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INTERNATIONALIZATION OF COMMUNICATION A VIEW ON THE EVOLUTION OF SCIENTIFIC JOURNALS

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Starting from a characterization of the level of internationalization of SCI journals, based on their authoring scope, the process of internationalization of scientific communication throughout the period 1981-97 is described. The growth of the classes of international journals at the expense of national-oriented ones, appears as a general trend in all disciplines. A kindred measure of internationalization at the country-level is proposed, based on the balance of country-authored publications between national-oriented and international-oriented journals. A typology of countries is sketched. The general trend towards internationalization is also clear at the country level. It can be generally interpreted as a positive evolution, with some exceptions as Russia in the recent period, where it appears together with the output decline, a counterpart of the disappearance of many journals from SCI. Some other examples of shocks with a covariation of internationalization and output are given. Country internationalization indexes also express the sensitivity of the country output indicators to the possible restriction of SCI sample to the international fraction. Considering evolutions of internationalization may be helpful for a comprehensive study of scientific long-term evolutions at the country level.

Introduction

Globalization of science has been approached from many points of view. Co-authorship network studies are probably the most prolific area[1] but several other facets have been investigated in the literature. Citation networks, convergence of countries' specialization profiles,[2] migration of students and scientists,[3] multinational equipments and programs especially in physics and biology are a few examples. Another level of investigation is the journal, established as a central object in library science as well as in bibliometrics.[4,5] Though the future of scientific journals has been somewhat obscured by current evolutions of electronic media,[6] we are still in a situation where most national science indicators rely on journal sets, mainly on ISI databases.[7] The journal remains a central node for scientific monitoring, and in-depth mechanisms in scientific

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communication such as internationalization can be watched at the journal level,[8] also relevant for "scientific gatekeeping" studies.[9] There is a growing independence between country of authors, country of publishers and language, with a quasi-universal usage of English in primary communication. This shows deep trends towards more transnationality of science.[10] A particular aspect of this long-term movement is the strong decline of national-oriented journals, for example journals with a strong majority of German authors and/or German readers and citers. These journals are decreasing in SCI-CMCI whereas international journals that reflect more or less the national variety of contributions in their field, whatever the country of publishing, are becoming more important.

Observing national profiles of journals in terms of authoring or citing countries opens a means of monitoring the globalization of scientific activity at the very center of the communication process, that is the publication system. This approach does not address coauthorship as such. A high internationalisation index may be obtained either through a high level of international co-authorship in the articles of the journal, or through the juxtaposition of articles from various national origins. Several analyses of samples of journals in a micro perspective can be found in the literature.[8,11,12] At the 6th ISSI meeting we proposed a systematic appraisal of the degree of internationalization of individual scientific journals, either on publication or citation scope, each journal being assigned an internationalization index or class in a given discipline.[13,14] This paper examines the evolution of the whole SCI journal collection from this point of view. In the first section we describe the long-term evolution of scientific production through the proportion of the various classes of internationalization in the SCI output. This clearly shows the drift towards more internationalized media.

The next section focuses on the country level. A country internationalization index can be defined on the model of country expected citations, based on a weighted average of impacts of journals in which a country publishes (see, e.g., Ref. 15). The internationalization index for a country is based on the weighted average of internationalization of journals in which this country publishes. It must be emphasized that country internationalization in this acception is not a "performance" per se as impact can be. It merely expresses the balance of national- or international-oriented media in the country's scientific output. For instance, we can expect that low internationalization indexes will be found for countries strongly dependent on their own local journals. Highly internationalized countries will be found both among high-performing countries with very strong publication strategies, and among small countries lacking national-based scientific publishers. The comparison of internationalization and impact performance will suggest a crude typology.

The third point will be discussed briefly. If internationalization is not a performance, its links to the performance measures such as the publication output, is of interest especially in a dynamic view. In the short term, a negative linkage between country output variations* and internationalization variations are expected in some cases, as a result of the turn-over of "national-oriented" journals in SCI journals list. A few recent examples will be given. In the long-term, the interpretation of internationalization trends depends on the specific history of countries.

