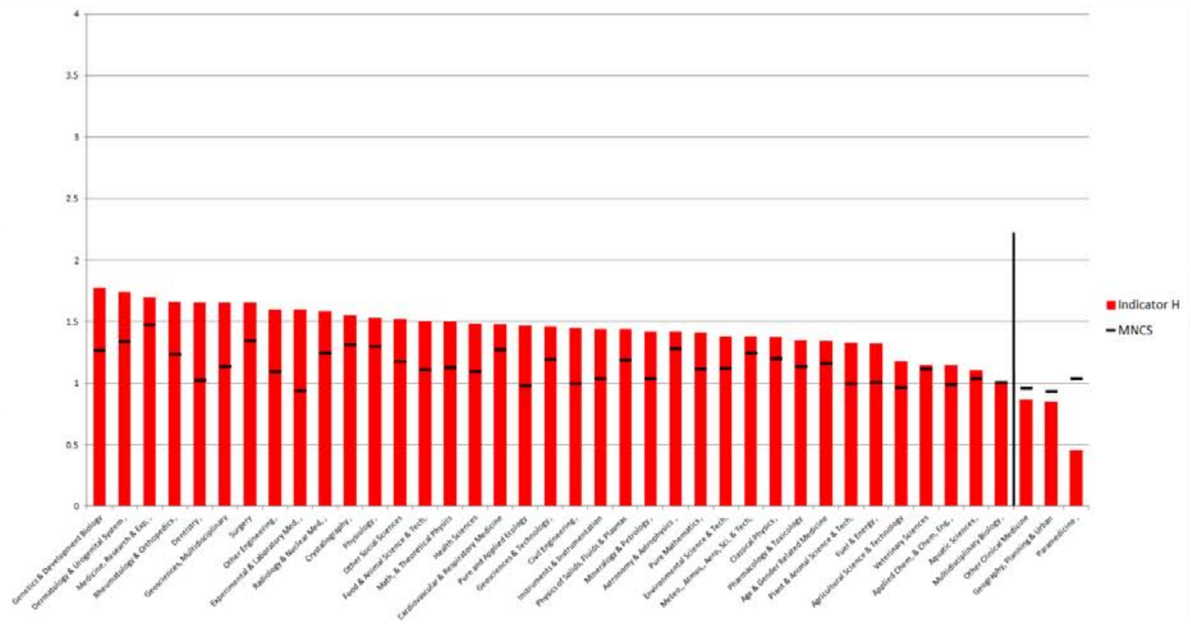
Table 3. The U.S./EU Gap at the Field and All Sciences Level, Measured With Normalized and Un-normalized High- and Low-impact Indicators, As Well As the Mean Normalized Citation Score

	HIGH-IMPACT	**LOW-IMPACT**	**MNCS**	
FIELDS	**(1)**	**(2)**	**(3)**	**(4) = (1) – (3) In %**
I. BIOSCIENCES	1.794	0.824	1.281	40.0
II. BIOMEDICAL RESEARCH	2.200	0.863	1.223	79.8
III. CLINICAL MEDICINE I (INTERNAL)	1.985	0.786	1.367	45.3
IV. CLIN. MED. II (NON-INTERNAL)	1.863	0.811	1.328	40.2
V. CL. MED. III (HEALTH & OTHER SCS.)	1.401	1.005	1.093	28.2
VI. NEUROSCIENCE & BEHAVIOR	1.975	0.862	1.251	57.9
VII. CHEMISTRY	2.363	0.877	1.307	80.8
VIII. PHYSICS	2.029	0.882	1.268	60.1
IX. SPACE SCIENCES	1.418	0.797	1.285	10.4
X. MATHEMATICS	2.953	0.944	1.181	150.1
XI. COMPUTER SCIENCE	2.439	0.931	1.255	94.4
XII. ENGINEERING	1.897	0.992	1.163	63.1
XIII. MATERIALS SCIENCE	2.389	0.917	1.258	89.8
XIV. GEOSCIENCES	1.444	0.903	1.187	21.6
XV. AGRICULT. & ENVIRONMENT	1.376	0.966	1.086	26.7
XVI. PLANT & ANIMAL SCIENCE	1.596	0.946	1.118	42.7
XVII. MULTIDISCIPLINARY	2.215	0.917	1.352	63.8
XVIII. RESIDUAL SUB-FIELDS	1.150	0.893	1.316	-12.6
XIX. SOCIAL SCIENCES, GENERAL	1.797	0.932	1.171	53.5
XX. ECONOMICS & BUSINESS	2.017	0.864	1.392	44.9
ALL SCIENCES	1.609	0.878	1.248	28.9

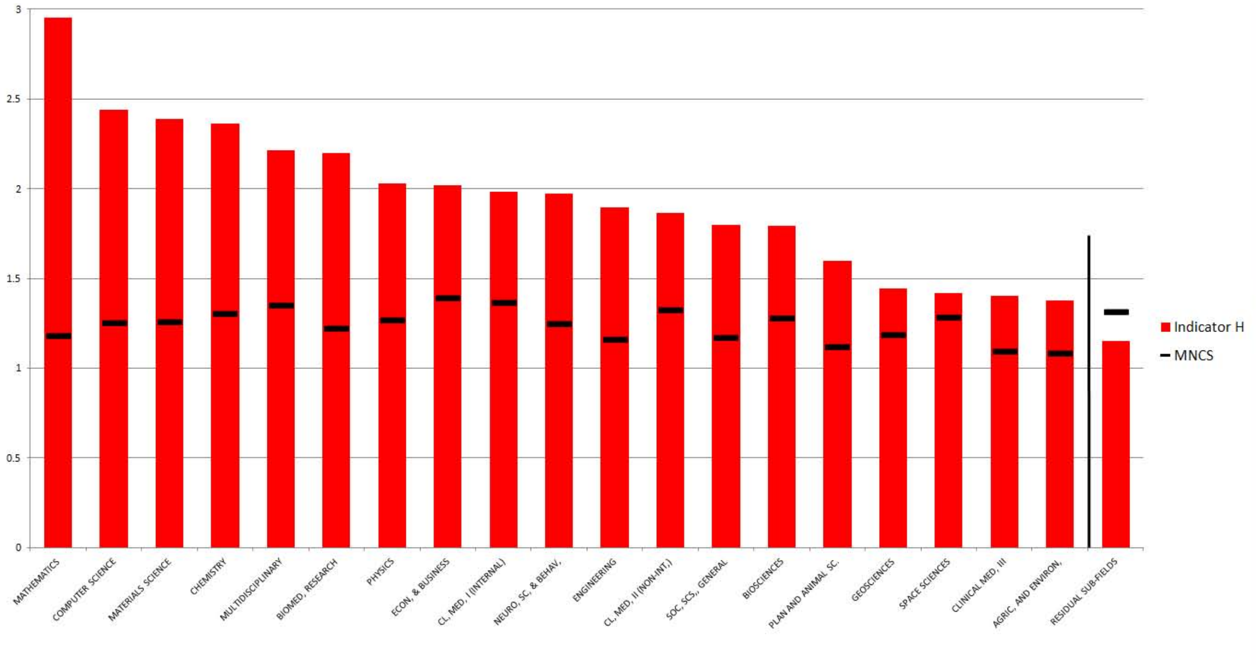
Figure 1. The U.S./EU gap at the discipline and field level according to the high-impact indicator H and the Mean Normalized Citation Score ($MNCS$)



A. Disciplines I



B. Disciplines II


3
2.5
2
1.5
1
0.5
0
MATHEMATICS
COMPUTER SCIENCE
MATERIALS SCIENCE
CHEMISTRY
MULTIDISCIPLINARY
BIOMED, RESEARCH
PHYSICS
ECON, & BUSINESS
CL, MED, I (INTERNAL)
NEURO, SC, & BEHAV,
ENGINEERING
CL, MED, II (NON-INT,)
SOC, SCS,, GENERAL
BIOSCIENCES
PLAN AND ANIMAL SC.
GEOSCIENCES
SPACE SCIENCES
CLINICAL MED, III
AGRIC, AND ENVIRON,
RESIDUAL SUB-FIELDS
🟥 Indicator H
— MNCS

C. Fields

APPENDIX

Table A. Number of Articles, Mean Citation Rates, and Critical Citation Lines In the Double Extended Counts for Disciplines and Fields, As Well As the All Sciences Case In the Geographical Extended Count

