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HOW TO MEASURE THE DEGREE OF INDEPENDENCE OF A RESEARCH SYSTEM?

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The French bibliographic data-base PASCAL is used to study relations between Research Systems in terms of dependance of a periphery upon a Center.

The deployment of disciplines, the productivity and the use of mother tongue of 9 developped countries are quantified (on the Life Science file only).

This dependance is also quantified by reference to who studies whom, and in which language the results are available. A search in Life Science and Earth Science files by means of subject terms added by PASCAL indexers at input to papers published by 5 developped countries working on fourteen Latino-american and African countries.

Introduction

Economists specializing in underdeveloped countries speak of "autonomous development". The U.S. economy, for instance, is, for them, more independent than, say, the Ivory Coast economy. The former can produce everything it needs inside its own boundaries – apart from raw materials –, whereas the latter has to import everything it needs and can get nothing from its internal market. Other economists have been so struck by the differences between countries that they have coined the notion of Center versus Periphery to describe the relations between dominated and dominating economies.[1] Most of the needs and means of the economic system are decided at the Center; at the Periphery, nothing can be decided without taking into account the will of the Center. This is not to say that there is no relation between them. On the contrary, there are many, but they show a characteristic form: they are all *from* the Center *to* the Periphery and none link the countries of the Periphery to themselves. Instead of being autocentered, these countries are heterocentered.

The question has been raised[2] whether the relations between Center and Periphery, can be adapted to the relationships between Research Systems (R.S.). Subjectively at least, the notion is easy to grasp. For instance, two biologists working in the Institute Pasteur in Paris may ignore each other but each may be so closely related to the American scene that both of them receive their rewards, their information and their computerized bibliographies independently from the U.S. and they send their papers to American journals. For another example, if most of the geology of Algeria is stored in Paris and in French language, it is easier for a French geologist to have access to it than for an Algerian geologist living in Oran. In the R.S. too, there must be something like Centers and Peripheries. The Centers produce both the knowledge and the means of production for that knowledge (technicians, instruments, journals, data bases). At the Periphery, no knowledge can be produced without importing from the Centers all these means of production.

This notion, however, is much more difficult to grasp when an objective and quantitative definition is needed. It is clear that poor countries would like to produce knowledge instead of being the area where others come for doing field studies and extracting data. Sometimes rich but small countries like France fight hysterically for the defense of their national language which is seen as the best means of insuring the independence of their science. American scientists are often now up in arms to delay the time when they will be dependent on European science to pursue their research. All these discussions are interesting, because they clearly show that, subjectively at least, everyone agrees that the world of science is as unequal and as tense as the world trade market, but this is still a far cry from a good quantitative definition of what it is to be dependent.

In order to clarify the question, it is first necessary to get a base line by comparison to which changes in the various indicators can show if a R.S. is more or less dependent than another one.

Since this is obviously impossible, we can only propose a few hypotheses to help the reader interpret the quantitative results we gathered here.

If a R.S. were independent it would probably produce knowledge in all disciplines, or, at least, could not leave large domains totally unexplored and rely only on other countries. One way to measure this general effort would be to check if a R.S. publishes in all disciplines above or below the mean weight of these disciplines in the world publication output. That means that the same system could produce information in biology, physics, tribology, etc., were all the documentation, instrumentation and manpower that it entails available. This definition is acceptable except if one believes in a nice world division of labor with all the biochemistry produced in the Soviet Union for instance, and all the physics in Botswana.

It would probably publish mainly in the mother tongue of the country on which it is based, so that every scientist in that nation could communicate freely without a language barrier with every other, and were able to work within his own cultural framework. Conversely, all scientists that depend on the Center would have to give up their own mother tongue and take up the language of the Center even when they communicate with other scientists at the Periphery. This is indeed what happened successively for Latin, French and German. This definition is difficult to dispute except for those who think that English is the really "universal" language like mathematics or chemistry, and not the language spoken in Britain and in the U.S.

We could also assume without risk that a truly independent R.S. would concentrate on its own territory the results of all the research carried out by it and by others so that all data bases and libraries would be easily accessible for its nationals. Conversely, it would study the rest of the world as thoroughly as possible. For instance, if an Italian agronomist must go to Novosibirsk to get a satellite picture of Sicilian agriculture, he will be said to be less independent than the Russian agronomist who can survey the state of the crop in Italy from his own office. Again, there are fewer Guinean anthropologists in California than Californian anthropologists in Guinea.