Methods

Sources

This study was carried out on the ISI's *Science Citation Index* database, namely a OST customized and simplified version of the "Integrated Citation File" 1981-97. Aggregations and classifications follow OST current standards, especially for document selection: only the major four types of documents are used (proceedings excluded), either for output country measures or journal authoring scope. We considered the union SCI + CompuMath (SCI sensu stricto, which is a smaller set than SCISEARCH on line). A journal may appear in several aggregates, specialties (ISI's subject categories) or disciplines (OST aggregates). All counts are fractional (at the document level for multiauthoring, at the journal level for disciplinary multiassignment). Internationalization indexes for journals were based on 3-year cumulatives in order to give robustness. At the country level, as the experiment involved short-term fluctuations monitoring, annual output figures were considered.

Definition of internationalization indexes and classes

The internationalization scope of journals can be studied on various grounds, especially authoring and citation distributions. In the above mentioned work,[14] we focused on both scopes to assess the degree of internationalization of journals, especially through "normalized indexes" based on profile distances between the journal and some aggregates, field or subfield, used as a reference. Non-normalized indexes

* Measured by the "dynamic journal set" method. The "constant journal set" -used for instance by CHI- favors strict comparability in short term series. The "dynamic journal set" keeps pace with editorial changes at the expense of short-term comparability (a smoothing is recommended; OST usually relies on a 3-years averaging).

(concentration indexes, or more crudely number of distinct countries) need no aggregation but they would give poor measures of internationalization: in the skew distribution of scientific countries, a 80% US journal and a 80% Ukrainian journal cannot be put on the same line. "National-oriented" journals are efficiently detected as deviants to the average profile. A set of normalized indexes were presented, most of them strongly correlated. Some problems with these measurements were raised, such as field normalization and balanced inter-country representation. Several normalized indexes tend to over-rate the internationalization of US journals. Symmetrically, it is necessary to avoid an over-estimation of the internationalization of an European journal that would ignore US authors. Therefore we eventually relied on a composite index INTJNAL, which is the geometric mean of two indexes proposed in our previous work, the Euclidian Index and the Maximum Positive Difference, the latter with an additional normalization*. The former overrates the internationalization of US journals and the latter is able to detect 100% US authored journals as national-oriented ones. An example of rating for the last period is shown in Table 1 for the field Astronomy & Astrophysics.

As disciplines exhibit significant differences in country profiles, it seems reasonable to give a multi-assigned journal a rating by discipline. The composite index INTJNAL is defined for journal-discipline pairs (8-discipline level), with a set of rules. The analysis is carried out both at the discipline and the specialty level. Within a discipline A, the journal may also be assigned to several subfields, say a and b: we use the most favourable measure for the journal over A, a and b. If a journal gathers a large percentage (here over 25%) of a specialty, it attracts the mean profile and jeopardizes the measure; in such cases only, the last rating is not used. For instance if the above journal represents 30% of a, its rating will be the best one from A and b. The case is however rare because of the fractional assignment of multiassigned journals to the specialties. Reference sets are used without further internal impact stratification.

* Let x_i be the proportion of the country i in the journal x, and m_i the proportion of this country in the aggregate (subfield, field) to which the journal belongs.
A simple measure is the maximum deviation index
MAXDIF1= $\max_i (x_i - m_i)$. We use here the modified form:
MAXDIF2= $\max_i ((x_i - m_i)/(1 - m_i))$. These indexes are expressed in percentages in the text.

Table 1
Classes of internationalization (composite index, without impact normalization)
Astronomy & Astrophysics 1996

