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Introductory Note

Future of Sciento-Informetrics

What is the future of sciento-Informetrics (the term I am using as gemeroc to scientometrics, informetrics, bibliometrics, librametrics and similar other species ? It seems there is a declining trend in the spate of publications and interestgs among its potential activitists and clients in midnineties after a gusto of activities for about two decades. Is this a time for consolidation ?

I can see a few reasons for this declining trend. First there is no grand theory or even a comprehensive working base for sciento-informetrics. Despite attempts by Brookes, Egghe, Rousseau, Haitun (to name a few) and many others, a sound Zipfian model has not emerged as yet. I had shown in the previous issue of JISSI the state of affairs for citation theory (Wouters also examined the case). Second problem is that of precise measurement. Bookstein (in this issue of JISSI) very elegantly highlights it. The third problem is that of sampling. No two results can be compared with sufficient confidence.

The other major crisis is the crisis for all subjects of the social sciences. In the article on social science in the Encyclopaedia Britannica (15th edition) the author points out that almost all social research (particularly policy research) is prone to unconscious or implicit bias. This is due to conditioning for the aspirations of the funding agencies and due to adjusting the collection procedure of data (again related to sampling) and analysis of data (lack of precise procedural tools and measurement techniques). I am afraid if this is also going to be the case with at least a part of scientometric research.

The other major problem with which many third world sciento-informetricians are both concerned and bothered is the fact of North - South (or rich - poor) divide. Sciento-informetric research would probably be hampered because of informationally haves and have-nots (Arunachalam's article in this issue discusses some aspects of the problem).

Despite all these I like to agree with Ronald Rousseau (Similarities between informetrics and econometrics. *Scientometrics* **30(2-3),** 1994, 385) that sciento-informetrics should be considered in the background of its mother field informatin science. Let us share hope with him that problematic issues will be resolved in the field of sciento-informetrics will gain strength "in a similar way as econometrics gains its strength from its role in general economics".

Subir K. Sen

We are Sorry !!

There occurred some crucial problems with publication of JISSI. We thought the problems could be resolved soon and easily. But they lingered on. The publisher could not overcome the constraints. We are therefore forced to close down JISSI in its present form. We had materials for an almost completed issue at hand preserved for exactly 30 months (two and half years)! We are putting this through print now as the last (and 4th) issue of volume 2, December 1996 (Published in June 1999!). This issue contains some of the papers presented at the 6th ISSI Conference in Jerusalem (Israel) in July 1997 (a forced anachronism!). Some of the older articles we have not accommodated here.

I can not but regret the whole matter. I however expect to continue the journal in some other form. We were overwhelmed by the support and help we received from our authors, editors, friends and peers throughout over all these years. JISSI makes another addition to the set of short lived international journals!

Even then I am optimistic and expecting JISSI to turn to a phoenix !

Subir K Sen

Sixth International Conference on Scientometrics and Informetrics Jerusalem 16-19June 1997 - A Report on the Conference

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This series of conferences began 10 years ago at the Limburg University in Diepenbeck, Belgium. The conference was the brainchild of **Leo Egghe**, its organizer. His vision was for a series, but he could only go on "faith" that other conferences would follow. Well, we all now know that they did — all of them offering a unique experience for our scholarly community. this series has given scientometricians a view of the world and of the state of the knowledge in our developing field by taking us to Canada to the University of Western Ontario, to India to the Statistical Institute in Bangalore, to Germany to the Humboldt University of Berlin, to the United States and Rosary College, River Forest, near Chicago and most recently to Israel to the Mount Scopus campus of the Hebrew University of Jerusalem. It was a truly international gathering with around 120 delegates representing 25 countries.

The first session was dedicated to the memory of **Jean Tague** who died last year. The session's Chair, **Mike Koenig** (US), spoke of Jean's life, and her dedication to the field and of her scholarly commitment in organizing the second Scientometrics conference at the University of Western Ontario, London, Canada.

In his Keynote Address, **Abraham Bookstein** (US) reflected on the origins of these conferences and the emergence and development of scientometrics and informetrics. He then described some of the theoretical issues that particularly interest him and which are continuing problems for the field. The primary issue he said is the problem of uncertainty and ambiguity - for example, about data, about units of measurement. Another aspect of scientometrics where ambiguities need to be resolved is the notion of the 'time span'. He spoke of the tensions caused by having to make decisions relating to research designs and what is to be measured and then to test models under conditions of uncertainty. In order to continue testing hypotheses, we have to construct and test models based on our intuition and knowledge of the area despite ambiguities. Bookstein suggests that continuing work should focus on how we learn under conditions of ambiguity, on the tensions between facts and data and between conceptualization and theory testing. He spoke of his fascination with Lotka's Law — which is for him both very simple and complex — when everything entering this measurement is ambiguous. Despite inherent problems with informetric distributions, he reasserted the necessity of being conscious of how important the measurement mechanisms are.

Francis Narin (US) spoke of his research on the linkage between the development of technology and basic science. His paper described findings about the important role and contribution of publicly-funded science to the creation of patents for [private] industry. Narin's findings that patents now increasingly cite scientific papers thus showing the strength of the links between science and technological innovation. Narin's work also reveals that citation is rather 'local' in that his studies have found that scholars tend to cite their own countrymen more than others. Narin speaks of

strong local effects or patterns of citing where citations act rather like a human conversation reflecting ideas back into a specific circle of scholars. This paper continues the work reported at Antwerp (October 1995).[1]

Jane Russell (Mexico) reported on a case study of the publishing habits of Mexican scientists at UNAM (National Autonomous University of Mexico). Despite scholars having a commitment to supporting and publishing in Mexican domestic journals, Mexican scientists frequently published in foreign journals in order to be competitive internationally and to gain greater visibility for their contributions. The studies reported by B. M. Gupta (India), Subir Sen (India) and Ali Uzun (Turkey) illustrate this particular problem and the 'push' for scientists to send their work to ISI source journals. Most international citation studies take their data from the ISI citation indexes. Because the journals of less-developed or small scientific nations are generally not indexed by ISI, their work is rendered invisible at the international level.

Henk Moed et al.[2] (Netherlands) reported on their investigation of competitive funding models for distributing research funds. Moed reported that external funding seems to have increased the ratio of junior to senior staff, but the downside of this may result in imbalances and a decline in publishing productivity, at least in the short term.

There was a feeling expressed in a number of papers, for example, **Peter Vinkler** (Hungary), **E. J. Rinia et al.**[3] (Netherlands) and **J. Rey et al.**[4] (Spain), that the increasing reliance of policy mak13.1

Sylvan Katz (UK) also addressed the issue that the demand for metrics on science performance is driving change in publication practices of scholars and altering the strategies they employ for submitting scientific articles. Katz seemed to suggest that by adopting certain publication strategies, a scholar may increase personal or institutional publication counts. One of the strategies that provides increased visibility is collaboration and especially collaboration with scholars in another country. What we are witnessing here is subversion of scholarly communication processes where the once dominant 'noblesse oblige' rule gives way to a programmatic strategy to gain increased citation counts.