	DISCIPLINES				FIELDS			
	Number Of Articles (1)	% (2)	MCR (3)	CCL (4)	Number Of Articles (5)	% (6)	MCR (7)	CCL (8)
I. BIOSCIENCES					*429,332*	*7.8*	*15.4*	*22*
D1. Multidisciplinary Biology	42,034	0.69	9.5	15				
D2. Biochemistry, Biophysics, Mol. Biology	287,797	4.71	16.0	23				
D3. Cell Biology	97,545	1.60	22.5	32				
D4. Genetics & Development Biology	91,943	1.51	16.7	24				
II. BIOMEDICAL RESEARCH					*317,909*	*5.7*	*8.8*	*13*
D5. Anatomy & Pathology	39,021	0.64	8.9	13				
D6. Biomaterials & Bioengineering	91,185	1.49	8.9	13				
D7. Experimental & Laboratory Medicine	15,423	0.25	6.4	10				
D8 Pharmacology & Toxicology	136,684	2.24	8.1	12				
D9 = Physiology	49,225	0.81	10.7	17				
III. CLINICAL MEDICINE I (INTERNAL)					*509,541*	*9.2*	*13.2*	*18*
D10. Cardiovascular & Respiratory Medicine	79,780	1.31	12.2	18				
D11 = 21. **Endocrinology & Metabolism**	55,583	0.91	13.3	20				
D12. General & Internal Medicine	149,527	2.45	11.9	13				
D13. Hematology & Oncology	131,133	2.15	16.1	23				
D14. Immunology	115,554	1.89	13.8	20				
IV. CLIN. MED. II (NON-INTERNAL)					*549,174*	*9.9*	*8.3*	*12*
D15. Age & Gender Related Medicine	59,716	0.98	7.4	12				
D16 = Dentistry, Oral Surgery	23,294	0.38	5.5	8				
D17. Dermatology & Urogenital System	59,102	0.97	8.3	13				
D18. Ophthalmology & Otorhinolaryngology	47,410	0.78	6.1	9				
D19 = Integrative & Complementary Medicine	2,633	0.04	4.4	7				
D20. Psychiatry & Neurology	110,370	1.81	10.1	15				
D21 = 46. **Radiology, Nuclear Med. & Imaging**	58,950	0.97	7.9	12				
D22. Rheumatology & Orthopedics	55,519	0.91	7.1	11				
D23. Surgery	155,182	2.54	9.1	13				
D24 = Pediatrics	45,506	0.75	5.9	9				

V. CL. MED. III (HEALTH & OTHER SCS.)					*114,753*	*2.1*	*5.9*	*9*
D25. Health Sciences	105,469	1.73	6.2	9				
D26. Other Clinical Medicine	15,378	0.25	3.5	5				
VI. NEUROSCIENCE & BEHAVIOR					*231,219*	*4.2*	*10.2*	*15*
D27. Neurosciences & Psychopharmacology	129,562	2.12	13.4	20				
D28. Psychology & Behavioral Sciences	113,029	1.85	6.5	10				
VII. CHEMISTRY					*580,050*	*10.5*	*7.3*	*11*
D29 = Chemistry, Multidisciplinary	107,816	1.77	8.9	13				
D30. Analytical, Inorganic & Nuclear Chemistry	125,780	2.06	7.3	11				
D31. Applied Chemistry & Chemical Engineering	95,175	1.56	4.7	8				
D32. Organic & Medicinal Chemistry ,	105,557	1.73	7.8	12				
D33. Physical Chemistry	165,622	2.71	7.8	12				
D34 = Polymer Science	61,649	1.01	6.2	9				
VIII. PHYSICS					*610,826*	*11.0*	*7.1*	*10*
D35. Multidisciplinary Physics	136,906	2.24	8.4	11				
D36. Applied Physics	208,980	3.42	5.7	8				
D37. Physics, Atomic, Molecular & Chemical	74,351	1.22	8.6	13				
D38. Thermodynamics (Classical Physics)	19,276	0.32	3.5	5				
D39. Physics, Mathematical	41,061	0.67	5.9	9				
D40. Particle & Nuclear Physics	74,155	1.21	8.8	12				
D41. Physics of Solids, Fluids & Plasmas	160,097	2.62	6.0	9				
IX. SPACE SCIENCES					*82,073*	*1.5*	*12.5*	*18*
D42. Astronomy & Astrophysics ,	82,073	1.34	12.5	18				
X. MATHEMATICS					*163,098*	*2.9*	*3.0*	*4*
D43. Applied Mathematics	106,187	1.74	3.5	5				
D44. Pure Mathematics	76,078	1.25	2.1	3				
XI. COMPUTER SCIENCE					*132,264*	*2.4*	*3.5*	*5*
D45. Computer Science & Information Tech.	132,264	2.17	3.5	5				
XII. ENGINEERING					*392,455*	*7.1*	*3.5*	*5*
D46. Electrical & Electronic Engineering	135,308	2.22	3.6	5				
D47. Civil Engineering	49,282	0.81	4.2	6				
D48. Mechanical Engineering	99,768	1.63	3.1	5				
D49. Instruments & Instrumentation	48,605	0.80	4.1	6				

D50. Fuel & Energy	69,897	1.14	3.4	5				
D51. Other Engineering	60,713	0.99	3.0	5				
XIII. MATERIALS SCIENCE					*138,254*	*2.5*	*4.3*	*7*
D52. Materials Science	138,254	2.26	4.3	7				
XIV. GEOSCIENCES					*137,187*	*2.5*	*6.6*	*10*
D53. Geosciences & Technology	64,682	1.06	6.6	10				
D54. Hydrology & Oceanography	24,878	0.41	7.2	12				
D55 Meteo., Atmosph., Aero., Sc. & Tech.	42,560	0.70	6.7	10				
D56. Mineralogy & Petrology	14,782	0.24	4.7	7				
XV. AGRICULT. & ENVIRONMENT					*235,573*	*4.3*	*5.6*	*9*
D57. Agricultural Science & Technology	46,943	0.77	4.5	7				
D58. Plant & Soil Science & Tech,	22,045	0.36	5.7	9				
D59. Environmental Science & Technology	91,032	1.49	6.2	9				
D60. Food & Animal Science & Technology	98,654	1.62	5.6	9				
XVI. BIOLOGY (ORGANISMIC AND SUPRAORG. LEVEL)					*404,113*	*7.3*	*7.3*	*11*
D61. Animal Sciences	65,071	1.07	5.0	8				
D62. Aquatic Sciences ,	73,019	1.20	5.3	8				
D63. Microbiology	100,770	1.65	11.5	17				
D64. Plant Sciences	91,487	1.50	7.0	10				
D65 = 180. **Pure and Applied Ecology**	46,672	0.76	8.6	13				
D66 = 181. **VETERINARY SCIENCES**	54,380	0.89	3.8	6				
XVII. MULTIDISCIPLINARY					*27,961*	*0.5*	*3.2*	*4*
D67. MULTIDISCIPLINARY SCIENCES	27,961	0.46	3.2	4				
XVIII. RESIDUAL SUB-FIELDS					*288,618*	*5.2*	*6.6*	*8*
D68. MATERIALS SCIENCE, MULT.	153,666	2.52	4.9	7				
D69. CRYSTALLOGRAPHY	32,344	0.53	4.4	6				
D70. GEOSCIENCES, MULT.	54,564	0.89	5.6	9				
D71. MED., RES. & EXPERIMENTAL	48,413	0.79	14.7	18				
XIX. SOCIAL SCIENCES, GENERAL					*129,000*	*2.3*	*3.0*	*5*
D72. Law & Criminology	12,480	0.20	3.5	5				
D73. Political Science & Public Administration	15,769	0.26	2.4	4				
D74. Sociology & Other Social Studies	28,575	0.47	3.0	5				
D75. Education	18,810	0.31	2.6	4				

D76. Geography, Planning & Urban	20,550	0.34	3.2	5				
D77. Ethics	3,948	0.06	2.5	4				
D78. Other Social Sciences	44,619	0.73	3.0	5				
XX. ECONOMICS & BUSINESS					*65,360*	*1.2*	*3.9*	*6*
D79. Economics	42,067	0.69	3.6	5				
D80. Business & Management	28,360	0.46	4.6	7				
ALL CATEGORIES	**6,107,509**	**100.0**	**7.0**	**-**	**5,538,760**	**100.0**	7.0	
ALL SCIENCES	**4,142,281**	**-**	**8.2**	**11**				

Table B. Publication Shares By Geographical Area for Disciplines, Fields, and the All Sciences Case

	U.S.	EU	RW	U.S.	EU	RW
	DISCIPLINES			FIELDS		
	(1)	(2)	(3)	(4)	(5)	(6)
I. BIOSCIENCES				*33.3*	*32.8*	*33.9*
D1. Multidisciplinary Biology	31.4	31.7	36.9			
D2. Biochemistry, Biophysics, Mol. Biology	33.1	32.8	34.0			
D3. Cell Biology	36.2	32.9	30.9			
D4. Genetics & Development Biology	35.3	34.3	30.4			
II. BIOMEDICAL RESEARCH				*30.1*	*33.1*	*36.7*
D5. Anatomy & Pathology	29.5	35.7	34.8			
D6. Biomaterials & Bioengineering	27.1	34.4	38.5			
D7. Experimental & Laboratory Medicine	32.8	34.9	32.3			
D8. Pharmacology & Toxicology	29.2	32.4	38.4			
D9. Physiology	39.0	28.5	32.5			
III. CLINICAL MEDICINE I (INTERNAL)				*31.9*	*37.3*	*30.7*
D10. Cardiovascular & Respiratory Medicine	35.1	36.9	27.9			
D11. Endocrinology & Metabolism	31.4	38.9	29.7			
D12. General & Internal Medicine	28.2	37.5	34.3			
D13. Hematology & Oncology	33.8	37.0	29.2			
D14. Immunology	33.8	36.5	29.7			
IV. CL. MEDICINE II (NON-INTERNAL)				*34.0*	*36.6*	*29.5*
D15. Age & Gender Related Medicine	34.6	35.6	29.8			
D16. Dentistry, Oral Surgery	29.5	34.7	35.8			
D17. Dermatology & Urogenital System	30.6	40.5	29.0			
D18. Ophthalmology & Otorhinolaryngology	36.5	34.3	29.2			
D19. Integrative & Complementary Medicine	21.3	26.2	52.4			
D20. Psychiatry & Neurology	34.4	37.4	28.2			
D21. Radiology, Nuclear Med. & Imaging	33.8	37.9	28.3			
D22. Rheumatology & Orthopedics	38.8	34.9	26.3			
D23. Surgery	33.3	35.5	31.2			
D24. Pediatrics	35.6	33.4	31.0			
V. CL. MED. III (HEALTH & OTHER SCS.)				*47.3*	*27.2*	*25.5*
D25. Health Sciences	46.8	27.4	25.7			
D26. Other Clinical Medicine	50.3	27.6	22.1			