Journal Title	internat index	class-int	publisher
IAU Symposia	**96**	**10**	**NLD**
Space Science Reviews	**95**	**10**	**NLD**
Solar Physics	**91**	**10**	**NLD**
Advances in Space Research	**90**	**10**	**GBR**
Journal of Geophysical Research-Oceans	90	9	USA
Planetary and Space Science	88	9	USA
Journal of Geophysical Research-Solid Earth	86	9	USA
Annales Geophysicae-Atmospheres Hydrospheres and Space Sciences	84	9	FRA
Journal of Geophysical Research-Space Physics	83	9	USA
Astrophysical Letters & Communications	83	9	GBR
Astronomy & Astrophysics Supplement Series	82	9	FRA
Astrophysics and Space Science	82	9	NLD
Astronomy and Astrophysics	82	9	DEU
Geophysical and Astrophysical Fluid Dynamics	**80**	**8**	**GBR**
International Journal of Modern Physics D	**77**	**8**	**SGP**
Journal of Geophysical Research-Atmospheres	**77**	**8**	**USA**
Earth Moon and Planets	**75**	**8**	**NLD**
Monthly Notices of the Royal Astronomical Society	**72**	**8**	**GBR**
Astrophysical Journal	68	7	USA
Icarus	66	7	USA
Astrophysical Journal Supplement Series	66	7	USA
Astronomical Journal	64	7	USA
Astronomische Nachrichten	63	7	DEU
Annual Review of Astronomy and Astrophysics	61	7	USA
Publications of the Astronomical Society of the Pacific	61	7	USA
Journal of Astrophysics and Astronomy	**59**	**6**	**IND**
Journal of Geophysical Research-Planets	**57**	**6**	**USA**
Revista Mexicana de Astronomia Y Astrofisica	**55**	**6**	**MEX**
Observatory	50	5	GBR
Annual Review of Earth and Planetary Sciences	46	5	USA
National Oriented Journals			
Acta Astronomica	**35**	**4**	**POL**
Astronomy Reports	**33**	**4**	**CEI**
Astronomy Letters-A Journal of Astronomy and Space Astrophysics	**31**	**4**	**CEI**
Publications Astronomical Society of Australia	**30**	**4**	**AUS**
Publications of the Astronomical Society of Japan	23	3	JPN
Not Significant.			
Astronomy and Astrophysics Review	71	-	DEU
Astronomy & Geophysics	45	-	GBR

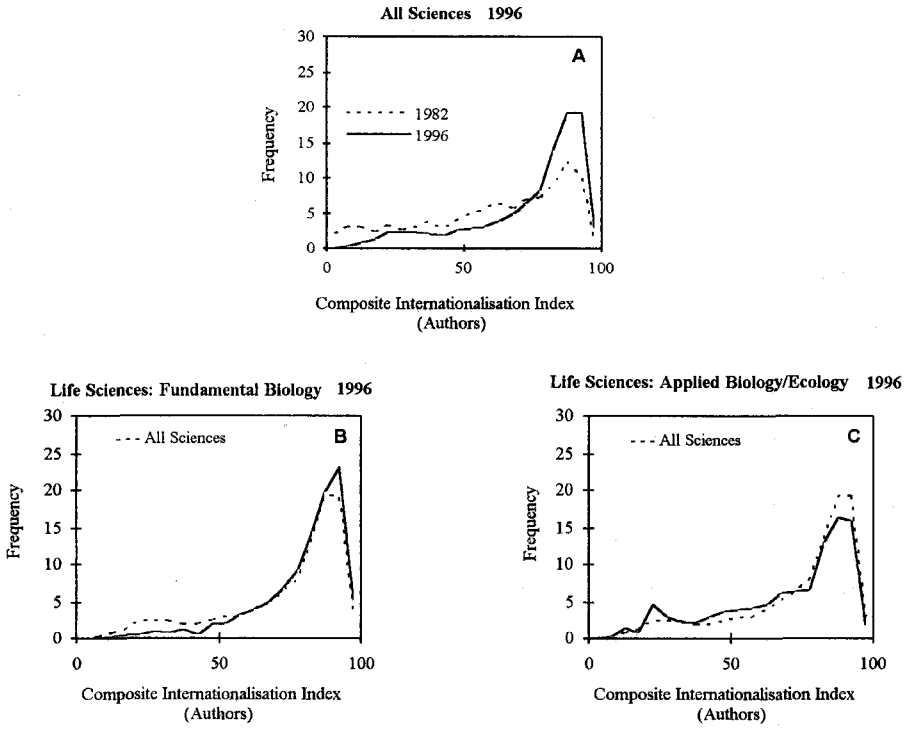

Fig. 1 Distribution of SCI journals after their Internationalization Index

With these rules, the distribution of the composite index (authoring) is shown in Fig. 1A for all science (1982-1996). As already mentioned, the distribution is much more skewed in 1996 than in 1982: the percentage of "highly internationalized journals" has doubled. In 1996 a similar skewed distribution is found for individual disciplines, with more or less clear indications of bimodality. The tail with the second mode can be assimilated to the collection of national-oriented journals. Figures 1B & C show two contrasting disciplines in Life Sciences (1996), one strongly internationalized (Fundamental Biology), the other with a heavier "national" tail (Applied Biology & Ecology). For simplicity, journals are split into five classes of internationalization, according to their internationalization index, expressed in %: very low (inferior to 40), low (40 to 60), medium (60 to 80), high (80 to 90), very high (above 90). Henceforth, we will refer to the first class as the "low-internationalized" or "national-oriented" class.