Grant Lewison (UK) however suggested in the question-time following Katz's presentation that one reason why collaboration yields higher citation counts may be because collaborative work is generally funded by several agencies and thus incurs several rounds of rigorous reviewing and prereading prior to publication. Lewison is suggesting that the papers that emerge from international collaborations have benefited from multiple reviewing processes and thus may be of higher 'quality'.

Benoit Godin (Canada) reported on the findings of a survey of scholars who collaborate. His methodology involved asking very open kinds of questions about collaboration such as how the subject began the collaboration; what were the perceived benefits, what forms the collaboration took and so on. Godin lets the subjects speak about their personal experience of collaboration and he made seemingly no distinction between the social and cognitive reasons behind their choice to collaborate. Godin's study found that an important factor in collaborative success is when scholars engage in the collaboration as social beings as well as scientists. Godin's findings suggest that it is important to know collaborators as friends, to socialize and to develop a relationship of trust. The implications for policy are clearly to provide resources

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[1] Narin, Francis (1995) 'Linkage between agency-supported research and patented industrial technology', Paper presented at the 4th International Conference on Science & Technology Indicators, Antwerp, Belgium October 5-7, 1995, *Abstracts* p.17-18.

[2] Authors include : H. F. Moed, M. Luwel, R. E. de Bruin, J. A. Houben, H. Van den Berghe, and E. Spruyt (Netherlands and Belgium).

[3] Authors include : E. J. Rinia, H. G. van Vuren, Th. N. van Leeuwen and A. F. J. van Raan (Netherlands).

[4] Authors include : J. Rey, M. -J. Martin, L. Plaza, J. -J. Ibanez and I. Mendez (Spain)

for socializing to take place so that friendship and trust can develop among the group, such as funds for attendance at joint meetings and for joint presentation of papers at international conferences. It is these kinds of activities which help create a feeling of social cohesion among a group of collaborators. Godin's survey indicates on the other hand that "forced" collaborations rarely work well as most scholars hold negative attitudes to such processes. During question time several comments focussed on the degree to which involvement relies on specific activities such as the swapping or sharing of skills, equipment, data, as well as travel and writing together. **Henry Small** (US) suggested that dynamics of scientific collaboration might be more easily investigated if process was broken down into its various activities or intellectual components. **P. S. Nagpaul's** (India) investigation on the scale and styles of networking among Indian scientists goes some way along this path. His data showed a typology of five clusters of communication patterns among Indian scientists from active to passive communication and collaborative styles.

Manfred Bonitz et al.[5] (Germany) presented their latest findings on the Matthew Effect for Countries (MEC). Bonitz et al.'s MEC is a redistribution phenomenon at the macro-level of the sciences. Based on citation data from Science Citation Index, Bonitz et al. show that, on the basis of the journals in which a country publishes, some (the minority) receive more citations to their work than are expected, while others (the majority) receive fewer than expected. Research on the MEC indicates two clear groups of nations, citation-gaining nations and citation-losing nations which the Bonitz team label as Right and Left Worlds (that is,. according to the position on the graphs showing the MEC distribution). However, there appears to be some flexibility for those nations at or close to the world average of expected citations per paper. Some nations near to the dividing line in the sciences overall may achieve more citations than the expected world average in some fields and thus shift for that particular field across to the right side (citation-gaining) of the graph. The redistribution or the MEC affects only about 5 per cent of the citations under study, yet the MEC is a clearly measurable phenomenon that stratifies the world of science into winner and loser nations. Some policy implications are noted. For example, citation-losing nations might consciously start to change their scientific and publication strategies in order to improve their share of world citations, a recommendation which resonates with the evidence and recommendations presented in Katz's paper.

Several speakers presented papers about electronic journals published on the Internet. Two new electronic journals relevant to the field were described : *Information Science Decision Making* on the Marseilles University web site and *Cybermetrics*, a Spanish initiative of **CINDOC** with its emphasis on the impact of electronic communication and new paradigm of measuring intellectual linkage as "sitations" rather than measuring citations as direct scholarly influences. The objective of these new electronic journals is not to overlap with printed journals, but to be very immediate providing fast release of submitted papers. Each of the journals includes peer evaluation or review.

The question of journal quality and the role of the peer review process in maintaining quality control were themes of many discussions. **Marc Luwel** (Belgium) and **Henk Moed** (Netherlands) referred to the revision of papers following peer review. They suggested that whether papers were actually revised following review was dependent upon the rigour or strictness of the rejection/acceptance processes of editors of specific journals. Much in the quality processes of journal publishing rests with editorial policy. **Michel Zitt's** (France) presentation focussed on the internationality of journals, their authorship and readership.

Paul Wouters (Netherlands) presented a model (based on an earlier one presented in Amsterdam, May 1996) in which he conceptualizes science as a 'credibility' inducing cycle with two separate but interlinked domains: the knowledge production cycle and the citation cycle. Wouters' work is a search for a theory of citing. His ideas on the culture of citations and the citation as symbol rather than objective data raised many interesting ques-

[5] Authors include : M. Bonitz, E. Bruckner and A. Scharnhorst (Germany)

tions from the floor that were hotly debated. The ideas expressed by Wouters are relevant to my own research on the subjective and individual choices which scholars make about what to read (from among a large range of potentially useful and relevant material) and what to cite when writing up their research as journal articles or papers. The scientometric community looks forward to Wouters' forthcoming book on this subject with considerable interest.

The conference afforded opportunity for participants to get to know each other better: at lunch each day in the Mount Scopus canteen; at the several cultural events, such as the visit to the Israeli Academy of Sciences and to the Israeli Museum and Art Gallery. Both these institutions are set in splendid gardens in the New City and there was ample opportunity to enjoy the food as well as look at the exhibits. The Conference Dinner at the beautiful courtyard of Beth Schmuel Hotel was a truly special occasion — beautiful warm weather, clear starry skies, delicious food and lovely music played by two young Israeli musicians on harp and violin. During this event, the 1997 Price Medal 6, the most significant honour in this scholarly community, was awarded to three distinguished scholars, to Ben Martin and John Irvine from the University of Sussex, UK, who have collaborated on many studies, and to Belver Griffith from Drexel University in the United States.

Bluma Peritz and her staff as organizers for this Sixth Conference are to be congratulated for providing us with a well-organized conference and opportunities to visit some of the beautiful places in this ancient and most interesting city. World travelling scientometricians and scholarly adventurers can look forward to meeting again in Mexico for the Seventh Conference which will be organized by Cesar A. Macias-Chapula and his team.

This report only provides a partial view of some of the highlights during those four days in Jerusalem. What has been reported is no substitute for having been there personally. However, for those not so lucky, copies of the *Proceedings* can be purchased from Professor Bluma Peritz, School of Library, Archive and Information Studies, Hebrew University of Jerusalem, Givat Ram Campus, P.O. Box 1225 Jerusalem 91904, Israel.

[6] Named to honour Derek J. de Solla Price

*Implications of Ambiguity for Scientometric Measurement**

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The essence of Scientometrics is precise measurement. Yet the measurements made in Scientometric research is steeped in ambiguity. This paper explores the nature of ambiguity in measurement, and probes for mechanisms that allow regularities to be discovered in an environment in which ambiguity is pronounced.