Lastly, if a R.S. were independent it is probable that it would generate its own research programs according to its own classification systems, its own social and cultural habits, its own priorities and would permeate all the other R.S. with its own models of thought and scale of rewards. The social patterns of behaviour in science, the style of publications, the paradigms themselves, would be generated from the Center to the Periphery so that, at the Periphery, no research program could survive or modify the rules of the competition.

All these hypotheses are subjectively credible, but it is much harder to firmly establish them on quantitative grounds. To make some progress, we would need a good enough data base so that we can calculate all the changes which we will then see as significant or not in what we could call the "degree of independence of a Research System".

To do so we could, of course, use the Science Citation Index and citation studies.[4] However, we decided to use a European data base in order to avoid the many biases imposed on the SCI by the privilege it grants to English by using it as its "lingua franca". For this reason, we chose PASCAL, a French documentation system that treats 9000 journals (instead of 3000 source journals at the SCI), and also indexes theses and various types of reports. The total number of articles indexed per year in PASCAL is of the order of 500 000. The main advantage of PASCAL for future studies is that it also includes a large number of keywords

indexing each item and often a few sentence long summary of the item. Citations are not treated, but the nationality of the first author, the name of the laboratory to which the first author is affiliated, the language of the publication and of the article, are all indexed and will be used in this study.

There have been very few scientometric papers published by French scientists about French science – which is a good indication of the autonomy of sociology of science in this country –, but PASCAL has nevertheless been used by *Gablot*[5] and, more recently, by *Callon, Turner* and *Courtial*[6] who analyzed the keywords and the written summaries.

Methods

The data presented here are all taken from the Life Sciences File that comprises about 40% of the whole data base (but excludes botany and agriculture which are treated in another file). This preliminary trial deals with the first 10 months of 1979. A total of 155 000 articles were analyzed.

From the wealth of information stored in PASCAL we considered only:

the discipline to which the publication pertains;

the country of the first author as indicated by the address (this was not always indicated);

the language of the paper, which is by no means always the same as the language of the journal;

if relevant, we used the keyword indicating the country about which the paper has been written.

All the data have been obtained through a specifically designed computer program. The results have been published in French[7] earlier, but have been recalculated for this study according to *Price*'s method.[8]

To simplify the tables, we amalgamated the twenty disciplines making up the Life Sciences file into five categories which were roughly compatible on scientific and statistical grounds:

I: clinical sciences (for instance, ophtalmology, dermatology, stomatology, etc.),

II: basic biological sciences (biochemistry, immunology, genetics, molecular biology and so on),

III: physiology and zoology,

IV: applied medical sciences (pharmacology, toxicology, medical engineering, prosthesis, instrumentation, etc.),

V: psychology and psychiatry.

All the details are given in the French article.[7]

Results

Comparison of the publication output of nine large countries (in Life Sciences)

The results are shown in Table 1. The first figure represents the absolute number of publications for 9 countries and 5 fields. The second one shows the ratio of actual to expected value for each element of the matrix (see *Price*[8]). The total number of references is only about 95 000, since 40% of the file is made up of papers from other or from unspecified countries.

A third of the papers comes from clinical sciences (I) and 12% from applied medical sciences (IV). This means that half of the papers pertain to Medicine. Another third is made up of basic biology (II), this is not surprising given the weight of the Health System in all the countries for the support of life sciences.

The U.S. is the source of as many papers as the eight other countries taken together, although it must be kept in mind that the USSR and Japan might be underrepresented in PASCAL.

The second type of figures has been obtained from *Price*'s method. They show the ratio of actual (the preceding absolute number of publications) to expected value for each cell of the matrix. By "expected value" we mean the number of publications that the country would have in a given field if this country dedicated to this field as much effort as all the other countries. For instance, all the countries dedicate 30.7% of their articles to medicine. So we would expected France to produce 30.7% of medical articles, a percentage which would correspond to, 3235 (expected value) out of 10 538 articles. But in fact France produces 4326 items (absolute number). She, then, publishes 1.33 times what she is expected to publish in that field. If we use these ratios, as *Price* advises us to do,[8] some interesting features become visible even though the weight of the U.S. overshadows the other variations (see below).