The sign of the skewness of this distribution, in contrast with impact distributions, expresses that a majority of journals are placed on the high rate side.

Derived country internationalization

A given country has a particular publication profile in journals, as a function of the power of its research system and its strategy of publication. This pattern is classically used to define, for instance, the expected impact of individual countries as a weighted average of the impact of journals of publication (for "expected impacts" and "relative citation ratios", see Ref. 15). In the same way, we can derive a country output internationalization measure, as a weighted average of internationalization indexes of the journals in which the country publishes:

$$INTCTRY1_{ctry,disc} = (1/pub_{ctry,disc}) \Sigma_j (pub_{ctry,j,disc} * INTJNAL_{j,disc}),$$

where j stands for journal.

A simple variant is the proportion of publications in international journals (i.e., journals having a composite index INTJNAL>=40).

$$INTCTRY2_{ctry,disc} = (1/pub_{ctry,disc}) \Sigma_j (pub_{ctry,j,disc} \mid INTJNAL_{j,disc} >= 40)$$

This bibliometric measure of "international orientation" is very different from a measure based on country of publishing (e.g., proportion of a country papers published in journals commercially based in the country[10]). International orientation may be high while self-publishing is also high; for example many Dutch journals are strongly international, and Dutch authoring in such journals is not a mark of national-orientation. Conversely, international orientation may be low while self-publishing is low; if, for example, in a particular discipline Morocco were to publish mainly in French journals with low internationalization indexes, Morocco would tend to get a low internationalization score. The interpretation of country indexes is discussed below.

Evolutions: linkages between variations of output and internationalization

Evolution of the internationalization of countries' communication in relation with output performances is a complex matter that needs to be addressed within a long-range analysis of countries' scientific activity. We will limit ourselves, in this paper, to mention a particular point, specific of the "dynamic journals" measures of output. If ISI adds or removes a journal with a large majority of national authors of a country (national-oriented medium), the repercussion is more important than for an international

journal, both on the country output and the internationalization measures (INTCTRY2) with opposite signs. For countries with a large and diversified output, such shocks tend to be absorbed within other fluctuations, either "constant-journal" output variations or variations due to the turn-over of international journals. But for countries where the added or removed journals represent an important fraction of the output, the turn-over can be significantly reflected simultaneously in indicators of internationalization and output. This can be observed more frequently among countries with a large proportion of targets (national-oriented journals). This effect would be reinforced if the turn-over of low-internationalized journals appeared to be significantly higher than for other types of journals. A test was conducted, comparing journal turn-over by class of internationalization of the journal. The turn-over was crudely characterized after titles changes (analyzing the turn-over in detail would imply a full management of individual journals demography: titles changes, merges, etc). This first test was sensitive to the delineation of classes and rather unconclusive.

In order to detect such configurations, we compared the relative annual changes of output and internationalization index (INTCTRY2) for country-discipline pairs (multidisciplinary group excluded), with at least 50 publications per year, from 1992 to 1997. In fact, two extreme cells of the cross-deciles contingency table are remarkable: the first one with the highest decrease of output and the highest increase of internationalization, the second one in the exactly reverse position. These two cells with extreme deviations gather almost one third of the total chi-square. Within these cells, a strong proportion of cases concern low-internationalized countries. We also identified a few country-discipline pairs with covariations of internationalization index and output throughout the period.

Results

The general landscape

The dynamic process of internationalization of science at the journal level can be observed in longitudinal series. Fig. 2 shows the distribution of the entire SCI output by class of internationalization of journals over the period. The changes are dramatic. The national class (index<40) goes down from 25% in 1981 to 10% in 1997. The growing importance of international-oriented journals (2 high groups >=80) is also remarkable. The changing balance is not due to the restriction of the global journal set, which increased during the period.