1. Introduction

I am glad, and honoured, to be here and to have the opportunity to address you as the opening speaker of this Conference, which marks the tenth anniversary of the Conference series. In preparing my remarks for this milestone event, I could not resist reflecting on the early days of the series.

The existence of this series owes much to the foresight of Leo Egghe, who ten years ago thought that the field of Bibliometrics had matured enough, and had enough content, to sustain a conference series dedicated to presenting research in its own domain, instead of being dependent on other conference venues. The result was the very successful meeting at Limburg University in Diepenbeck, Belgium. In looking back at the Proceedings of this meeting[7], I noted papers by Bertie Brookes, Michael Moravcsik, Gerry Salton and Jean Tague — people who contributed much to establishing the field, but are sadly not here to enjoy the tenth anniversary celebration of its formalization.

But there is also much to cheer us. The series thrives. The scope has expanded to include both Informetrics and Scientometrics. And we now enjoy the stability of having an organization supporting us.

At this stage in the Conference series's history, it is appropriate to step back the probe some of the fundamental issues that lie behind the diverse questions for which this series is the forum. One such issue that has fascinated me deals with the nature of measurement itself. I would like, in this opening presentation, to give an overview of some concerns that have interested me over the past twenty years.

2. Ambiguity

The various manifestations of ambiguity and uncertainty, and how one is able to function and make complex decisions in a world in which these are dominant, has been of much concern to me over the years. In particular, this touches the problems of measurement, where the goal of precision is the paramount notion.

Among the many impediments to good measurement, most attention has been given to the problem of random error. Typically, procedures are used that relate statistical models to data. But it is often overlooked that the techniques developed for handling random error, such as statistical tests, while rationally treating the effects of randomness within the framework of a given model, only indirectly guide us in formulating the model itself. For example, one can make statements about the parameters of a normal distribution, alone or as a component of a more complex model, but the normality of errors is generally taken for granted — curiously, some of the most striking theoretical properties that are used to justify the widespread

*This paper was presented as the Keynote Address of the 1997 ISSI Conference in Jerusalem

appearance of the normal distribution reappear in the regularities that recur in ambiguity laden contexts, even though these have received much less attention.

Model building, at its best, depends on intuition and good conceptual command of a subject domain and the regularities that govern it. This introduces a strange circularity in the learning process : We needed some basic understanding to construct models; yet we rely on models to guide the formal investigations that develop such insight. This tension is especially pronounced in the early stages of an investigation (and in those domains in which research seems to be perpetually at an early stage). For it is here that conceptualization is especially weak, and measurement imprecise and even misleading. It seems that in such situations, where what I have termed ambiguity is prevalent, that successful exploration should be impossible. Yet, the history of science shows that systematic investigations of new domains do occur and are often breathtakingly successful. The ultimate question is : How is it possible that we can learn when ambiguity is the dominating factor at a given stage of investigation?

The reason so little attention is given to this issue is that "ambiguity" is, after all, ambiguous. We don't have the type of regularity that characterizes statistical uncertainty, and allows it to be investigated mathematically. (We shouldn't overlook the fact that the *mathematics* of randomness is, like all mathematics, fully deterministic. That is, although the mathematics of probability models uncertainty, it first represents it in a form that is fully understood and deterministic — indeed, whose properties can be encapsulated by a small number of axioms). Thus, without such regularities, it is hard to see how ambiguity can be studied in a systematic way. This leaves us focusing on randomness, with which we are familiar, rather than on ambiguity, which is elusive.

It is here that the regularities occurring in Informetrics are very helpful — here I am referring to the regularities, or "laws", of Bradford[6], of Lotka[10], of Zipf[12], and the many others that approximately describe the data accumulated in many fields, outside as well as within the Information Sciences. Because of the striking simplicity of the regularities, and the complexity of the phenomena they describe, it seemed possible, here at least, to precisely describe various ways in which ambiguity might enter, and to see, once and for all, what type of impact ambiguity can make in a specific data collection problem. Here, at least, we can examine a special, narrow, problem carefully as a case study.

To illustrate the approach I am referring to, let me use the Lotka law as a simple example. Although I shall focus on one type of ambiguity, the range of problems it illustrates has by now been considerably extended.

3. Lotka's Law

Lotka's law is often used to describe the distribution of publication within a community of scientists. Lotka formulated it to describe publication patterns among chemists. To recall : Lotka took a five-year cumulation of *Chemical Abstracts* and counted how many authors published a single article [denoted by N(1)], how many published two articles [N(2)], etc. Lotka found the data took the following form :

$$N(n) \propto \frac{1}{n^a}$$

where,

n : Number of papers published in a period;

N : Number of scientists (eg chemists) publishing n papers.

As published by Lotka, log N is linearly related to log n, with the slope, α, taking a value close to two. Figure 1 shows Lotka's own data.

I include this figure because so much emphasis has been put on the approximate nature of these regularities that is can be surprising to recall how well one can work! Though these data fit particularly well, it is by no means unusual to get a fit that does as well. For example, surprising levels of fit have been reported in areas as diverse as the literature of Finno-Ugric studies (a highly specialized area in the Humanities)[11] and in the first issues of the *Philosophical Transactions of the Royal Society of London* (about 1660)[8]. I mention these because, in both cases, the study was