As expected from our definition of a Center, the U.S. publishes equally in all fields. This is either a proof of their independence or a proof that it sets the trend for the rest of the world. There is a strikingly higher ratio in psychology and psychiatry (V), as *Price* has already noticed (private communication);

– France, the FRG and Italy have a higher ratio than expected for medicine (I), but lower for basic biology(II) and much lower in psychology and psychiatry (V):

– the United Kingdom follows the same pattern as the U.S. although its absolute output is only a fifth of it. This is an indication that the R.S. at the Center includes both the United States and the United Kingdom, separated, as the saying goes, by the same language;

Table 1
Distribution of articles according to country and scientific field in life sciences

Field	Country									
	France	U.K.	F.R.G.	Italy	U.S.A.	U.S.S.R.	G.D.R.	Japan	India	Total
Medicine	(4326)	(2644)	(3445)	(2281)	(12 590)	(920)	(1171)	(1710)	(275)	(29 362)
	1.33	0.90	1.32	1.41	0.91	0.56	1.47	0.90	0.37	30.7%
Basic sciences	(2931)	(3591)	(2479)	(1556)	(15 546)	(2507)	(728)	(2809)	(1105)	(33 252)
	0.80	1.07	0.84	0.85	1	1.35	0.80	1.29	1.31	34.8%
Physiology	(1454)	(1541)	(1015)	(467)	(5972)	(1282)	(272)	(859)	(751)	(13 613)
Zoology	0.97	1.13	0.84	0.62	0.93	1.69	0.73	0.97	2.17	14.2%
Applied sciences	(1399)	(1287)	(1162)	(821)	(5606)	(421)	(349)	(800)	(264)	(12 109)
	1.05	1.06	1.08	1.23	0.98	0.62	1.06	1.01	0.86	12.7%
Psychology	(428)	(542)	(416)	(123)	(5336)	(200)	(80)	(68)	(36)	(7229)
Psychiatry	0.54	0.75	0.65	0.31	1.57	0.50	0.41	0.14	0.20	7.6%
Total	(10 538)	(9605)	(8517)	(5248)	(45 050)	(5330)	(2600)	(6246)	(2431)	(95 565)
	11%	10%	9%	5%	47%	6%	3%	7%	3%	

The nine countries are arranged in columns and crossed with fields. The figures in brackets give the absolute numbers of papers per field and per country. The second figure is the expected ratio (see text and Ref. 8).

– in Japan, the language barrier certainly accounts for the very low ratio in psychology and psychiatry (V), but the higher ratio in basic biology (II) might indicate a special effort of Japan in that area or a special interest of other R.S. for Japanese publications in their own journals;

– in the Soviet Union and still more in India there is a much higher ratio in the more traditional parts of biology, physiology and zoology (III), whereas in the GDR, a socialist country, the pattern of publication is very similar to that of the other European countries.

In order to check the reliability of PASCAL, we compared the publication outputs of these nine countries with their Gross National Product. If the U.S. is chosen as the base line, in life sciences at least, France, Italy, the GDR and India, produce exactly the proportion of papers that could be expected from their G.N.P. The FRG, on the contrary, has a much lower output of papers, and the U.K. a higher than expected ratio. As for the USSR and Japan, the number of papers treated in PASCAL is one fourth of what could be expected, which is probably due to the linguistic and cultural barriers.

Which disciplines speak which language and who speaks in one's mother tongue?

For the five large disciplines listed above, we looked at the languages in which they mostly published and we then, weighted the figures according to the calculation proposed by *Price.*[8]

The results are shown in Table 2. English makes up 70% of all the literature indexed by PASCAL in its life sciences file. This is mentioned also in other sources,[9] but it is interesting to have this confirmed from a data base that is supposed to be strongly biased in favor of European languages. French, although strongly favored as could be imagined, amounts to only 12% and German to 7%.

The striking feature of this publication pattern is that although French and German are much less employed in basic biology (II) than could be expected, they are much more employed in medicine (I). It could be said that the degree of dependence on the Center varies according to the field, but it is difficult to know what an increase in national language really means: does it indicate a greater autonomy or a greater provincialism and backwardness?