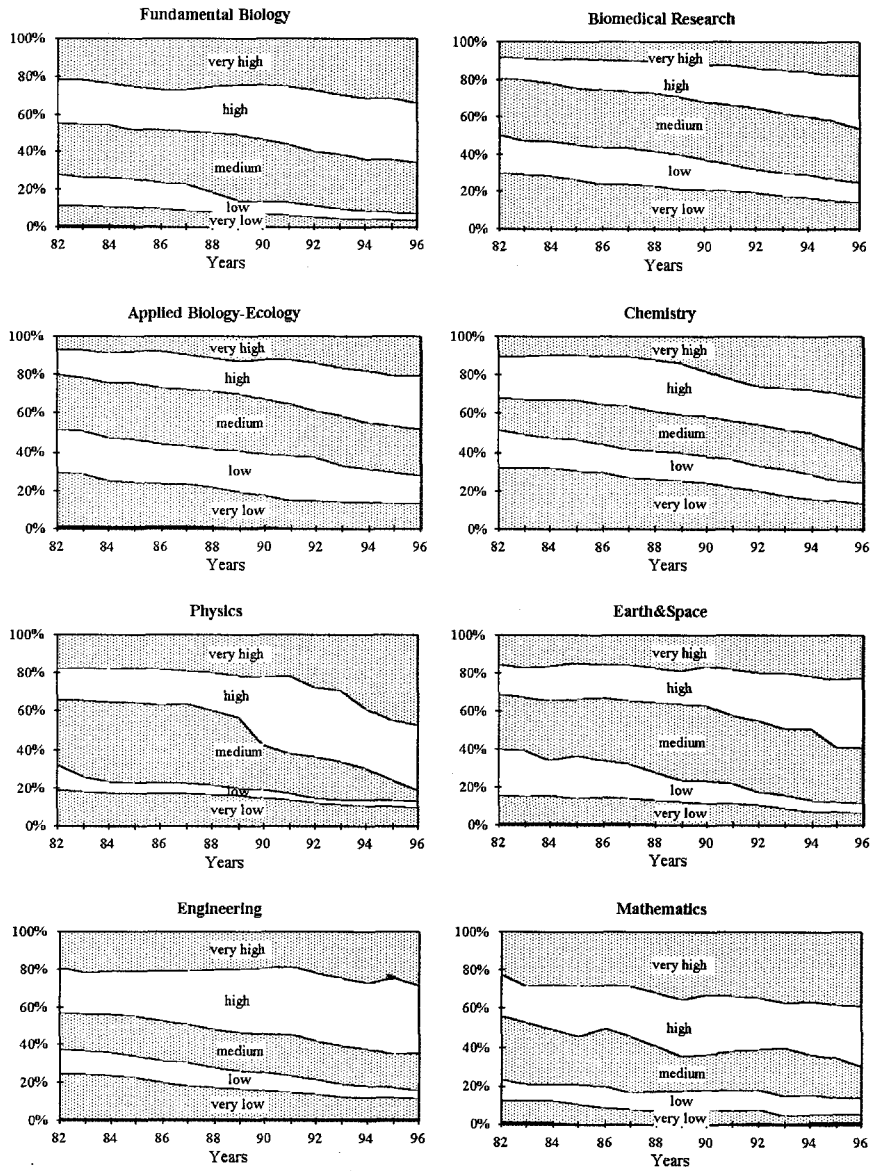

Fig. 2. Distribution of SCI output by class of internationalisation of journals

The final state (1996) stresses the differences between disciplines, as in Fig. 1. Physics at first, Mathematics, Fundamental Biology and Engineering display the more internationalized patterns. Biomedical Research and Applied Biology are the less international. Chemistry and Earth & Space stay in the middle.

The general trend towards internationalization is clearly visible for all disciplines, with a catch-up movement of fields which were once more national-oriented. The movement in Physics, already quite international in the beginning of the period, is spectacular in the central years. For the whole period, stronger evolutions affect Chemistry, Physics, Biomedical Research and Applied Biology-Ecology. Mathematics and Fundamental Biology, starting from a higher level, show a slower change.

At "all science" level, the drift toward internationalization is impressive, with an annual absolute gain of ca. 1 point for the average index.

Country internationalization indexes

Profile of countries are synthetized by the two internationalization indexes defined above, the weighted average INTCTRY1 and the proportion of international-oriented literature INTCTRY2. Figure 3 shows examples for selected countries* (belonging to the first 50 scientific ones).