VI. NEURO, SCIENCE & BEHAVIOR				*42.3*	*30.7*	*27.0*
D27. Neurosciences & Psychopharmacology	35.0	34.0	30.9			
D28. Psychology & Behavioral Sciences	50.3	27.2	22.5			
VII. CHEMISTRY				*18.6*	*31.1*	*50.3*
D29. Chemistry, Multidisciplinary	18.1	23.7	58.2			
D30. Analytical, Inorganic & Nuclear Chemistry	17.9	37.0	45.0			
D31. Applied Chemistry & Chemical Engineering	19.0	31.3	49.7			
D32. Organic & Medicinal Chemistry ,	20.6	33.3	46.0			
D33. Physical Chemistry	17.7	34.1	48.2			
D34. Polymer Science	16.2	28.0	55.8			
VIII. PHYSICS				*21.2*	*32.2*	*46.6*
D35. Multidisciplinary Physics	18.5	31.8	49.8			
D36. Applied Physics	22.5	28.8	48.7			
D37. Physics, Atomic, Molecular & Chemical	23.9	36.3	39.8			
D38. Thermodynamics (Classical Physics)	24.0	27.4	48.6			
D39. Physics, Mathematical	21.1	35.7	43.1			
D40. Particle & Nuclear Physics	21.9	35.8	42.3			
D41. Physics of Solids, Fluids & Plasmas	18.4	35.1	46.5			
IX. SPACE SCIENCES				*31.5*	*34.8*	*33.7*
D42. Astronomy & Astrophysics	31.5	34.8	33.7			
X. MATHEMATICS				*26.1*	*33.5*	*40.3*
D43. Applied Mathematics	27.4	33.7	38.9			
D44. Pure Mathematics	23.5	32.2	44.3			
XI. COMPUTER SCIENCE				*31.0*	*34.2*	*34.9*
D45. Computer Science & Information Tech.	31.0	34.2	34.9			
XII. ENGINEERING				*27.5*	*28.8*	*43.7*
D46. Electrical & Electronic Engineering	29.6	27.2	43.2			
D47. Civil Engineering	33.3	28.2	38.5			
D48. Mechanical Engineering	27.1	28.1	44.8			
D49. Instruments & Instrumentation	23.8	33.6	42.6			
D50. Fuel & Energy	21.0	31.3	47.7			
D51. Other Engineering	28.9	29.9	41.2			
XIII. MATERIALS SCIENCE				*18.1*	*29.2*	*52.7*
D52. Materials Science	18.1	29.2	52.7			

XIV. GEOSCIENCES				*30.1*	*32.2*	*37.7*
D53. Geosciences & Technology	27.0	34.2	38.8			
D54. Hydrology & Oceanography	30.0	32.0	37.9			
D55 Meteo., Atmosph., Aero., Sc. & Tech.	38.1	29.3	32.6			
D56. Mineralogy & Petrology	19.3	31.3	49.4			
XV. AGRIC. AND ENVIRONMENT				*27.4*	*32.1*	*40.5*
D57. Agricultural Science & Technology	22.8	29.6	47.5			
D58. Plant & Soil Science & Tech,	27.9	32.3	39.8			
D59. Environmental Science & Technology	31.7	32.8	35.5			
D60. Food & Animal Science & Technology	24.5	34.0	41.5			
XVI. BIOLOGY				*27.9*	*32.6*	*39.5*
D61. Animal Sciences	33.7	27.3	39.0			
D62. Aquatic Sciences ,	25.7	32.9	41.4			
D63. Microbiology	28.2	37.3	34.5			
D64. Plant Sciences	22.4	32.7	44.9			
D65. **Pure and Applied Ecology**	35.4	30.0	34.6			
D66. **VETERINARY SCIENCES**	27.8	31.9	40.2			
XVII. MULTIDISCIPLINARY				*22.7*	*22.7*	*54.5*
D67 = 182. **MULTIDISCIPLINARY SCIENCES**	22.7	22.7	54.5			
XVIII. RESIDUAL SUB-FIELDS				*21.1*	*31.3*	*47.6*
D68. **MATERIALS SCIENCE, MULT.**	16.9	30.7	52.4			
D69. **CRYSTALLOGRAPHY**	12.9	34.1	53.0			
D70. **GEOSCIENCES, MULT.**	25.7	32.1	42.2			
D71. **MED., RES. & EXPERIMENTAL**	35.0	30.5	34.4			
XIX. SOCIAL SCIENCES, GENERAL				*54.0*	*24.7*	*21.3*
D72. Law & Criminology	73.3	15.6	11.1			
D73. Political Science & Public Administration	52.2	27.4	20.4			
D74. Sociology & Other Social Studies	56.3	21.2	22.5			
D75. Education	62.6	19.8	17.6			
D76. Geography, Planning & Urban	39.8	33.6	26.5			
D77. Ethics	52.8	23.0	24.2			
D78. Other Social Sciences	51.5	26.5	22.0			
XX. ECONOMICS & BUSINESS				*47.8*	*29.6*	*22.5*
D79. Economics	44.8	31.8	23.4			

D80. Business & Management	54.5	25.0	20.4			
ALL CATEGORIES	29.0	32.6	38.5	*29.0*	*32.5*	*38.5*

Table C. High- and Low-impact Normalized Indicators for Disciplines, Fields, and the All Sciences Case

	HIGH-IMPACT				LOW-IMPACT			
	U.S.	EU	RW	WORLD	U.S.	EU	RW	WORLD
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
I. BIOSCIENCES	1.976	1.101	0.944	1.340	0.331	0.401	0.506	0.413
D1. Multidisciplinary Biology	0.699	0.689	0.310	0.552	0.360	0.361	0.541	0.427
D2. Biochemistry, Biophysics, Mol. Biology	2.345	1.234	1.158	1.576	0.319	0.391	0.498	0.404
D3 = Cell Biology	1.488	0.705	0.556	0.942	0.343	0.435	0.525	0.429
D4. Genetics & Development Biology	1.379	0.776	0.574	0.928	0.345	0.405	0.484	0.408
II. BIOMEDICAL RESEARCH	1.537	0.699	0.604	0.917	0.340	0.394	0.475	0.407
D5. Anatomy & Pathology	1.045	0.572	0.322	0.624	0.364	0.433	0.517	0.442
D6. Biomaterials & Bioengineering	3.822	1.113	1.366	1.945	0.360	0.398	0.496	0.425
D7. Experimental & Laboratory Medicine	0.838	0.525	0.357	0.573	0.455	0.400	0.477	0.443
D8. Pharmacology & Toxicology	0.809	0.601	0.292	0.543	0.357	0.388	0.461	0.407
D9. Physiology	0.279	0.182	0.124	0.201	0.286	0.397	0.474	0.379
III. CLINICAL MEDICINE I (INTERNAI	2.548	1.283	1.042	1.613	0.361	0.459	0.508	0.443
D10. Cardiovascular & Respiratory Medicine	1.346	0.911	0.613	0.980	0.384	0.470	0.503	0.449
D11. Endocrinology & Metabolism	0.850	0.468	0.402	0.569	0.314	0.401	0.441	0.386
D12. General & Internal Medicine	7.665	3.566	2.595	4.388	0.398	0.502	0.562	0.493
D13. Hematology & Oncology	1.576	0.590	0.513	0.901	0.337	0.437	0.469	0.413
D14. Immunology	1.153	0.647	0.622	0.811	0.350	0.441	0.485	0.423
IV. CLIN. MED. II (NON-INTERNAL)	0.964	0.518	0.382	0.629	0.373	0.460	0.487	0.438
D15. Age & Gender Related Medicine	0.516	0.384	0.266	0.394	0.378	0.433	0.447	0.418
D16. Dentistry, Oral Surgery	0.601	0.363	0.337	0.424	0.402	0.373	0.396	0.390
D17. Dermatology & Urogenital System	0.927	0.533	0.391	0.612	0.377	0.466	0.491	0.446
D18. Ophthalmology & Otorhinolaryngology	0.894	0.377	0.337	0.554	0.358	0.466	0.470	0.428
D19. Integrative & Complementary Medicine	0.236	0.518	0.221	0.302	0.427	0.462	0.369	0.406
D20. Psychiatry & Neurology	1.082	0.561	0.415	0.699	0.366	0.452	0.508	0.438
D21. Radiology, Nuclear Med. & Imaging	1.059	0.669	0.317	0.701	0.386	0.446	0.508	0.443
D22. Rheumatology & Orthopedics	0.710	0.426	0.407	0.531	0.401	0.455	0.438	0.430
D23. Surgery	0.972	0.587	0.409	0.660	0.366	0.471	0.512	0.449
D24. Pediatrics	1.476	0.428	0.364	0.781	0.383	0.491	0.499	0.455
V. CL. MED. III (HEALTH & OTHER SC	0.631	0.451	0.308	0.500	0.425	0.422	0.472	0.436
D25. Health Sciences	0.610	0.409	0.295	0.474	0.411	0.414	0.464	0.425