The weight of the English language is so great in the total file as well as in specific fields that in order to evaluate the residual autonomy left to the various national languages, we had to treat again the data according to the *Price* ratio[8] but this time with a new twist. We calculated the tendency to produce in one's own language as could be expected from the usual pattern by country and by field, and compared it to the actual values from one country from one field. Part

Table 2
Distribution of articles with respect to language and scientific field in life science

Field	Language								
	French	English	German	Russian	Spanish	Italian	Japanese	Others	Total
Medicine	(8644)	(26 371)	(5485)	(1151)	(683)	(1878)	(693)	(780)	(45 685)
	1.62	0.82	1.62	0.57	1.60	1.63	1.56	0.83	29.4%
Basic Sciences	(3505)	(41 279)	(2237)	(2925)	(318)	(1040)	(369)	(1206)	(52 881)
	0.56	1.12	0.57	1.25	0.64	0.78	0.72	1.11	34.1%
Physiology	(2376)	(18 965)	(1454)	(1876)	(172)	(300)	(197)	(768)	(26 108)
Zoology	0.78	1.04	0.75	1.62	0.70	0.46	0.78	1.43	16.8%
Applied Sciences	(2451)	(13 919)	(1670)	(614)	(111)	(562)	(220)	(271)	(19818)
	1.06	1.00	1.14	0.70	0.60	1.12	1.14	0.66	12.8%
Psychology	(1161)	(8099)	(671)	(330)	(169)	(138)	(27)	(169)	(10 764)
	0.92	1.08	0.84	0.70	1.68	0.51	0.26	0.76	6.9%
Total and %	(18 139)	(108 633)	(11 517)	(6896)	(1453)	(3918)	(1506)	(3194)	(155 256)
of the language	12%	70%	7%	4%	1%	3%	1%	2%	

The seven languages are arranged in columns and are crossed with the five fields. The figures in brackets give the absolute numbers of papers per field and per country. The second figure is the expected ratio.

of the results are summarized in Table 3 for six countries only. This table is based on the same figures as the two others but limited to the use of mother tongues for these six countries.

For instance, France is so dependent on English in producing basic biology (II) that she publishes in it 70% of what is expected. But when this performance is compared to the general tendency to publish in English in that field anyway, France is slightly better than might be expected. This pattern is well known in the study of colonialism. Some colonies tend to be "over-dependent", like those French scientists who publish only in English and speak English even with their countrymen.

If we now consider the five fields, we see that the more basic it is, the more English there is in it. Psychology (V) is usually a national science – with 86% of the papers written in the mother tongue of the first author as shown in the right hand column –; medicine (I) and applied medicine (IV) are more integrated to the world – that is the American – market, with, respectively, 78% and 66% of the publications in national languages. For physiology and zoology (III), the proportion goes down to 61% and then 51% for basic biology (II).

If we now look at the countries and search for their general publication policy – if there is such a policy –, the FRG and Italy are clearly publishing much less basic biology (II) in their own language even when the general imbalance in favor of English is taken into account. They are over-dependent. The two socialist countries, the USSR and the GDR, on the other hand, tend to produce in their own language more than is expected given the formidable weight of English. Once again, it is not clear if speaking English is proof that a discipline is more mature and stronger, or more dependent of on American influence and weaker.

The publication pattern either by country or by field is interesting, especially when smaller subfields are taken into account. France seems to follow exactly the pattern that can be expected from her independence, except in biochemistry and molecular biology – not show in the table – where she publishes more in English than even a dependent country usually does. FRG and Italy follow the same pattern, and, like France, are overdependent in basic biology (II) or in physiology and zoology (III). This is important, because an alternative research program is much less likely to develop in these peripheral R.S. than at the Center.

The two socialist countries, the GDR and the USSR, have a pattern of publication which is more regular and quite different from that of the western countries. Even in basic biology (II) and in physiology and zoology (III) they publish as much as is expected but publish in their own language twice as much as expected in subfields like biochemistry or molecular biology – not shown in the table.

Table 3
Use of mother tongue by country and by field

Field	Country												% in mother tongue
	France		F.R.G.		Italy		U.S.S.R.		G.D.R.		Japan		
	1	2	1	2	1	2	1	2	1	2	1	2	
Medicine	1.14	0.93	1.29	1.06	1.26	1.03	1.05	0.86	1.07	0.88	1.49	1.22	78%
Basic sciences	0.70	0.87	0.58	0.73	0.68	0.85	1.0	1.25	0.89	1.11	0.64	0.80	51%
Physiology Zoology	1.01	1.06	0.83	0.87	0.73	0.77	0.91	0.96	1.0	1.05	0.75	0.79	61%
Applied sciences	1.08	1.05	1.07	1.04	0.95	0.92	1.06	1.03	0.98	0.95	0.95	0.92	66%
Psychology Psychiatry	1.18	0.88	1.41	1.05	1.34	0.99	1.12	0.83	0.97	0.71	1.68	1.29	86%
% in mother tongue	78		61		59		85		88		25		64

$1 = \frac{\text{Actual}}{\text{Expected}}$ production,

$2 = \frac{\text{Actual}}{\text{Expected rectified}}$ production

The six countries are arranged in columns and crossed with the five fields. On the left side of each column is the expected ratio calculated according to the *Price*[5] method. On the right side of each column, the same ratio is multiplied by a corrected factor that eliminates the weight of the English language (see text).