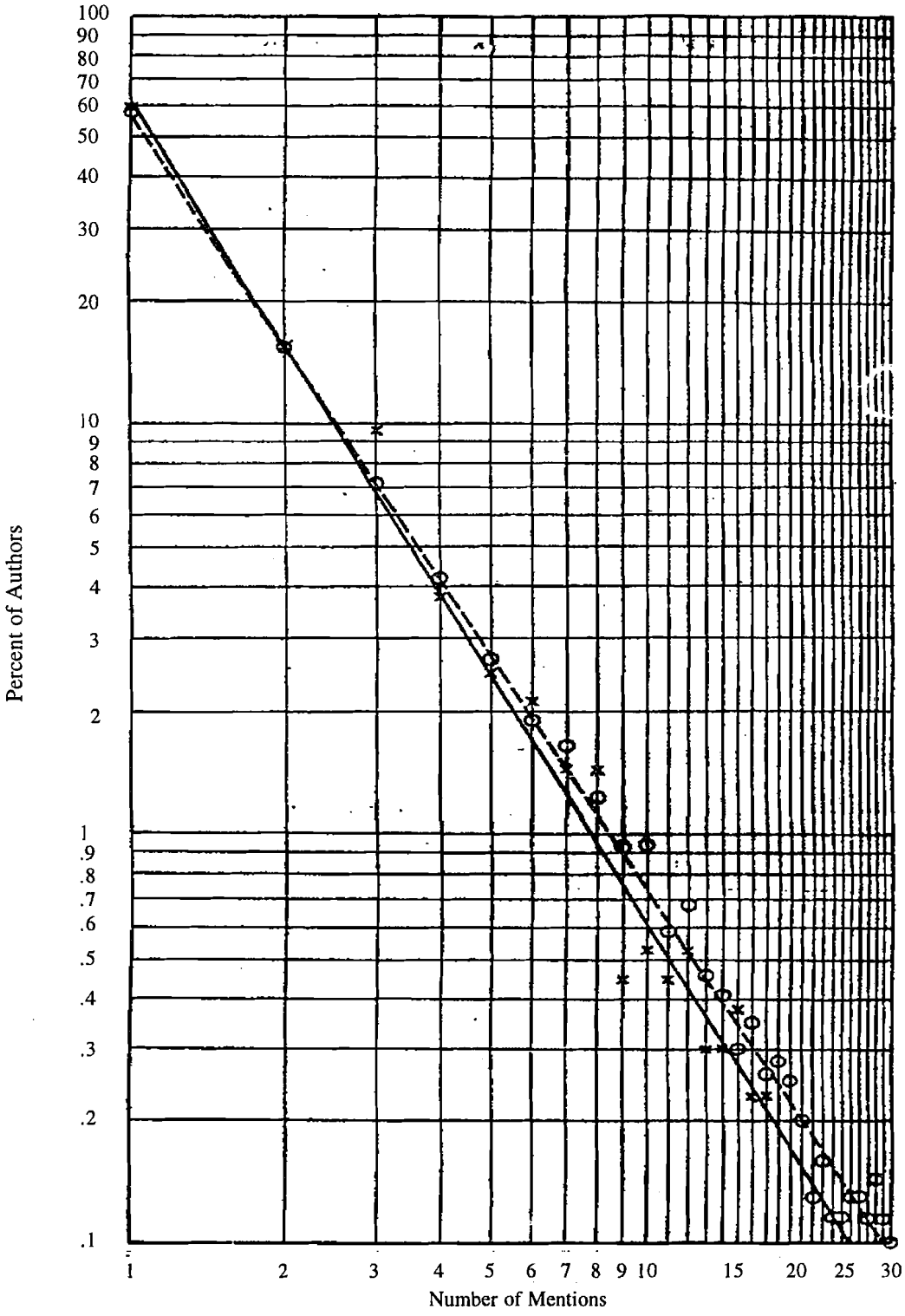


Fig. 1. Graph taken from original paper by Lotka[10]. Logarithmic frequency diagram showing number of authors mentioned once, twice, etc, in Aurbach's table (points indicated by crosses), and in Chemical Abstracts, letters A and B (points indicated by circles). The fully drawn line indicates points given by inverse square law, exponent = 2; the line of dashes corresponds to exponent 1.89

carried out by friends, dubious about these regularities, and determined to find a counter-example. For by common-sense and instinct, this regularity shouldn't exist. Let's leave out the issue of content — the surprise that 17th and 20th century science should be governed by the same regularity; that a huge, multi-disciplinary science and a narrow, highly specialized branch of the humanities should respect the same "laws". Instead I would like to focus on issues of methodology.

My main comment is that we don't have any reason to expect a simple regularity to emerge because we have a very vague sense of what type of data to collect. As is the case with the other regularities in IS, and in other fields too, the concepts that guide our data collection are very ill-defined, so our data collection is, of necessity, arbitrary. Note here how different this inadequacy is from that of statistical randomness. For example :

Bradford : What are the core journals on which the law is defined and tested?

Zipf : What constitutes a word? For example, are *boy* and *boys*, or *see* and *saw* one or two words? How do we interpret variant spellings? Contractions

Lotka : What defines a person as a Chemist? (Mere appearance in *Chemical Abstracts*?)

Why is five-year accumulation period the appropriate one to manifest the regularity?

Thus my friends had every reason to be skeptical of such claims of regularity, not only on the basis of substantive grounds, but also for methodological reasons. From another point of view, we can ask : even if a law *did* exist, how likely is it that it would emerge from the highly flawed data we collect? Wouldn't the data collection process itself be adequate to discourage a search for regularity? — At least until we improve our theoretical understanding of the problems to the point of knowing what it is we should be measuring. To note a parallel in physics : for some time people had an instinct that force was associated with motion. But the exact relation was elusive — because in the earliest research, motion was measured by *velocity*. When force was related to *acceleration*, the simple linear relation of Newton appeared and progress in mechanics became rapid.

Thus, it isn't surprising that a naive person should be suspicious when he first hears of these regularities. Yet, in spite of all the reasons for not existing, these regularities continue to emerge — sometimes very strongly, sometimes requiring some determination to see the straight line going through the meandering pattern of dots, but typically strikingly enough to cause surprise and comment.

It is this persistence in yielding law-governed behaviour in spite of conceptual imprecision that has fascinated me : in part because of the intrinsic interest of the informetric phenomena described by these regularities, but increasingly because of the very much more general question it inevitably raises, of how we can learn about a subject when our concepts relating to that subject are still vague.

My approach to investigating this paradox was quite simple[2,5] : Ideally, I would have enlisted for study a population of actual scientists, who would carry on with their research activities as normal, but who would be willing to modify their behaviour, perhaps even radically, as convenient for my research objectives. This was of course impossible. But if the simple regularities I am studying emerge when actual scientists publish, with all the complexities and vicissitudes of the real-life research and publication process in effect, then it is highly plausible that these same regularities would emerge if a population, subject to the same ambiguities, but whose publication behaviour was more regular, were studied.

Thus, as a substitute for an actual population of scientists, I created a *conceptual,* more cooperative, population of scientists, and then manipulated their activities to see the effect these manipulations had on the regularities I was examining. Like all models, this one simplifies reality. But precisely because of this simplicity, we can examine exactly what happens when our data collecting is limited by conceptual imprecision.

The simplest example is that of time-span ambiguity — to isolate one of many ambiguities studied. That is : suppose it is true that Lotka's

law would emerge if data were collected over a given time span, taken as the unit of time below. What would happen if, lacking knowledge of the correct time span, we chose a different, more convenient, one? Is it possible for the same regularity to emerge?

As indicate in figure 2, if we suppose Lotka's law reveals that $Af(x)$ scientists publish x articles over the initial span of time, then $A'f(x)$ must publish x articles over z such expenses of time, if the law is to be invariant over time span change. Assuming regularity of publication, each participating scientist who published x articles over the z unit period must have published x/z articles over the initial span of time. But we know how many such scientists there are in our population : it is given by the original form of the Lotka regularity, which asserts there are $Af(x/z)$ such persons. To be consistent, the two estimates must be equal :

$$A'f(x) = Af(x/z)$$

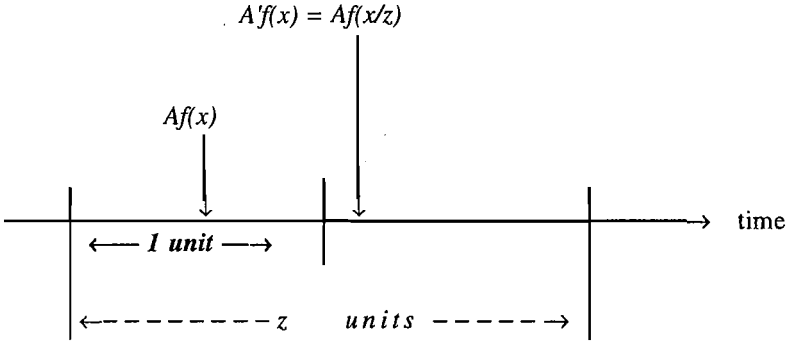
We can normalize the function $f(x)$ so $f(1) = 1$; if so, it is now a simple matter to show $f(x)$ must satisfy $f(xy) = f(x)f(y)$[2].