D26. Other Clinical Medicine	1.136	1.313	0.723	1.094	0.477	0.432	0.492	0.468
VI. NEUROSCIENCE & BEHAVIOR	0.886	0.448	0.305	0.595	0.367	0.425	0.484	0.416
D27. Neurosciences & Psychopharmacology	0.922	0.457	0.298	0.571	0.319	0.407	0.483	0.400
D28. Psychology & Behavioral Sciences	0.862	0.455	0.330	0.632	0.402	0.441	0.475	0.429
VII. CHEMISTRY	1.308	0.554	0.329	0.580	0.331	0.377	0.515	0.438
D29. Chemistry, Multidisciplinary	2.970	1.027	0.425	1.029	0.280	0.401	0.611	0.501
D30. Analytical, Inorganic & Nuclear Chemistr	0.951	0.372	0.364	0.472	0.345	0.375	0.488	0.421
D31. Applied Chemistry & Chemical Engineeri	0.748	0.654	0.293	0.493	0.429	0.405	0.513	0.463
D32. Organic & Medicinal Chemistry ,	0.922	0.357	0.232	0.416	0.294	0.348	0.453	0.385
D33. Physical Chemistry	1.187	0.509	0.287	0.522	0.317	0.373	0.478	0.414
D34. Polymer Science	1.662	0.780	0.441	0.733	0.340	0.390	0.472	0.428
VIII. PHYSICS	2.482	1.223	0.716	1.253	0.372	0.422	0.524	0.459
D35. Multidisciplinary Physics	5.653	1.998	1.043	2.198	0.361	0.450	0.584	0.500
D36. Applied Physics	1.659	0.849	0.522	0.872	0.398	0.424	0.523	0.466
D37. Physics, Atomic, Molecular & Chemical	0.752	0.393	0.286	0.436	0.312	0.367	0.440	0.383
D38. Thermodynamics (Classical Physics)	0.915	0.664	0.356	0.575	0.348	0.398	0.451	0.412
D39. Physics, Mathematical	1.342	0.897	0.480	0.811	0.384	0.404	0.497	0.440
D40. Particle & Nuclear Physics	5.073	2.578	2.062	2.906	0.413	0.458	0.517	0.473
D41. Physics of Solids, Fluids & Plasmas	1.300	0.902	0.413	0.748	0.391	0.424	0.518	0.462
IX. SPACE SCIENCES	1.571	1.107	0.661	1.103	0.348	0.437	0.516	0.435
D42. Astronomy & Astrophysics ,	1.571	1.107	0.661	1.103	0.348	0.437	0.516	0.435
X. MATHEMATICS	6.322	2.141	2.683	3.451	0.433	0.459	0.549	0.488
D43. Applied Mathematics	8.923	2.868	4.078	4.998	0.436	0.457	0.537	0.482
D44. Pure Mathematics	1.330	0.940	0.526	0.849	0.434	0.457	0.557	0.496
XI. COMPUTER SCIENCE	6.910	2.833	3.629	4.373	0.474	0.509	0.567	0.519
D45. Computer Science & Information Tech.	6.910	2.833	3.629	4.373	0.474	0.509	0.567	0.519
XII. ENGINEERING	1.493	0.787	0.493	0.853	0.455	0.458	0.539	0.493
D46. Electrical & Electronic Engineering	2.486	1.105	0.737	1.355	0.436	0.467	0.549	0.493
D47. Civil Engineering	0.875	0.604	0.422	0.624	0.505	0.464	0.497	0.491
D48. Mechanical Engineering	1.069	0.484	0.300	0.560	0.418	0.445	0.522	0.472
D49. Instruments & Instrumentation	1.174	0.814	0.558	0.790	0.450	0.419	0.537	0.477
D50. Fuel & Energy	1.300	0.983	0.558	0.847	0.481	0.444	0.521	0.488
D51. Other Engineering	1.082	0.678	0.411	0.684	0.469	0.465	0.557	0.504

XIII. MATERIALS SCIENCE	1.605	0.672	0.586	0.795	0.411	0.448	0.528	0.483
D52. Materials Science	1.605	0.672	0.586	0.795	0.411	0.448	0.528	0.483
XIV. GEOSCIENCES	0.916	0.634	0.324	0.602	0.366	0.405	0.510	0.433
D53. Geosciences & Technology	0.988	0.676	0.304	0.616	0.350	0.404	0.489	0.422
D54. Hydrology & Oceanography	0.726	0.350	0.250	0.425	0.348	0.353	0.501	0.408
D55 Meteo., Atmosph., Aero., Sc. & Tech.	0.928	0.672	0.334	0.660	0.381	0.450	0.538	0.452
D56. Mineralogy & Petrology	1.167	0.820	0.532	0.745	0.413	0.376	0.542	0.465
XV. AGRICULT. & ENVIRONMENT	0.834	0.606	0.326	0.555	0.381	0.395	0.501	0.434
D57. Agricultural Science & Technology	0.827	0.703	0.347	0.562	0.404	0.374	0.542	0.461
D58. Plant & Soil Science & Tech,	0.418	0.315	0.183	0.291	0.385	0.362	0.474	0.413
D59. Environmental Science & Technology	0.860	0.622	0.377	0.611	0.387	0.408	0.463	0.421
D60. Food & Animal Science & Technology	0.796	0.528	0.263	0.484	0.371	0.402	0.519	0.443
XVI. BIOLOGY (ORGANISMIC AND SUPRAORG. LEVE	0.786	0.493	0.305	0.501	0.365	0.385	0.481	0.417
D61. Animal Sciences	0.745	0.373	0.203	0.432	0.393	0.406	0.483	0.432
D62. Aquatic Sciences ,	0.319	0.288	0.234	0.274	0.376	0.381	0.436	0.403
D63. Microbiology	0.645	0.350	0.220	0.388	0.308	0.355	0.464	0.379
D64. Plant Sciences	1.433	0.737	0.463	0.770	0.371	0.378	0.490	0.427
D65. Pure and Applied Ecology	0.514	0.351	0.243	0.371	0.378	0.329	0.434	0.383
D66. Veterinary Sciences	0.895	0.780	0.390	0.655	0.416	0.466	0.554	0.487
XVII. MULTIDISCIPLINARY	5.633	2.543	0.829	2.310	0.408	0.445	0.616	0.530
D67. Multidisciplinary Sciences	5.633	2.543	0.829	2.310	0.408	0.445	0.616	0.530
XVIII. RESIDUAL SUB-FIELDS	6.379	5.548	2.257	4.158	0.395	0.443	0.528	0.473
D68. MATERIALS SCIENCE, MULT.	3.279	1.184	0.775	1.322	0.394	0.435	0.519	0.472
D69. CRYSTALLOGRAPHY	64.796	41.791	14.397	30.253	0.402	0.457	0.504	0.475
D70. GEOSCIENCES, MULT.	0.796	0.481	0.290	0.481	0.385	0.406	0.522	0.449
D71. MED., RES. & EXPERIMENTAL	4.156	2.446	1.670	2.778	0.388	0.486	0.591	0.488
XIX. SOCIAL SCIENCES, GENERAL	0.963	0.536	0.356	0.728	0.471	0.505	0.565	0.499
D72. Law & Criminology	0.897	0.250	0.766	0.782	0.450	0.611	0.530	0.484
D73. Political Science & Public Administration	1.268	0.546	0.392	0.892	0.499	0.558	0.628	0.541
D74. Sociology & Other Social Studies	1.208	0.537	0.272	0.855	0.441	0.486	0.605	0.488
D75. Education	0.868	0.402	0.313	0.678	0.498	0.474	0.548	0.502
D76. Geography, Planning & Urban	0.570	0.672	0.292	0.531	0.462	0.443	0.515	0.470
D77. Ethics	0.465	0.212	0.245	0.354	0.463	0.500	0.572	0.498
D78. Other Social Sciences	0.979	0.643	0.474	0.779	0.490	0.528	0.539	0.511

XX. ECONOMICS & BUSINESS	1.589	0.788	0.555	1.118	0.426	0.493	0.541	0.472
D79. Economics	1.819	0.935	0.658	1.267	0.419	0.486	0.547	0.470
D80. Business & Management	1.048	0.410	0.378	0.751	0.450	0.511	0.535	0.482
ALL SCIENCES	1.713	1.106	0.650	1.093	0.380	0.433	0.521	0.452

Table D. High- and Low-impact Un-normalized Indicators for Disciplines, Fields, and the All Sciences Case