The behavior of countries is more apparent when comparing internationalization (INTCTRY1) and a performance measure such as the expected impact (the two indexes are similarly built after a journal qualification and a publication pattern, see above). Figure 4 (1996) shows the position of countries (abscissa: expected impact, normalized to the world average; ordinate: national orientation of output=100-internationalization, log scale; multidisciplinary field excluded).

* CEI (CIS) stands for former Soviet Union before 1990, for Russia alone afterwards. This must be kept in mind for longitudinal comparisons of Fig. 3.

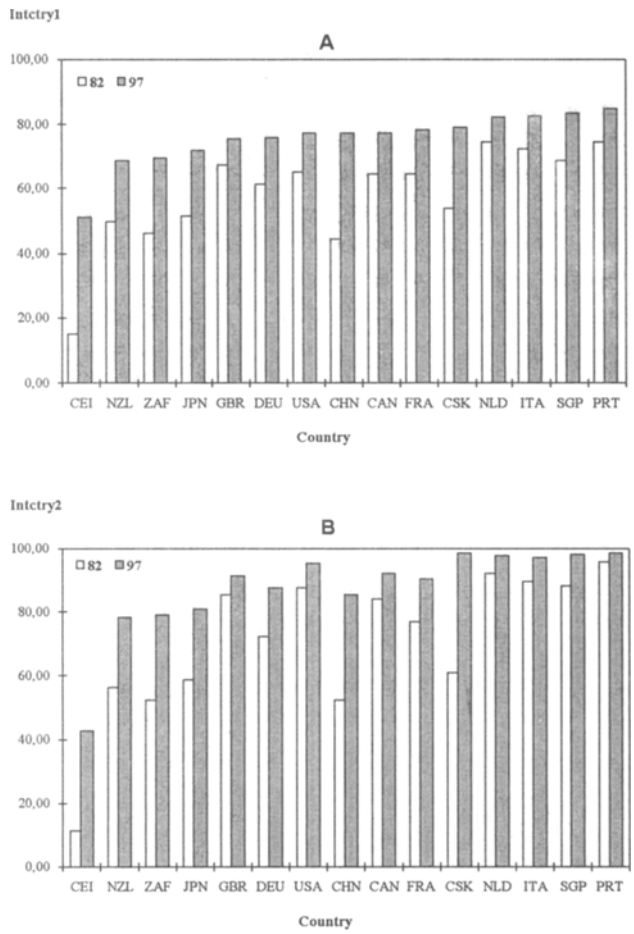

Fig. 3. Evolution of countries internationalization, 1982-1997

Four groups of countries can be delineated. In group I (upper zone) we find countries that publish less than the average in international-oriented classes: Chile, New Zealand, South-Africa and to a lesser degree Japan and Australia. In some cases, this is related to strong national journals in specific areas (e.g., Applied Biology for New Zealand). Russia remains a remote outlier in this class, with a high percentage of its SCI production in strongly national-oriented journals.

Group II (bottom left) is a low-impact/high-internationalization category. It includes small countries but also emerging Asian countries with rapidly growing output. The latter might also gain visibility in coming years. Scientific publishers in these countries, when they exist, are not well represented in highly selective Citation Indexes, and authors have no other choice than to publish in international journals in order to become visible.