Several comments are now in order[1, 2, 5] :

1. Let me first assert that a large number of ambiguity probes, more complex but of the same character as the one just illustrated, require the same restriction on $f(x)$. So it is plausible to expect an $f(x)$ satisfying this condition can enjoy this property.
2. The Lotka function, $f(x) = 1/x^{\alpha}$, does indeed satisfy this condition.
3. This form can be shown to be unique among nice, smooth functions.
4. The other famous laws take different forms. But they express relationships among different variables. When these variables are translated into those appearing in the Lotka formulation, the regularities also take the Lotka form, to a good approximation.

The conclusions following from these observations are nothing short of amazing :

- The very great variety of regularities circumscribed as informetric can be thought of as being nothing more than different manifestations of the same distribution;
- That distribution is unusually resilient to misunderstanding; and further,
- The class of such candidate distributions is small.



Require : $f(1) = 1$;
$f(x)$ must satisfy : $f(xy) = f(x)f(y)$
Solution : $f(x) = 1/x^{\alpha}$ (Interpret $f(x)$ as expected value).

Figure 2. Schematic Illustrating Time-Span Ambiguity Invariance

As presented, the distributional form is deterministic. I have argued elsewhere[3, 4] that $f(x)$ is best interpreted as an *expected value*: that, in a given population, we *expect* $Af(x)dx$ members to produce between x and $x + dx$ items (for example, papers, within a population of scientists). Of course, there will be some randomness associated with this, and the expected value need not be the same as the actual number of papers produced — for example, no scientist will produce 0.1 paper, even though there may be some who have an expected output of 0.1, just as the expected value of a dice-roll is 3.5, even though a die never actually rolls a 3.5.

What is needed to make the theory complete is a way to introduce a random component : if a chemist has an expected value of .1, how likely is it that he will in fact produce 0 papers? 1 paper? 10 papers? In this sense, the problem now is formulated in the standard terms of probability theory, except that we now demand that the error component observe the same resilience to ambiguity that the underlying deterministic component does. I spoke a bit about this problem at the last ISSI conference in Chicago[3], and more recently published a detailed paper in JASIS[4].

But by way of summary, suppose we denote by $g(n; x)$ the probability that an entity actually produce n events, given that the number of events it is expected to produce is x. Then, $P(n)$, the fraction of the population that will yield n events, will be given by $P(n) = A \int g(n; x)f(x)dx$; here $f(x)$ denotes the distribution of expected values, x : for example, $f(x)$ may be given by the Lotka distribution. In the JASIS paper, I show that for $g(n; x)$ to be resilient to time span ambiguity, it must satisfy the constraint, $g(n; x_1 + x_2) = g(n; x_1) * g(n; x_2)$, with the asterisk (*) denoting the convolution operator[9]. We can show that the most general set of distributions satisfying this condition is the class of compound Poisson distributions, the most prominent members being the Poisson distribution itself and the Negative Binomial Distribution[9].

4. Conclusion

I spoke in detail about the Informetric Distributions, in part because it is very heavily used by many of us, so we should understand its most interesting properties; but also, because it serves as a case study for a broader range of problems. I opened the talk with the question : How can we learn anything, without knowing something at the beginning? How can we investigate a subject systematically, without first understanding enough of it to define its basic concepts and thereby make meaningful measurements.

What this study suggests is that there are mechanisms that are resilient to confusion and imprecision, probably a lot more diverse than those I have been speaking about, and that in the course of investigating a subject we naturally gravitate towards these — simply because they work. I believe that such mechanisms play a much larger role than has been recognized in the evolution of scientific investigation, and that we sould be attuned to uncovering and exploiting these in a wider range of research domains.

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The Research Challenge of the Aids Epidemic in Latin America and Caribbean

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The Acquired Immune Deficiency Syndrome (AIDS) epidemic constitutes a great challenge to society due not only to its damaging impact but also to the need to keep abreast on the rapid development of the knowledge generated in order to apply such knowledge swiftly. The objective of this analysis was to describe patterns of publication on AIDS by authors from Latin America and the Caribbean (LAC).

In order to identify the research output of the region we searched the major database, MEDLINE, using the occurrence of each of the countries within the region from January 1980 to July 1996. The papers were also matched against Science Citation Index.

Two hundred and fifteen papers were retrieved; 70 were cited at least once. Brazil and Mexico accounted for 66% of the published papers. Articles from Brazil, Haiti and Mexico were the most cited (84% of all citations), while Haiti, Trinidad and Tobago, and Brazil accounted for the highest citation impact scores. Researchers from Brazil and Mexico published in their national journals and abroad; they also published two-thirds of the articles in AIDS-related journals. The ten most cited papers were clinically-oriented (medicine). Basic sciences were poorly represented as well as social sciences.

The publication of clinically-oriented articles from LAC countries may arise from the need for information on infectious diseases, prevalent in AIDS patients, which are relatively less common in similar patients in developed countries. The motives for publishing in prestigious journals may reflect an effort to reach the international scientific community and gain career visibility, although we also concluded that the self-interest of the more developed countries plays a crucial role in acceptance of the published articles.

Keywords : AIDS; HIV; Latin America; Caribbean; Bibliometric Indicators.

1. Introduction

Analyses on the growth of AIDS literature[1, 2, 3] have highlighted the increase in both the number of papers published worldwide and in the use of different languages in these publications. Studies on subject access within the field of AIDS lit-

erature have also been carried out[4,5]. Various papers give some light on the trends of AIDS research[6, 7]. Nevertheless, there are several reasons why AIDS research should be measured. Firstly, the effects of AIDS can be seen to be spreading rapidly within the Latin America and Caribbean region. The British Medical Journal points out that "(...) in contrast to the relative stability of AIDS in industrialized countries, the epidemic is expanding rapidly in resource-poor areas. Like so many other infectious diseases including those that are sexually transmitted, AIDS is emerging as a disease of poverty, both globally and within individual societies"[10]. Gays, bisexuals, injecting drug users, heterosexuals, men, women, and children are among the infected groups[11]. Migrants, refugees and prostitutes are also being infected. It is estimated that as of December 1997, 1.3 million individuals live with HIV in Latin American countries, and 310,000 in the Caribbean with about 10,000 of these cases being fully developed AIDS.

Secondly, there has been economic pressure on health financing as the costs of the epidemic have been difficult to estimate due to the increase in patient numbers, changes in therapies, type of care and the duration of the treatment[12].

In the case of the 44 countries of the region there is the question of whether to import knowledge or to find domestic strategies to target research where it is needed. Therefore, in this paper, we attempted to determine the scientific publishing activity and the citation impact of Latin American and Caribbean countries in AIDS-related fields, as the fight against AIDS requires a global effort on the part of governments, multinational organizations, industry, scientists, public health workers, and educators, amongst others[13].