	HIGH-IMPACT				**LOW-IMPACT**			
	U.S.	**EU**	**RW**	**WORLD**	**U.S.**	**EU**	**RW**	**WORLD**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
I. BIOSCIENCES	**1.956**	**1.057**	**0.783**	**1.264**	**0.330**	**0.406**	**0.511**	**0.416**
D1. Multidisciplinary Biology	0.682	0.553	0.270	0.489	0.371	0.374	0.558	0.441
D2. Biochemistry, Biophysics, Mol. Biology	2.033	1.072	0.822	1.305	0.319	0.399	0.503	0.408
D3 = Cell Biology	1.488	0.705	0.556	0.942	0.343	0.435	0.525	0.429
D4. Genetics & Development Biology	1.306	0.723	0.535	0.872	0.349	0.411	0.489	0.413
II. BIOMEDICAL RESEARCH	**1.716**	**0.737**	**0.667**	**1.006**	**0.340**	**0.397**	**0.476**	**0.409**
D5. Anatomy & Pathology	1.363	0.723	0.420	0.806	0.350	0.426	0.508	0.432
D6. Biomaterials & Bioengineering	4.364	1.257	1.552	2.213	0.363	0.400	0.493	0.426
D7. Experimental & Laboratory Medicine	0.834	0.519	0.354	0.569	0.455	0.401	0.478	0.444
D8. Pharmacology & Toxicology	0.864	0.653	0.314	0.584	0.354	0.383	0.454	0.402
D9. Physiology	0.279	0.182	0.124	0.201	0.286	0.397	0.474	0.379
III. CLINICAL MEDICINE I (INTERNAI	**3.431**	**1.692**	**1.388**	**2.154**	**0.357**	**0.456**	**0.506**	**0.440**
D10. Cardiovascular & Respiratory Medicine	1.337	0.898	0.600	0.969	0.390	0.476	0.510	0.455
D11. Endocrinology & Metabolism	0.850	0.468	0.402	0.569	0.314	0.401	0.441	0.386
D12. General & Internal Medicine	15.884	7.310	5.304	9.038	0.388	0.491	0.555	0.484
D13. Hematology & Oncology	1.611	0.667	0.539	0.948	0.333	0.432	0.467	0.409
D14. Immunology	1.303	0.701	0.699	0.904	0.349	0.445	0.484	0.424
IV. CLIN. MED. II (NON-INTERNAL)	**1.397**	**0.848**	**0.630**	**0.970**	**0.375**	**0.458**	**0.489**	**0.439**
D15. Age & Gender Related Medicine	0.445	0.337	0.249	0.348	0.392	0.443	0.456	0.430
D16. Dentistry, Oral Surgery	0.601	0.363	0.337	0.424	0.402	0.373	0.396	0.390
D17. Dermatology & Urogenital System	1.063	0.591	0.418	0.685	0.378	0.477	0.497	0.453
D18. Ophthalmology & Otorhinolaryngology	1.184	0.501	0.472	0.742	0.358	0.468	0.465	0.427
D19. Integrative & Complementary Medicine	0.236	0.518	0.221	0.302	0.427	0.462	0.369	0.406
D20. Psychiatry & Neurology	1.111	0.570	0.423	0.715	0.364	0.450	0.506	0.436
D21. Radiology, Nuclear Med. & Imaging	1.059	0.669	0.317	0.701	0.386	0.446	0.508	0.443
D22. Rheumatology & Orthopedics	0.830	0.761	0.618	0.750	0.426	0.456	0.445	0.441
D23. Surgery	1.716	1.161	0.872	1.255	0.372	0.473	0.522	0.455
D24. Pediatrics	1.476	0.428	0.364	0.781	0.383	0.491	0.499	0.455
V. CL. MED. III (HEALTH & OTHER SC	**0.767**	**0.533**	**0.385**	**0.606**	**0.436**	**0.423**	**0.464**	**0.440**
D25. Health Sciences	0.830	0.570	0.412	0.651	0.410	0.405	0.447	0.418

D26. Other Clinical Medicine	1.162	1.665	0.661	1.191	0.491	0.423	0.492	0.472
VI. NEUROSCIENCE & BEHAVIOR	**0.990**	**0.628**	**0.437**	**0.730**	**0.398**	**0.423**	**0.479**	**0.428**
D27. Neurosciences & Psychopharmacology	0.901	0.432	0.291	0.553	0.322	0.411	0.486	0.403
D28. Psychology & Behavioral Sciences	0.683	0.449	0.313	0.536	0.413	0.443	0.481	0.437
VII. CHEMISTRY	**1.638**	**0.618**	**0.375**	**0.685**	**0.332**	**0.378**	**0.514**	**0.438**
D29. Chemistry, Multidisciplinary	2.970	1.027	0.425	1.029	0.280	0.401	0.611	0.501
D30. Analytical, Inorganic & Nuclear Chemistr	1.114	0.427	0.418	0.547	0.335	0.365	0.478	0.411
D31. Applied Chemistry & Chemical Engineeri	0.637	0.581	0.252	0.428	0.439	0.414	0.524	0.473
D32. Organic & Medicinal Chemistry ,	0.886	0.344	0.224	0.401	0.298	0.351	0.457	0.389
D33. Physical Chemistry	1.180	0.506	0.284	0.518	0.318	0.374	0.479	0.415
D34. Polymer Science	1.662	0.780	0.441	0.733	0.340	0.390	0.472	0.428
VIII. PHYSICS	**4.076**	**1.944**	**1.171**	**2.035**	**0.375**	**0.422**	**0.524**	**0.460**
D35. Multidisciplinary Physics	7.619	2.670	1.431	2.967	0.363	0.449	0.575	0.496
D36. Applied Physics	2.123	1.078	0.685	1.122	0.383	0.407	0.504	0.449
D37. Physics, Atomic, Molecular & Chemical	0.752	0.393	0.286	0.436	0.312	0.367	0.440	0.383
D38. Thermodynamics (Classical Physics)	0.915	0.664	0.356	0.575	0.348	0.398	0.451	0.412
D39. Physics, Mathematical	1.342	0.897	0.480	0.811	0.384	0.404	0.497	0.440
D40. Particle & Nuclear Physics	7.454	3.702	2.941	4.201	0.410	0.459	0.523	0.475
D41. Physics of Solids, Fluids & Plasmas	1.438	0.973	0.445	0.813	0.376	0.414	0.509	0.451
IX. SPACE SCIENCES	**1.571**	**1.107**	**0.661**	**1.103**	**0.348**	**0.437**	**0.516**	**0.435**
D42. Astronomy & Astrophysics ,	1.571	1.107	0.661	1.103	0.348	0.437	0.516	0.435
X. MATHEMATICS	**17.354**	**5.161**	**7.317**	**9.216**	**0.419**	**0.451**	**0.545**	**0.480**
D43. Applied Mathematics	15.894	4.785	7.290	8.804	0.432	0.460	0.544	0.485
D44. Pure Mathematics	1.330	0.940	0.526	0.849	0.434	0.457	0.557	0.496
XI. COMPUTER SCIENCE	**12.517**	**4.681**	**6.925**	**7.890**	**0.476**	**0.517**	**0.571**	**0.523**
D45. Computer Science & Information Tech.	12.517	4.681	6.925	7.890	0.476	0.517	0.571	0.523
XII. ENGINEERING	**2.099**	**1.121**	**0.679**	**1.197**	**0.443**	**0.443**	**0.528**	**0.480**
D46. Electrical & Electronic Engineering	2.538	1.169	0.780	1.407	0.433	0.463	0.546	0.490
D47. Civil Engineering	2.045	1.267	0.769	1.334	0.501	0.452	0.501	0.487
D48. Mechanical Engineering	1.071	0.527	0.287	0.567	0.428	0.449	0.530	0.479
D49. Instruments & Instrumentation	1.520	0.948	0.643	0.954	0.440	0.412	0.531	0.469
D50. Fuel & Energy	1.555	1.200	0.683	1.028	0.470	0.427	0.505	0.473
D51. Other Engineering	0.962	0.624	0.374	0.618	0.475	0.471	0.564	0.510