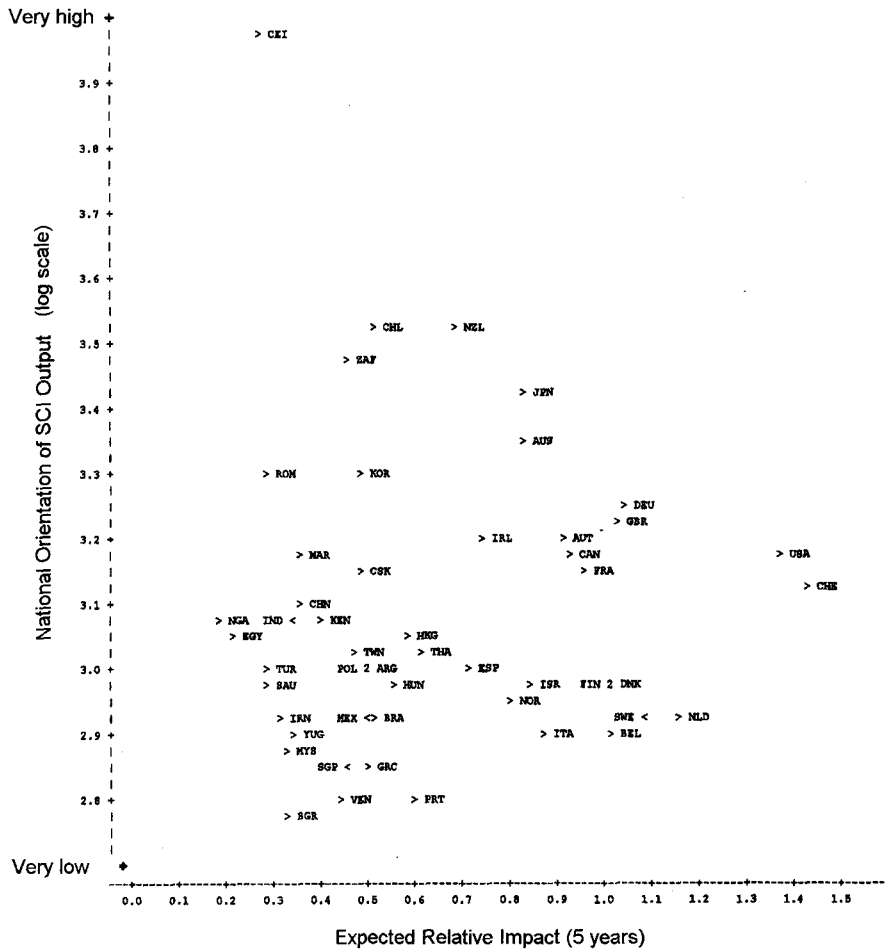

Fig. 4. Countries internationalization vs. Expected Relative Impact (1995)

Group III (bottom right) combines high visibility and high internationalization. It mainly gathers Nordic and Northern countries, some of them with international-oriented scientific publishers. The "Dutch model" is particularly outstanding, with the well-known home-published highly internationalized journals.

Group IV is a club of European and North-American countries with strong scientific traditions and high impact research. In these countries there are still journals with a relatively concentrated spectrum of national authoring. In the "second best" and non English-speaking countries, such as Germany and France, the persistence of national publishers once reluctant towards internationalization could have had adverse effects. This is in contrast to the countries of groups II and III above, which are forced to competition in international journals.[10] In the long run the conversion to international media is likely to encourage a more competitive research.

There may be some arguments (see discussion section) to build a restricted set of SCI for specific purposes, thus discarding low-impact and/or low-internationalization journals. The country internationalization indexes, especially INTCTRY2, allow to assess the insensitiveness of a given country output to a restriction of SCI based on journal internationalization. For instance if national-oriented journals are dropped, Russia's output will be far more severely affected than other countries (Fig. 3). A similar index, based on impacts (proportion of publication in "medium or high-impacts" journals) would express the insensitiveness of the country's output to a restriction of SCI based on journal impact.

Evolution of country internationalization

As mentioned before, time variations of country internationalization should be carefully interpreted. A short term co-variation of internationalization, especially INTCTRY2, and output, can occur as a result of the turn-over of the national-oriented journals. Several other phenomena interfere such as the turn-over of international journals, fluctuations of output in the constant-journal set either in international journals or in national-oriented journals, and also changes in status of particular journals (e.g., shifting from "national" to "international").

The first extreme configuration associates the highest annual decreases of output and the highest annual increases of internationalization. It mainly concerns the countries of groups I and II above. The Russian case is the most dramatic one and must be set apart. In this country, the spectacular increase of the internationalization index is the effect of the successive eliminations of national-oriented Russian journals from SCI, with only a slow redirection on other media, and as a result a decline of the measured output.

The sequence of such shocks also determines observable negative correlations (weak to moderate) between variations of internationalization index and output throughout the period.

Similar accidents, however less dramatic, are found in some country-discipline pairs, for example: Brasil/Biomedical Research/1993; Hungary/Fundamental Biology/1993; Poland/Fundamental Biology/1994. In these cases, the phenomenon can be directly associated with the disappearance of country-published journals (*Basu*[16] reported such shocks for India). But of course some other brutal variations in this group II cannot be attributed to turnover, as concerned countries have no national journals in the SCI journal set at this time.