2. Methods

The primary data source was unique journal articles retrieved from MEDLINE. AIDSLINE was not used because it includes a large variety of documents other than scientific reports : for example of the richness of the International AIDS Conferences covered by AIDLINE is the inclusion of abstracts on community interventions, problems faced by community based on non-government groups, human rights violations, etc. Although the diffusion of these materials is vital in the fight against AIDS not all of these presentations are scientific communications pertinent to the objective of this paper. Neither were regional database (e.g. LILACS) used because of the limitations of their search fields and problems within author affiliation.

A total of 215 papers published by 763 authors in 22 Latin American and Caribbean countries was retrieved using the occurrence of the country's name combined with the term AIDS (Table 1).

Table 1. Countries Output and Manpower Base.

Country	No. papers	Unique authors	Average authors per paper
Argentina	8	35	4.4
Bahamas	1	3	3.0
Barbados	1	6	6.0
Brazil	67	304	4.5
Chile	8	35	4.4
Columbia	3	8	2.7
Costa Rica	3	7	2.3
Cuba	4	10	2.5
Dominican Rep.	3	21	7.0
French Guyana	4	13	3.3
Guadeloupe	2	12	6.0
Haiti	5	23	4.6
Honduras	1	3	3.0
Jamaica	2	7	3.5
Mexico	74	172	2.3
Netherlands Ant	1	2	2.0
Panama	1	10	10.0
Paraguay	2	9	4.5
Peru	5	22	4.4
Puerto Rico	14	34	2.4
Trinidad & Tobago	2	11	5.5
Venezuela	4	18	4.5
Total	215	763	3.5

The sample was then reduced by matching the 215 articles against the Science Citation Index (SCI). This resulted in a population of 70 papers from 16 countries that were cited at least once.

The papers were grouped by authors' institutional affiliation based on the address-field data,

as well as the papers' focus. The journals in which the papers were published were classified by subject according to the SCI Journal Citation Reports (JCR) list.

3. Results

The 215 papers retrieved when searching MEDLINE were published by authors distributed across 22 countries within the Latin American and Caribbean region. Mexico and Brazil accounted for the 66% of the total output (Table 1). Of the articles that were cited at least once, Brazil, Haiti and Mexico were the most cited : 84% of all citations. However, Haiti, Trinidad and Tobago, and Brazil accounted for the highest citation impact scores : 22.7, 13 and 7.7 respectively (Table 2).

Table 2. Countries Ranked by Total Number of Citations and Citation Impact

Rank	Country	Citations	Country	Citation impact
1	Brazil	202	Haiti	22.66
2	Haiti	68	Trinidad & Tobago	13
3	Mexico	58	Brazil	7.7
4	Trinidad & Tobago	13	Peru	5
5	Puerto Rico	12	Venezuela	4
6	Venezuela	8	Mexico	3.4
7	Dominican Republic	6	Puerto Rico	2.4
8	Peru	5	Argentina	2
9	Argentina	4	Bahamas	2
10	Chile	3	Dominican Rep.	2
	Cuba	3	Panama	2
11	Bahamas	2	Cuba	1.5
12	Colombia	1	Colombia	1
12	Fr Guyana	1	French Guyana	1
12	Jamaica	1	Jamaica	1

Half of the papers were published in non-regional journals. Researchers from small countries seemed to seek out foreign journals whilst authors from Brazil and Mexico published in their national journals as well as in foreign journals (Table 3).

Table 3. Distribution of Papers by Origin of Publication

Country	Total	Domestic	Foreign
Argentina	8	4	4
Bahamas	1	0	1
Barbados	1	0	1
Brazil	67	33	34
Chile	8	7	1
Colombia	3	0	3
Costa Rica	2	0	3
Cuba	4	1	3
Dominican Rep.	3	0	3
French Guyana	4	0	4
Guadeloupe	2	0	2
Haiti	5	0	5
Honduras	1	0	1
Jamaica	2	1	1
Mexico	74	52	22
Netherlands Antilles	1	0	1
Panama	1	0	1
Paraguay	2	0	2
Peru	5	1	4
Puerto Rico	14	8	6
Trinidad & Tobago	2	0	2
Venezuela	4	0	4
Total	215	107	108

Eleven percent of the papers were published in AIDS-related journals, 26% in journals devoted to general medicine, 61% in specialised medical journals, and the rest in other type of publications.

All the AIDS-related journals were based outside the LAC region. Brazil and Mexico published the highest number of articles in these journals as well as accounting equally for two-thirds of the total number of publications in such journals (i.e. 8 papers from each country). The remain published articles in AIDS specific journals came from the Dominican Republic and Haiti (2 articles each), and Cuba, Jamaica, Paraguay and Puerto Rico with one published paper each.

Twenty-five of the 107 articles published in national journals were cited at least once; altogether these publications received an average of 1.52 ci-

tations per article. Forty-five of the 108 articles published in international journals outside LAC received total of 351 citations, i.e. 7.8 citations per article. Of the total number of citations, only 11% were from publications in national journals.

The 215 papers were grouped into 29 subject categories. Fifty-six papers of the total were published in general medicine journals. Cited papers were grouped into 18 subjects categories. The subject categories that received more citations were general medicine, AIDS, respiratory system, tropical medicine and pathology (Table 4).

Table 4. Subject Category of Cited Journals in Rank Order of Citations

	No. of citations	No. of cited papers
Medicine, general	127	19
AIDS	86	15
Respiratory system	42	2
Tropical medicine	29	9
Pathology	29	4
Infectious diseases	19	3
Public health	16	5
Microbiology	10	2
Neurology	7	1
Hematology	6	1
Substance abuse	5	2
Parasitology	4	1
Multidisciplinary	2	1
Obstetrics & gynaecology	2	1
Immunology	2	1
Pediatrics	1	1
Gastroenterology	1	1
Demography	1	1

The articles were mainly cited in the text of other articles (65%), in reviews (18%), in letters, notes, editorials, and meeting abstracts (9%).

According to the address field, 38% of the articles were authored by individuals affiliated to universities, 30% to health care institutions, 22% to government agencies, and the rest to various other institutions. Research was mainly oriented towards clinical medicine (52%), and only a small proportion towards biomedical research (6%); seven of the ten most cited papers were clinical-medicine-oriented (Table 5).

Table 5. Ten Most Cited Papers (Rank, Article, Institution/Country, and Citations)

1. Cortes Ed, R Detels , Aboulafia D, Li XI, T Moudgil, Alam M, A Bonecker Gonzaga, Oyafuso L, Tondo M.(1989). HIV-1, HIV-2, and HTLV-1 infection in higher groups in Brazil. New England Journal Medicine 320 : 953-8, (Federal University of Rio de Jeneiro, Brazil) (104 citations).
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4. Discussion

The intensity of the research activity in the AIDS fields is increasing while the epidemic is spreading rapidly in the countries of the region.