XIII. MATERIALS SCIENCE	**1.736**	**0.633**	**0.485**	**0.755**	**0.422**	**0.460**	**0.550**	**0.501**
D52. Materials Science	1.736	0.633	0.485	0.755	0.422	0.460	0.550	0.501
XIV. GEOSCIENCES	**1.162**	**0.802**	**0.352**	**0.741**	**0.375**	**0.404**	**0.521**	**0.439**
D53. Geosciences & Technology	1.260	0.861	0.331	0.763	0.347	0.400	0.495	0.423
D54. Hydrology & Oceanography	0.489	0.250	0.183	0.296	0.372	0.371	0.522	0.429
D55 Meteo., Atmosph., Aero., Sc. & Tech.	1.230	1.017	0.486	0.925	0.409	0.450	0.551	0.467
D56. Mineralogy & Petrology	1.128	0.706	0.470	0.671	0.414	0.357	0.543	0.460
XV. AGRICULT. & ENVIRONMENT	**0.943**	**0.562**	**0.298**	**0.560**	**0.398**	**0.413**	**0.525**	**0.454**
D57. Agricultural Science & Technology	0.868	0.756	0.357	0.592	0.412	0.373	0.543	0.463
D58. Plant & Soil Science & Tech.	0.493	0.306	0.207	0.319	0.377	0.369	0.480	0.416
D59. Environmental Science & Technology	1.029	0.714	0.462	0.724	0.385	0.404	0.453	0.415
D60. Food & Animal Science & Technology	1.112	0.546	0.265	0.568	0.380	0.415	0.541	0.459
XVI. BIOLOGY (ORGANISMIC AND SUPRAORG. LEVE	**1.030**	**0.628**	**0.345**	**0.628**	**0.382**	**0.395**	**0.502**	**0.434**
D61. Animal Sciences	0.752	0.399	0.203	0.442	0.399	0.407	0.485	0.435
D62. Aquatic Sciences	0.360	0.330	0.251	0.305	0.369	0.370	0.430	0.395
D63. Microbiology	0.767	0.397	0.250	0.450	0.298	0.356	0.477	0.381
D64. Plant Sciences	1.590	0.843	0.513	0.862	0.369	0.373	0.481	0.421
D65. Pure and Applied Ecology	0.514	0.351	0.243	0.371	0.378	0.329	0.434	0.383
D66. Veterinary Sciences	0.895	0.780	0.390	0.655	0.416	0.466	0.554	0.487
XVII. MULTIDISCIPLINARY	**5.633**	**2.543**	**0.829**	**2.310**	**0.408**	**0.445**	**0.616**	**0.530**
D67. Multidisciplinary Sciences	5.633	2.543	0.829	2.310	0.408	0.445	0.616	0.530
XVIII. RESIDUAL SUB-FIELDS	**10.724**	**5.829**	**2.617**	**5.335**	**0.360**	**0.431**	**0.527**	**0.462**
D68. MATERIALS SCIENCE, MULT.	3.279	1.184	0.775	1.322	0.394	0.435	0.519	0.472
D69. CRYSTALLOGRAPHY	64.796	41.791	14.397	30.253	0.402	0.457	0.504	0.475
D70. GEOSCIENCES, MULT.	0.796	0.481	0.290	0.481	0.385	0.406	0.522	0.449
D71. MED., RES. & EXPERIMENTAL	4.156	2.446	1.670	2.778	0.388	0.486	0.591	0.488
XIX. SOCIAL SCIENCES, GENERAL	**0.852**	**0.538**	**0.320**	**0.661**	**0.482**	**0.515**	**0.577**	**0.510**
D72. Law & Criminology	0.927	0.268	0.834	0.814	0.448	0.606	0.524	0.481
D73. Political Science & Public Administration	1.271	0.549	0.393	0.894	0.498	0.558	0.628	0.541
D74. Sociology & Other Social Studies	1.015	0.371	0.208	0.697	0.457	0.507	0.620	0.504
D75. Education	1.020	0.542	0.386	0.814	0.481	0.464	0.538	0.488
D76. Geography, Planning & Urban	0.644	0.933	0.313	0.653	0.476	0.432	0.525	0.474
D77. Ethics	0.622	0.367	0.344	0.496	0.456	0.466	0.553	0.482
D78. Other Social Sciences	0.910	0.575	0.408	0.711	0.498	0.542	0.546	0.520

XX. ECONOMICS & BUSINESS	**1.336**	**0.584**	**0.437**	**0.910**	**0.442**	**0.515**	**0.561**	**0.490**
D79. Economics	1.787	0.918	0.646	1.244	0.423	0.488	0.551	0.473
D80. Business & Management	1.048	0.394	0.374	0.747	0.450	0.515	0.538	0.484
ALL SCIENCES	2.994	1.593	0.953	1.752	0.404	0.452	0.551	0.476

Table E. The U.S./EU Gap Disciplines, Fields, and the All Sciences Case, Measured With Normalized and Un-normalized High- and Low-impact Indicators, As Well As the Mean Normalized Citation Score

	HIGH-IMPACT			LOW-IMPACT			MNCS	
	Norm. (1)	Un-norm. (2)	(3) = (1) – (2) In %	Norm. (4)	Un-norm. (5)	(6) = (4) – (5) In %	(7)	(8) = (1) – (7) In %
I. BIOSCIENCES	**1.794**	**1.850**	**-3.038**	**0.824**	**0.814**	**1.302**	**1.281**	**40.004**
D1. Multidisciplinary Biology	1.015	1.234	-17.703	0.997	0.992	0.450	1.010	0.483
D2. Biochemistry, Biophysics, Mol. Biology	1.900	1.897	0.145	0.814	0.799	1.992	1.295	46.664
D3. Cell Biology	2.110	2.110	0.000	0.787	0.787	0.000	1.405	50.122
D4. Genetics & Development Biology	1.777	1.807	-1.608	0.851	0.850	0.062	1.275	39.440
II. BIOMEDICAL RESEARCH	**2.200**	**2.327**	**-5.469**	**0.863**	**0.856**	**0.768**	**1.223**	**79.792**
D5. Anatomy & Pathology	1.827	1.885	-3.078	0.841	0.822	2.379	1.268	44.067
D6. Biomaterials & Bioengineering	3.434	3.471	-1.077	0.905	0.908	-0.411	1.305	163.206
D7. Experimental & Laboratory Medicine	1.596	1.607	-0.670	1.136	1.135	0.128	0.943	69.211
D8 .Pharmacology & Toxicology	1.346	1.323	1.725	0.919	0.924	-0.597	1.145	17.596
D9. Physiology	1.532	1.532	0.000	0.722	0.722	0.000	1.307	17.146
III. CLINICAL MEDICINE I (INTERNAL)	**1.985**	**2.028**	**-2.108**	**0.786**	**0.784**	**0.281**	**1.367**	**45.278**
D10. Cardiovascular & Respiratory Medicine	1.478	1.489	-0.772	0.817	0.820	-0.312	1.279	15.512
D11. Endocrinology & Metabolism	1.817	1.817	0.000	0.782	0.782	0.000	1.304	39.332
D12. General & Internal Medicine	2.150	2.173	-1.069	0.793	0.789	0.480	1.434	49.931
D13. Hematology & Oncology	2.669	2.418	10.397	0.770	0.771	-0.149	1.397	91.079
D14. Immunology	1.782	1.858	-4.094	0.794	0.784	1.222	1.336	33.380
IV. CLIN. MED. II (NON-INTERNAL)	**1.863**	**1.646**	**13.149**	**0.811**	**0.819**	**-0.967**	**1.328**	**40.231**
D15. Age & Gender Related Medicine	1.343	1.322	1.599	0.871	0.885	-1.512	1.166	15.177
D16. Dentistry, Oral Surgery	1.657	1.657	0.000	1.076	1.076	0.000	1.033	60.308
D17. Dermatology & Urogenital System	1.741	1.797	-3.114	0.808	0.793	1.821	1.343	29.687
D18. Ophthalmology & Otorhinolaryngology	2.371	2.363	0.363	0.767	0.765	0.281	1.443	64.339
D19. Integrative & Complementary Medicine	0.456	0.456	0.000	0.924	0.924	0.000	1.045	-56.334
D20. Psychiatry & Neurology	1.929	1.947	-0.933	0.812	0.810	0.208	1.310	47.259
D21. Radiology, Nuclear Med. & Imaging	1.583	1.583	0.000	0.866	0.866	0.000	1.253	26.379
D22. Rheumatology & Orthopedics	1.666	1.091	52.714	0.881	0.934	-5.741	1.240	34.341
D23. Surgery	1.655	1.478	11.941	0.778	0.786	-0.969	1.352	22.389
D24. Pediatrics	3.445	3.445	0.000	0.780	0.780	0.000	1.532	124.885
V. CL. MED. III (HEALTH & OTHER SCS.)	**1.401**	**1.440**	**-2.706**	**1.005**	**1.031**	**-2.538**	**1.093**	**28.236**