Japan follows a different route altogether. Even though the data base indicates only the articles published in English or with an English summary – which explains the relatively low figure of 20% – Japanese publications show striking variations depending on the field. In basic biology (II), Japan is as much dependent on English as are western countries, but in psychology (V) much more published in Japanese than is expected for that field and the same is true for medicine (I). But in ophthalmology – not shown – they publish three times as much as can be expected from the general use of English as "lingua franca" of that subfield. According to PASCAL, Japanese scientists seem to publish mainly in English in some areas and mainly in Japanese in some others. Once again, it is hard to tell if being insulated from English is a proof of strength or a proof of weakness.

Who studies whom and in which language are the results available?

In order to see if it was possible to measure the degree to which a country is dependent on another even to know what happens on its own territory, we used the PASCAL data base in a different way. We took the life sciences and earth sciences files and chose fourteen developing countries (6 from Latin America and 8 from Africa). We then took five developed countries, and retrieved from the data base all the articles published *by* one of the five developed countries *about* one or more of the fourteen developing countries. This was possible by the use of the keyword coding for the name of the country, but since this code was not always relevant we retrieved only 1393 articles. These figure is extremely low and such data should be interpreted with caution.

As is clear from Table 4a, one fourth of the articles published about Latin America, are published in the U.S. and one fourth of the articles about the African countries are written by the two former colonial powers – England and France. There are, however, great variations among countries. Some countries publish only a third of the articles that concern their own territory, but some others which are culturally and economically more developed, like Egypt. Brazil, Nigeria or Argentina, publish much more of the sciences that is relevant to their own territory. The apparent autonomy of some countries does not necessarily reflect a stronger R.S. It might only indicate that these countries are the home of subsidiaries of major European or American laboratories.

The language in which articles are published can also be considered as in Table 4b. In order to study the literature published about the eight African countries, it is enough to know French (27%) and English (66%). For the 6 Latin American countries, however, Spanish and Portuguese are important, 33% altogether, which indicates that there are a few areas in these countries where local

Table 4a
Distribution of research done by developed countries about some developing countries*

	Argentina		Bolivia		Brazil		Jamaica		Peru		Venezuela		Total	
F.R.G.	8	8	3	8	8	4	–	–	3	6	3	8	25	6
France	6	6	3	8	3	2	–	–	4	8	2	5	18	4
U.K.	2	2	3	8	3	2	5	28	1	2	1	3	13	3
U.S.S.R.	–	–	–	–	–	–	–	–	2	4	2	5	4	1
U.S.A.	25	26	11	29	4	22	4	22	25	52	13	35	119	28
Country	56	58	18	47	130	71	9	50	13	27	16	43	242	57
Total	97		38		183		18		48		37		421	

	Algeria		Cameroun		Egypt		Ethiopia		Ghana		Nigeria		Senegal		Tunisia		Total	
F.R.G.	–	–	1	4	5	4	3	8	–	–	2	1	3	6	4	7	18	4
France	8	53	9	32	5	4	5	13	–	–	6	4	12	24	18	31	63	13
U.K.	–	–	5	18	2	1	6	15	6	40	14	10	1	2	4	7	38	8
U.S.S.R.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	1	0.2
U.S.A.	–	–	4	14	15	11	12	31	2	13	5	4	3	6	5	8	46	10
Country	7	47	9	32	114	81	13	33	7	47	109	80	31	62	27	46	317	66
Total	15		28		141		39		15		136		50		59		483	

Fourteen developing countries are arranged in columns and crossed with five developed countries.
*First column: number of articles; second column: %.