We were aware that an important drawback of MEDLINE is that only one author affiliation is provided, despite this, we were able to identify that the distribution of the publishing activity in geographical and institutional terms is highly skewed, i.e., the greatest proportion of articles are from Mexico and Brazil, which are also the two countries that have reported the highest number of AIDS cases[14], have the highest national populations, and have a relatively large and strong scientific community[15, 16, 17].

The ten most cited publications were clinical reports, with the exception of three epidemiologic studies. Seven of the ten most cited papers were originated in health care facilities, while 30% of the total publications of the region originated in this kind of institutions. None of the articles dealing with biomedical research were among the 10 most cited.

Universities, some of them with affiliated teaching hospitals, played the most active role, whilst governental agencies showed more limited publishing activity. It is noteworthy that government officers authored 22% of the total publications, even when their main activity is not meant tobe an academic one. In Mexico a different pattern is observed : most of the health sciences publications are originating in the health sector[18]. However, we found that none of the ten most cited papers were published by authors based in government agencies.

The results suggest that researchers of the region have been fairly successful at targeting foreign journals which could be an indication of the quality per se, and perhaps, that appropriate research is being conducted in some countries, although we assume that some of these publications might be focused towards the self-interest of developed countries. For instance, treated and untreated opportunistic infections are far more prevalent in developing-countries, therefore, the feasibility of learning from studies with a larger sample group arises from the publication of clinical reports from these countries.

The motives of Latin American and Caribbean researchers in using prestigious journals may also reflect individual efforts to reach the international scientific community and gain career visibility.

Clinical research predominated in the AIDS field in a similar way that it predominates in other health areas[19], and in a similar way that AIDS dominates clinical practice in the industrialised countries[20]. The relative success of published articles from LAC countries may rely on the need for information on bacterial, viral and micotic infections characteristic of AIDS patients which are relatively less frequent in developed countries or by a genuine interest in the epidemiological variability in the Latin American and Caribbean region for comparative purpose.

The smaller number of cited papers in other areas, could also be indicative of this pattern. For example, basic sciences were poorly represented because LAC countries may be comparatively disadvantaged. Reports from the social sciences were also lacking, however, this finding could be due o methodological flaws (i.e., search in MEDLINE), but it could also indicate the relative low impact of these types of papers on the high-productivity authors who were also the most heavily cited.

Our results could be used to inform govern-

ments and funding organisations where resources for research may be re-directed, and could also be used in determining "return-for-investment" in research grants.

Given the impact of AIDS on the LAC region and in health care services, research should be priority with manpower planning being a short-term goal.

The need to be updated with new knowledge produced worldwide about HIV and AIDS, and the need of disseminating the lessons learned in a region, which is geographically and culturally vulnerable, mandate and wider and stronger diffusion process.

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Integration Ways into European S&T Domain Results of the Sociological Study

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During the last three years STEPS Centre have been carrying out the research project devoted to the problems in the National Academy of Sciences in transition period. One of the tasks of this project is to study the ways and prospectives of the international scientific co-operation of the Ukrainian scientists, participation them in competitions held by international, foreign foundations and S&T (science and technology) programmes. In the last decades international co-operation has strongly intensified in the scientific community. But the studies of the international co-operation of the scientists from transition countries have begun only recently.

In the course of the project various of S&T indicators are monitored by way of statistical data analysis, the latter were taken from reports on institutes' activities, surveys of scientists, which included the use of a single questionnaire with broad set of questions, and experts interviews, made in the institutes among the heads of scientific departments. The results obtained in this project enable us to make some general conclusions on the scale and critical points of crisis in S&T system as well as to outline possible scenarios on how to come out of it.

Keywords : transition period, science system, scientific international co-operation, sociological study, academy science, kinds of co-operation, economy crisis, scientific results, economic indicators, financial problems.

1. Introduction

Crisis, caused by the market transition and in consequence of crisis in S&T system of Ukraine made its unfavourable and broadscale impact on the academy sector. This sector is the important component of the science system, which embodies fundamental science on the whole, possesses its own unique genesis and structure and cannot rely upon support coming from newly-emerged business entities, but has to be supported by the Government. 1994-1996 were marked by a number of sociological studies held in academy institutes within the framework of the international project aimed at analysis of transformation processes within S&T systems of the Central and Eastern Europe and the former USSR[1-3,5,8].

2. Distinctive Features of Academy Sciences in Ukraine in transition

During the recent 5 years the level and conditions of doing researches in the academy institutes were objects of drastic worsening. Economy crisis and funds shrinkage in S&T system led to deficiencies in financial and informational support of researches done, curtail in scientific communication, deforming of links with users of S&T results and products.

During analysed period such processes were monitored, as cut of funds allocated in science, decrease of academy budget, inflation growth. On

account of shrinkage in contracted (from outside partners) projects, disruption of Al-Union programmes ways and methods of funds inflows changed to a considerable extent, priority being assigned to budget sources.

Breakdown of finances in the institutes for research activity underwent cardinal change L costs for S&T projects fell down, so much so their level reached down the lowest possible point, which is unimaginable and unacceptable in normal conditions (we mean costs for literature, information sources, arrangement of various meetings, conferences), as for equipment, the level is also the same; but, as regards costs meant for personnel payments and overhead costs, their shares increased considerably.

External, e.g. socio-economic, conditions caused reorientation of institutes' projects. The scope of researches of fundamental nature was kept intact in general, but shrinkage tendencies were observed as regards their support level, as well as conditions in which they had to be done. On account of economic crisis, cessation of former major All-Union projects and programmes, the share of mission-oriented researches and applied ones in particular, decreased, and this is true as regards the projects done on the contracts entered with industrial enterprises. Scientific results did not reach their potential users, e.g. production sphere and society as a whole, and this adverse process has been gaining forth. Former ways of S&T innovations transfer to users ceased to be effective, but market ways did not started working because of grievous conditions in economy.

Rotation and migration tendencies among research personnel increased (Table 1).

Table 1. S&T Personnel of the Ukraine Academy of Sciences (*in thousands*)

Indicator	1990	1991	1992	1993	1994	1995	1996
Total S&T persons	87.0	81.0	73.0	69.0	61.0	55.0	50.0
Total researchers	18.0	17.0	18.0	17.0	16.0	15.0	14.0
Doctors of sciences	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Candidates of sciences	11.0	10.0	11.0	10.0	10.0	9.0	8.5

Statistical data on S&T personnel show a continuous decrease, due to the unfavourable economic conditions. Year after year the inflow of young researchers had been decreasing, the most gifted scientists were forced to leave S&T domain. During recent five years the academy institutes have been living through the process of "ageing" of personnel concerned. The total number of S&T personnel decreased on 40% for the 1990-1996. These rates of decrease, can be explained in a way, that the institutes started to practice enforced vacations without payment several months long, this practice being accepted in order to keep intact the institutes' potential; the whole departments and research teams (sometimes and the whole institutes) are being assigned the status of those working part-time; redistribution of shrunk budgeting from governmental sources in favour of labour costs, etc. All these measures comprise "survival strategy" of science, designed to keep personnel. But it has its back side - ageing of scientific staff, which would lead to the ruining of scientific schools and fields, especially if seen against fall down of science's prestige in society.