D25. Health Sciences	1.489	1.456	2.277	0.993	1.013	-1.912	1.105	34.706
D26. Other Clinical Medicine	0.866	0.698	24.007	1.102	1.161	-5.044	0.964	-10.217
VI. NEUROSCIENCE & BEHAVIOR	**1.975**	**1.576**	**25.305**	**0.862**	**0.940**	**-8.236**	**1.251**	**57.914**
D27. Neurosciences & Psychopharmacology	2.016	2.084	-3.256	0.784	0.785	-0.117	1.339	50.574
D28. Psychology & Behavioral Sciences	1.895	1.523	24.419	0.913	0.932	-2.096	1.169	62.140
VII. CHEMISTRY	**2.363**	**2.649**	**-10.781**	**0.877**	**0.878**	**-0.112**	**1.307**	**80.795**
D29. Chemistry, Multidisciplinary	2.892	2.892	0.000	0.699	0.699	0.000	1.574	83.749
D30. Analytical, Inorganic & Nuclear Chemistry	2.553	2.606	-2.017	0.920	0.917	0.329	1.269	101.165
D31. Applied Chemistry & Chemical Engineering	1.143	1.097	4.225	1.060	1.061	-0.089	0.997	14.599
D32. Organic & Medicinal Chemistry ,	2.581	2.575	0.232	0.846	0.850	-0.382	1.277	102.168
D33. Physical Chemistry	2.331	2.332	-0.074	0.849	0.850	-0.028	1.318	76.776
D34. Polymer Science	2.131	2.131	0.000	0.873	0.873	0.000	1.317	61.778
VIII. PHYSICS	**2.029**	**2.097**	**-3.208**	**0.882**	**0.890**	**-0.847**	**1.268**	**60.092**
D35. Multidisciplinary Physics	2.830	2.853	-0.837	0.803	0.808	-0.672	1.443	96.141
D36. Applied Physics	1.955	1.969	-0.713	0.939	0.943	-0.356	1.219	60.394
D37. Physics, Atomic, Molecular & Chemical	1.914	1.914	0.000	0.852	0.852	0.000	1.216	57.391
D38. Thermodynamics (Classical Physics)	1.378	1.378	0.000	0.872	0.872	0.000	1.207	14.090
D39. Physics, Mathematical	1.496	1.496	0.000	0.951	0.951	0.000	1.137	31.618
D40. Particle & Nuclear Physics	1.968	2.014	-2.268	0.902	0.893	0.908	1.302	51.171
D41. Physics of Solids, Fluids & Plasmas	1.442	1.478	-2.489	0.923	0.908	1.582	1.196	20.498
IX. SPACE SCIENCES	**1.418**	**1.418**	**0.000**	**0.797**	**0.797**	**0.000**	**1.285**	**10.414**
D42. Astronomy & Astrophysics ,	1.418	1.418	0.000	0.797	0.797	0.000	1.285	10.414
X. MATHEMATICS	**2.953**	**3.362**	**-12.161**	**0.944**	**0.929**	**1.661**	**1.181**	**150.132**
D43. Applied Mathematics	3.112	3.322	-6.328	0.954	0.939	1.569	1.194	160.636
D44. Pure Mathematics	1.415	1.415	0.000	0.950	0.950	0.000	1.125	25.709
XI. COMPUTER SCIENCE	**2.439**	**2.674**	**-8.780**	**0.931**	**0.919**	**1.222**	**1.255**	**94.362**
D45. Computer Science & Information Tech.	2.439	2.674	-8.780	0.931	0.919	1.222	1.255	94.362
XII. ENGINEERING	**1.897**	**1.872**	**1.346**	**0.992**	**1.000**	**-0.860**	**1.163**	**63.149**
D46. Electrical & Electronic Engineering	2.250	2.171	3.664	0.933	0.934	-0.100	1.307	72.181
D47. Civil Engineering	1.449	1.614	-10.195	1.090	1.110	-1.770	1.005	44.175
D48. Mechanical Engineering	2.208	2.030	8.796	0.939	0.954	-1.599	1.206	83.117
D49. Instruments & Instrumentation	1.442	1.604	-10.080	1.072	1.069	0.325	1.041	38.507
D50. Fuel & Energy	1.322	1.296	1.989	1.083	1.099	-1.538	1.009	31.054
D51. Other Engineering	1.597	1.540	3.661	1.009	1.009	0.034	1.106	44.400

XIII. MATERIALS SCIENCE	**2.389**	**2.742**	**-12.893**	**0.917**	**0.918**	**-0.062**	**1.258**	**89.813**
D52. Materials Science	2.389	2.742	-12.893	0.917	0.918	-0.062	1.258	89.813
XIV. GEOSCIENCES	**1.444**	**1.449**	**-0.375**	**0.903**	**0.928**	**-2.659**	**1.187**	**21.652**
D53. Geosciences & Technology	1.463	1.463	-0.007	0.868	0.868	0.029	1.199	22.025
D54. Hydrology & Oceanography	2.072	1.952	6.129	0.984	1.004	-2.001	1.165	77.890
D55. Meteo., Atmosph., Aero., Sc. & Tech.	1.380	1.210	14.075	0.847	0.909	-6.880	1.254	10.117
D56. Mineralogy & Petrology	1.423	1.597	-10.901	1.098	1.161	-5.375	1.041	36.659
XV. AGRICULT. & ENVIRONMENT	**1.376**	**1.677**	**-17.957**	**0.966**	**0.964**	**0.227**	**1.086**	**26.710**
D57. Agricultural Science & Technology	1.177	1.148	2.496	1.081	1.104	-2.087	0.972	21.006
D58. Plant & Soil Science & Tech,	1.329	1.610	-17.414	1.063	1.021	4.124	1.007	31.965
D59. Environmental Science & Technology	1.383	1.441	-4.014	0.947	0.953	-0.648	1.132	22.137
D60. Food & Animal Science & Technology	1.508	2.037	-25.955	0.922	0.916	0.682	1.118	34.906
XVI. BIOLOGY (ORGANISMIC AND SUPRAORG. LEVEL)	**1.596**	**1.639**	**-2.606**	**0.946**	**0.968**	**-2.193**	**1.118**	**42.703**
D61. Animal Sciences	1.998	1.883	6.110	0.969	0.981	-1.196	1.063	87.938
D62. Aquatic Sciences ,	1.108	1.090	1.621	0.987	0.996	-0.921	1.042	6.365
D63. Microbiology	1.847	1.935	-4.553	0.866	0.838	3.393	1.195	54.487
D64. Plant Sciences	1.945	1.887	3.047	0.981	0.987	-0.698	1.144	70.078
D65. Pure and Applied Ecology	1.465	1.465	0.000	1.151	1.151	0.000	0.982	49.117
D66. Veterinary Sciences	1.147	1.147	0.000	0.892	0.892	0.000	1.122	2.233
XVII. MULTIDISCIPLINARY	**2.215**	**2.215**	**0.000**	**0.917**	**0.917**	**0.000**	**1.352**	**63.836**
D67. Multidisciplinary Sciences	2.215	2.215	0.000	0.917	0.917	0.000	1.352	63.836
XVIII. RESIDUAL SUB-FIELDS	**1.150**	**1.840**	**-37.502**	**0.893**	**0.834**	**6.993**	**1.316**	**-12.617**
D68. Materials Science, Mult.	2.769	2.769	0.000	0.904	0.904	0.000	1.367	102.513
D69. Crystallography	1.550	1.550	0.000	0.879	0.879	0.000	1.317	17.709
D70. Geosciences, Mult.	1.655	1.655	0.000	0.948	0.948	0.000	1.139	45.302
D71. Med., Res. & Experimental	1.699	1.699	0.000	0.798	0.798	0.000	1.485	14.436
XIX. SOCIAL SCIENCES, GENERAL	**1.797**	**1.583**	**13.518**	**0.932**	**0.935**	**-0.328**	**1.171**	**53.462**
D72. Law & Criminology	3.581	3.456	3.622	0.736	0.739	-0.389	1.907	87.830
D73. Political Science & Public Administration	2.322	2.314	0.344	0.894	0.894	-0.008	1.303	78.156
D74. Sociology & Other Social Studies	2.247	2.736	-17.866	0.909	0.901	0.839	1.213	85.255
D75. Education	2.158	1.881	14.711	1.051	1.038	1.315	1.005	114.857
D76. Geography, Planning & Urban	0.849	0.690	22.969	1.042	1.102	-5.452	0.943	-9.942
D77. Ethics	2.195	1.694	29.544	0.925	0.978	-5.389	1.184	85.463

D78. Other Social Sciences	1.522	1.581	-3.749	0.928	0.920	0.862	1.184	28.556
XX. ECONOMICS & BUSINESS	**2.017**	**2.286**	**-11.750**	**0.864**	**0.858**	**0.715**	**1.392**	**44.913**
D79. Economics	1.945	1.945	-0.001	0.863	0.867	-0.470	1.374	41.590
D80. Business & Management	2.556	2.660	-3.899	0.881	0.873	0.847	1.417	80.455
ALL SCIENCES	1.609	1.879	- 14.4	0.878	0.893	- 1.8	1.248	28.9

Table F. The US/EU High-impact Gap for Disciplines, Measured According to the Multiplicative and the Fractional Approach When the CCL Equal to the 80th percentile, As Well As According to the Multiplicative Approach When the CCL Equal to the 95th percentile

	Mult., 80th (1)	Frac., 80th (2)	(3) = (1) – (2) In %	Mult., 95th (4)	(5) = (1) – (4) In %
I. BIOSCIENCES					
D1. Multidisciplinary Biology	1.015	1.016	0.0	1.882	-46.1
D2. Biochemistry, Biophysics, Mol. Biology	1.900	1.656	14.7	2.292	-17.1
D3. Cell Biology	2.110	2.064	2.2	3.340	-36.8
D4. Genetics & Development Biology	1.777	1.604	10.8	1.899	-6.4
II. BIOMEDICAL RESEARCH					
D5. Anatomy & Pathology	1.827	1.875	-2.6	1.396	30.9
D6. Biomaterials & Bioengineering	3.434	3.783	-9.2	2.289	50.0
D7. Experimental & Laboratory Medicine	1.596	1.865	-14.4	1.721	-7.2
D8 .Pharmacology & Toxicology	1.346	1.377	-2.3	2.744	-50.9
D9. Physiology	1.532	1.335	14.7	0.224	582.4
III. CLINICAL MEDICINE I (INTERNAL)					
D10. Cardiovascular & Respiratory Medicine	1.478	1.564	-5.6	2.265	-34.8
D11. Endocrinology & Metabolism	1.817	1.781	2.0	1.626	11.7
D12. General & Internal Medicine	2.150	2.285	-5.9	1.715	25.3
D13. Hematology & Oncology	2.669	2.875	-7.2	1.656	61.2
D14. Immunology	1.782	1.728	3.2	4.624	-61.5
IV. CLIN. MED. II (NON-INTERNAL)					
D15. Age & Gender Related Medicine	1.343	1.410	-4.7	1.569	-14.4
D16. Dentistry, Oral Surgery	1.657	1.638	1.2	0.721	129.7
D17. Dermatology & Urogenital System	1.741	1.744	-0.2	2.206	-21.1
D18. Ophthalmology & Otorhinolaryngology	2.371	2.631	-9.9	2.468	-3.9
D19. Integrative & Complementary Medicine	0.456	0.496	-7.9	3.919	-88.4
D20. Psychiatry & Neurology	1.929	2.265	-14.8	3.112	-38.0
D21. Radiology, Nuclear Med. & Imaging	1.583	1.640	-3.4	1.194	32.6
D22. Rheumatology & Orthopedics	1.666	1.694	-1.6	3.405	-51.1
D23. Surgery	1.655	1.747	-5.3	2.634	-37.2
D24. Pediatrics	3.445	3.656	-5.8	2.415	42.7
V. CL. MED. III (HEALTH & OTHER SCS.)					