The second extreme configuration associates the highest annual increases of output and the highest annual decreases of internationalization. Again, it happens mainly in group II and especially for emerging countries with national journals entering the SCI set: Brasil/1996 in Fundamental Biology, China/1996 in Applied Biology and in Earth&Space, Korea for Physics/1993 and Fundamental Biology/1995, Mexico/1992 in Physics, Taiwan/1995 in Biomedical Research...

These movements must be interpreted within the general long-term country trends. The inclusion of journals of emerging countries can be related to the growth of their scientific community. For "old" scientific countries, the decrease of purely national media generally indicates more openness of the country's communication, and probably an enhanced competitiveness of the research system. The removal of national-journals from SCI can be compensated by the long-term payback of a more open strategy, with publication in more visible media.

Discussion and conclusion

We first considered a measure of internationalization of journals, based on the national scope of the authors. The complete study includes similar measures for the citing scope, replacing the national profile of authoring countries by the national profile of countries of authors citing the journal. Another journal/country characterization based on the citation distribution of authoring countries has been proposed by *Bonitz* et al.,[17,18] the Matthew effect indicator. The relations between internationalization and Matthew effect are indirect and deserve a particular study. Journal internationalization indexes, whatever the basis (authoring or citing countries) are not a measure of performance as such, contrary to the rich arsenal of impact or influence factors. High-level journals may be national-oriented in special cases; for example, micro-specialties in science may be quasi-monopolies of particular countries, especially dominant ones

like the US; also, emerging areas may undergo a "national" phase.[19] In most cases, however, the ability of a journal to reflect the variety of the international scope in its area may be regarded as a positive indication. Moreover it is moderately correlated with its impact.[14] In contrast, other features of the journals, such as the subscribers profile, may not be correlated with authoring or citing profile; this was observed by *Wormell*[12] on the set of the major "library and information science" journals. Along with many other features (e.g., presence in several databases), internationalization indexes can also help to characterize journals absent from citation indexes. They also allow, along with impacts, to conduct stratified comparisons of coverages between databases.

In the long run, we have shown the evolution of distribution of world science output between categories of journal, from national-oriented journals to very international ones. A massive phenomenon of internationalization in scientific communication clearly appears. The journal, still the privileged channel of this communication, with associated functions of research certification, becomes increasingly international in a measurable way.

Starting from internationalization measures at the journal level, we derived country internationalization indexes which reflect the balance of a country's output between national-oriented and international-oriented media. These indexes are helpful to investigate strategies of publications of countries in various fields, and especially the dependence of national research on national publishers (a kindred measure is the "fixation" of national publications by national-published journals, see Ref. 10). Possible developments include a measurement based on a world regions breakdown rather than on a countries breakdown. The discrepancy between the two measures would be appropriate to qualify, for instance, journals internationalized but within a limited region.

Country internationalization indexes also determine the sensitivity of countries to decisions of cutting off the SCI "sample" on the criterion of internationalization of journals. The national-oriented journals raise a difficult issue. The consistency and country balance of the SCI "census/sample" is probably easier to establish for international literature than for journals combining low-impacts and low-internationalization (with the usual warnings about impact definition, see, e.g., Ref. 20). In other words, the choice by ISI (or any selective database) of a national-oriented Ukranian journal rather than a national-oriented Korean or French journal, all supposed with low-impact factors, is a very difficult one, particularly since impact may be affected, among other factors, by the size of the corresponding national scientific community and possibly by the language question, rather than the intrinsic quality of journals. Therefore, the lower tail of SCI (in terms of impact and/or internationalization)

is far more controversial that its top journals collection (a census of the best sources). Perhaps, the "bigger" the science is, the safer the description using standard bibliometric tools. A further selection within the SCI may be envisaged for certain types of countries indicators, and is technically manageable. It is easier to solve what we could call the "Sivertsen's problem" (restricting SCI[21]), than the "Moravcsik's problem" (expanding SCI[22]) expressed in the "Philadelphia Program". But Sivertsen's proposal does not address the possible Anglo-American bias in "international" journals.

The linkage between country performances and internationalization was briefly addressed. We also discussed the short-term covariation of internationalization and output that occurs in particular cases. The long-term evolution of country internationalization as defined here would be worth a comprehensive analysis in relation with classic bibliometric indicators and their historical background.

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