Table 4b
Distribution of languages used in articles studying developing countries*

Language	Country													
	Argentina		Bolivia		Brazil		Jamaica		Peru		Venezuela		Total	
French	8	4	14	23	20	8	–	–	10	10	9	14	61	8.6
English	78	37	33	55	129	53	28	100	66	64	39	62	373	52.5
German	7	3	3	5	9	4	–	–	8	8	2	3	29	41
Russian	–	–	–	–	–	–	–	–	3	3	2	3	5	0.4
Spanish	114	54	8	13	7	3	–	–	10	10	8	13	147	33
Portugese	1	–	2	3	78	32	–	–	4	4	–	–	85	33
Others	3	1	–	–	2	1	–	–	2	2	3	5	10	
Total	211		60		245		28		103		63		711	

Language	Country																	
	Algeria		Cameroun		Egypt		Ethiopia		Ghana		Nigeria		Senegal		Tunisia		Total	
French	23	66	27	64	5	3	9	12	4	17	12	7	48	83	57	63	185	27
English	7	20	12	29	174	94	53	73	18	75	158	91	7	12	23	25	452	66
German	3	9	3	7	5	3	9	12	–	–	3	2	3	5	9	10	35	5
Russian	1	3	–	–	–	–	–	–	1	4	–	–	–	–	1	1	33	0.4
Others	1	3	–	–	2	1	2	3	1	4	–	–	–	–	1	1	7	1
Total	35		42		186		73		24		173		58		91		682	

Fourteen developing countries are arranged in columns and crossed with the main languages used by developed countries.
*First column: number of articles; second column: %.

scientists can still study local questions and publish them in their own language. These figures are to be compared with the total output in Spanish as shown in Table 2, where only 1% of the articles of life sciences was published in Spanish. It is interesting to note that PASCAL did not index any articles published on these countries from the USSR.

Conclusion

The figures obtained from PASCAL are still too sketchy to answer all the questions we asked at the beginning. We consider, nevertheless, that they are encouraging enough to warrant a full treatment of the data base and an extension of the number of years to be considered.

The first advantage of such a study is to show that a Research System is in no way uniform but shows strong variations according to geography and to the cultural and political system. The knowledge industry is no more unified than the economic world.

From the preliminary picture that we got from PASCAL, the outstanding fact is the weight of the U.S.A. or to be more precise, the weight of the Research System that includes the U.S.A. (47% of all publications) and the United Kingdom. This large R.S. with English as its "lingua franca" makes up 70% of all the papers we studies. Since the U.S.A. casts its language shadow – or aureola–much beyond its limits, and since it supports all fields, it certainly qualifies for the definition of the Center given in the introduction. The Center attracts not only brains – like during the Fifties – but, more importantly, attention, rewards, and now, information. The networks of data bases are so organized that it is now easier to get information from Washington when you live in Marseille than from Paris. Two laboratories are less related to one another than each of it is to the Center if they can pass through Washington so easily. This is what defines a periphery. This would not be of real importance, if together with its information, the Center would not also export its questions, its classifications, its evaluations, its styles of thought and its rewards. It is at the Center where it is decided what is worth studying and how to study it.

If *Price* is right in suggesting that only one-fifth of all information filters from one language to the next (personal communication), it is easy to imagine the degree of impoverishment of a science made in a language other than one's own. The situation is still worse when two scientists at the Periphery are forced to talk, write, read and work in a language that neither of them understands really well. This obvious fact is often derived by English speaking scientists, who picture science as made only of abstract theories that can be treated in any abstract lan-

guage. However, the more we come to realize that science is a cultural endeavour, the more it is necessary to understand the role of the language that in part shapes it.

In spite of the weight of the U.S. Research System, it is possible, to retain some degree of autonomy, depending on the country, and/or the topic and the political system. In all countries considered medicine, applied medical sciences, and, to a lesser extent, psychology and psychiatry, are less dependent on the international market and tend to be published in national languages. This is because they are more obviously linked with the social and cultural institutions of each country and do not easily interact with the others. Socialist countries seem to follow a pattern of publications quite different and based on a more voluntarist linguistic policy. Japan is obviously able to retain a large degree of autonomy, choosing to translate massively certain topics in English and hiding some others behind the linguistic barriers.

This first trial on PASCAL confirmed the idea that it was possible to use a European data base, much larger than the SCI, in order to study the dependence relationships between R.S. A new method developed by *Callon* et al.[10] to treat also the keywords will enable the authors to map the intellectual evolution of a field in a much more precise way than citation studies could allow.

References and notes

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