D25. Health Sciences	1.489	1.655	-10.0	3.350	-55.5
D26. Other Clinical Medicine	0.866	0.978	-11.5	2.210	-60.8
VI. NEUROSCIENCE & BEHAVIOR					
D27. Neurosciences & Psychopharmacology	2.016	2.153	-6.3	2.310	-12.7
D28. Psychology & Behavioral Sciences	1.895	2.095	-9.6	1.248	51.8
VII. CHEMISTRY					
D29. Chemistry, Multidisciplinary	2.892	3.033	-4.7	1.584	82.6
D30. Analytical, Inorganic & Nuclear Chemistry	2.553	2.980	-14.3	2.034	25.5
D31. Applied Chemistry & Chemical Engineering	1.143	1.202	-5.0	1.394	-18.0
D32. Organic & Medicinal Chemistry ,	2.581	2.614	-1.3	1.385	86.4
D33. Physical Chemistry	2.331	2.305	1.1	3.443	-32.3
D34. Polymer Science	2.131	2.208	-3.5	1.556	37.0
VIII. PHYSICS					
D35. Multidisciplinary Physics	2.830	2.916	-3.0	2.634	7.4
D36. Applied Physics	1.955	2.032	-3.8	1.768	10.6
D37. Physics, Atomic, Molecular & Chemical	1.914	1.847	3.6	3.160	-39.4
D38. Thermodynamics (Classical Physics)	1.378	1.143	20.5	1.561	-11.8
D39. Physics, Mathematical	1.496	1.659	-9.8	1.426	4.9
D40. Particle & Nuclear Physics	1.968	1.939	1.5	1.816	8.4
D41. Physics of Solids, Fluids & Plasmas	1.442	1.414	2.0	3.073	-53.1
IX. SPACE SCIENCES					
D42. Astronomy & Astrophysics ,	1.418	1.375	3.2	1.454	-2.5
X. MATHEMATICS					
D43. Applied Mathematics	3.112	3.008	3.4	1.783	74.5
D44. Pure Mathematics	1.415	1.414	0.1	1.145	23.6
XI. COMPUTER SCIENCE					
D45. Computer Science & Information Tech.	2.439	2.373	2.8	1.549	57.5
XII. ENGINEERING					
D46. Electrical & Electronic Engineering	2.250	2.409	-6.6	1.403	60.4
D47. Civil Engineering	1.449	1.417	2.3	1.753	-17.3
D48. Mechanical Engineering	2.208	2.138	3.3	3.098	-28.7
D49. Instruments & Instrumentation	1.442	1.613	-10.6	1.016	42.0
D50. Fuel & Energy	1.322	1.101	20.1	2.239	-40.9
D51. Other Engineering	1.597	1.716	-6.9	2.492	-35.9

XIII. MATERIALS SCIENCE					
D52. Materials Science	2.389	2.434	-1.9	2.694	-11.4
XIV. GEOSCIENCES					
D53. Geosciences & Technology	1.463	1.442	1.4	2.373	-38.4
D54. Hydrology & Oceanography	2.072	2.006	3.3	1.271	63.0
D55. Meteo., Atmosph., Aero., Sc. & Tech.	1.380	1.386	-0.4	1.533	-10.0
D56. Mineralogy & Petrology	1.423	1.886	-24.5	1.280	11.2
XV. AGRICULT. & ENVIRONMENT					
D57. Agricultural Science & Technology	1.177	0.999	17.8	0.996	18.2
D58. Plant & Soil Science & Tech,	1.329	1.480	-10.2	1.958	-32.1
D59. Environmental Science & Technology	1.383	1.308	5.8	2.303	-40.0
D60. Food & Animal Science & Technology	1.508	1.440	4.7	1.870	-19.3
XVI. BIOLOGY (ORGANISMIC AND SUPRAORG. LEVEL)					
D61. Animal Sciences	1.998	2.087	-4.3	2.037	-1.9
D62. Aquatic Sciences ,	1.108	1.203	-7.9	4.030	-72.5
D63. Microbiology	1.847	1.802	2.5	2.349	-21.4
D64. Plant Sciences	1.945	1.803	7.9	1.343	44.8
D65. Pure and Applied Ecology	1.465	1.599	-8.4	1.439	1.8
D66. Veterinary Sciences	1.147	1.118	2.6	1.494	-23.2
XVII. MULTIDISCIPLINARY					
D67. Multidisciplinary Sciences	2.215	2.302	-3.8	2.622	-15.5
XVIII. RESIDUAL SUB-FIELDS					
D68. Materials Science, Mult.	2.769	2.804	-1.2	3.277	-15.5
D69. Crystallography	1.550	0.766	102.4	1.549	0.1
D70. Geosciences, Mult.	1.655	2.032	-18.5	1.913	-13.4
D71. Med., Res. & Experimental	1.699	2.062	-17.6	1.632	4.1
XIX. SOCIAL SCIENCES, GENERAL					
D72. Law & Criminology	3.581	3.920	-8.6	4.151	-13.7
D73. Political Science & Public Administration	2.322	3.000	-22.6	3.110	-25.3
D74. Sociology & Other Social Studies	2.247	3.005	-25.2	3.272	-31.3
D75. Education	2.158	2.057	4.9	3.642	-40.7
D76. Geography, Planning & Urban	0.849	0.827	2.6	0.815	4.1
D77. Ethics	2.195	2.070	6.1	3.506	-37.4

D78. Other Social Sciences	1.522	1.498	1.6	1.592	-4.4
XX. ECONOMICS & BUSINESS					
D79. Economics	1.945	2.154	-9.7	1.973	-1.4
D80. Business & Management	2.556	2.762	-7.5	3.121	-18.1
ALL SCIENCES	1.609	1.609	0.0	1.608	0.02

Table G. The US/EU High-impact Gap for Fields, and the All-Sciences Case, Measured According to the Multiplicative and the Fractional Approach When the CCL Equal to the 80th percentile, As Well As According to the Multiplicative Approach When the CCL Equal to the 95th percentile

	Mult., 80th (1)	**Frac., 80th** (2)	**(3) = (1) – (2) In %**	**Mult., 95th** (4)	**(5) = (1) – (4) In %**
I. BIOSCIENCES	1.794	1.657	8.3	1.858	-3.4
II. BIOMEDICAL RESEARCH	2.200	2.096	5.0	2.651	-17.0
III. CLINICAL MEDICINE I (INTERNAL)	1.985	2.042	-2.8	2.125	-6.6
IV. CLIN. MED. II (NON-INTERNAL)	1.863	1.929	-3.4	2.010	-7.3
V. CL. MED. III (HEALTH & OTHER SCS.)	1.401	1.553	-9.8	1.417	-1.1
VI. NEUROSCIENCE & BEHAVIOR	1.975	2.158	-8.5	2.374	-16.8
VII. CHEMISTRY	2.363	2.491	-5.1	2.832	-16.6
VIII. PHYSICS	2.029	2.074	-2.1	2.239	-9.4
IX. SPACE SCIENCES	1.418	1.375	3.2	1.385	2.4
X. MATHEMATICS	2.953	2.621	12.7	3.423	-13.7
XI. COMPUTER SCIENCE	2.439	2.373	2.8	2.694	-9.5
XII. ENGINEERING	1.897	1.861	1.9	2.234	-15.1
XIII. MATERIALS SCIENCE	2.389	2.434	-1.9	3.073	-22.3
XIV. GEOSCIENCES	1.444	1.440	0.3	1.397	3.3
XV. AGRICULT. & ENVIRONMENT	1.376	1.313	4.8	1.495	-8.0
XVI. PLANT & ANIMAL SCIENCE	1.596	1.583	0.8	1.890	-15.6
XVII. MULTIDISCIPLINARY	2.215	2.302	-3.8	2.622	-15.5
XVIII. RESIDUAL SUB-FIELDS	1.150	0.733	56.8	1.082	6.2
XIX. SOCIAL SCIENCES, GENERAL	1.797	1.814	-0.9	2.242	-19.8
XX. ECONOMICS & BUSINESS	2.017	2.174	-7.2	2.048	-1.5
ALL SCIENCES	1.609	1.609	0.0	1.608	0.03