The grave economic situation in Ukraine made its influence on the respondents' opinions and views. When asked, whether or not they are satisfied by their research activities during the analysed period of time (1990-1995), respondents gave their opinions, which are distributed in the following way :

The level of satisfaction

increased	17%
the same	33.5%
decreased	48.7%

The level of research projects' fundamentality

increased	15.3%
the same	31.4%
decreased	53.3%

The level of jobs security

increased	13.5%
the same	27.6%
decreased	58.9%

Experts' opinions vary. Some of them suppose, that changements are not considerable, that the scope of basic researches was secured and even added : "The scope of fundamental researches became broader. Scientists do their utmost to extend it... In our department there always had been works and projects, which we did with willingness to promote our country's development. Now they are disrupted, but not because we are reluctant to do them, the reason is lack of funds for their support. There are no major projects which would integrate efforts of researchers and scientists in mathematics, cybernetics, economics and other fields".

"In our case, - said the head of department from the institute of chemical profile, - we'd better speak about how to secure existing level, and, may be, even to broaden basic researches to some extent, because we are trying to reinforce the chain from its starting point till the very finish, e.g. from fundamental researches up to the marketing and commercialization of them".

But, many persons still feel, that influence of external factors led to re-adjustments of projects' content in favour of extension of applied R&D : "All the works of fundamental nature are secured. But our conditions made us start doing applied researches too, hence, both in the department and in the institute on the whole there was re-adjustment in favour of applied R&D, but it's not us, who are to blame for this".

In the academic institutes of the technological profile such re-adjustment is seen as a necessary means, which could help &T system to enter market domain : "I think, that academy institutes should adopt different approach to compiling the list of fundamental and applied projects. They should realise the need to respond to every changement. We should remove bottlenecks in all the stages of the integrated S&T cycle. If any bottleneck exists, the whole of S&T system would fall apart and be ruined".

2. In Search of New Research Strategy

New development concept the law on autonomy and new statute, adopted by the Academy in 1991-1992 were steps on the way to assign independent status to the institutes which involved such issues as research strategy design and their inner organizational, managerial arrangements.

Institutes' independence became reality, but the environment in which independence could have brought positive results, was not adequate because of extension of crisis, weakening and ruining of academy infrastructure. Decentralizing tendency in the Academy of Sciences, in fact transformed the institutes into the entities, which became "the cells in the whole body" of its organization.

Present stage in the development of academy institutes is marked by the strategy, which can be called "revival at any cost and means". It denied such measures as cardinal institutional, cognitive, personnel transformations, and was implemented under the principle - to survive in a form, in which they found themselves in crisis. In course of implementing such strategy various kinds of compromises and concessions were put into work : putting aside objects and tasks of basic researches, entering into any sort of contracts, separation, liquidation of pilot production divisions, if not leaving them on their own, adoption of part-time working patterns etc. During the period of crisis the Academy has adopted the way of "minor steps" in reforming process.

Despite of many common things, which mark the process of transformation in the Academy institutes, their present condition, capabilities to adopt to unstable economic conditions and future development prospects differ. This can be explained by the difference of science fields, in which they operate, and (to a considerable extent) by the content, forms and methods of science policy, pursued both inside and outside the institutes. Great importance is assigned to democracy principles in relations among colleagues in the institute, opportunities to display individual initiative while se-

lecting projects, participation in S&T projects competitions, in looking for users of S&T products and results, partners for joint projects, while setting up contacts abroad, designing specific steps aimed at improvement of research organization and management.

The process of adaptation to new condition is better in the institutes, where extension of independence in divisions, departments and research teams has enhanced opportunities for better researchers' initiative while looking for new sources of funds for doing R&D, including those from abroad. The institutes, which were successful in reorienting their basic and applied researches to the needs of local (Ukrainian) economic sectors, avoided crisis caused by disruption of All-Union S&T programmes, succeeded intact the level and scope of basic researches.

Worse conditions were observed in large S&T complexes of the Academy, which earlier had been involved in major space and defence (military) programmes. Disruption of these programmes (after the breakdown of the USSR) stroke a blow on such institutes.

Efforts aimed at reorientation to the industry of Ukraine, which itself is in a grave crisis now, failed to bring about any perceptible results. In such institutes the process of shrinkage in mission-oriented and applied projects was observed, contracts stopped to add to their budgets. This forced the institutes to fire personnel, to close some divisions, which failed to get financial support by means of entering contracts with ministries, governmental agencies, entreprises, and, moreover, in a number of cases "lost" their experimental, pilot and production facilities. In condition of crisis some of the major Academy S&T complexes were to be divided into a number of separate and independent institutes, to assign independent status to their pilot and production (logistic) facilities. Valuable personnel capabilities of such complexes were decreased greatly during the most recent years and in fact were not added by young researchers. Now they are living through the period of stagnation.

3. Relations with World Science

Important and real opportunities for basic science to survive and to adopt to new conditions, marked by the crisis and uncertainty, are seen in —

- the extension of international scientific cooperation;
- the transformation of its forms and ways;
- the promotion of S&T results abroad
- the active participation in competitions, arranged by various foundations and programmes on S&T development promotion.

The analysis of international cooperation trends in the academy institutes gives us certain consideration and evidence in favour of this idea.

Upto now such factor of S&T system transformation , as international scientific cooperation, has been analysed only from "brain drain" point of view[4,5].

Before the breakdown of the USSR the Academy of Sciences of Ukraine was very active in international S&T cooperation.

But the highest rank in the list of priorities in this domain and traditionally been assigned to institutes' participation in joint research projects with the Academies of sciences, S&T establishments and universities, colleges in the former socialist countries, as well as to tasks, carried out in accordance with cooperation plans and programmes, signed by the states-members of the former socialist countries.

Here we are going to quite some data on international scientific cooperation in a large academy institute (the division of physics).

In 1990 the institute held joint projects with the academies of the former GDR, Poland, Bulgaria, Czechoslovakia, Yugoslavia, China on 32 fields, including 15 carried out on the basis of direct cooperation (e.g. without any intermediary agency). Joint research projects, held with physics institutes of the academies of GDR, Czechoslovakia, Poland proved to be the most effective and long-standing. Cooperation with the other countries also had been taken place in that period, but its scope and level were rather low when compared with the one mentioned above. Thus, cooperation with S&T institutes of Austria and Finland started as early as in 80s and has been going on upto

present time. Beginning with 1991 on account of socialist system destruction cooperation with a number of aforementioned countries, mostly with GDR, Yugoslavia and Bulgaria started to weaken or stopped at all, but some projects on contracts signed by the academies or within the framework of CMEA programmes went on upto 1992.

In 1992 the position of the institute in international S&T cooperation altered considerably. The institute had held joining research projects with institutes from 7 countries : Austria, Finland, Germany, Poland, Czechoslovakia, Romania, China on 11 fields. On the whole, the scope of joint researches, if compared with the previous year, decreased to a considerable extent. In 1993-1994 the conditions did not alter : the institute held joint researches with 7-8 countries on 10-11 fields.

In another institute (not so large, set up in 1989, chemistry division) international cooperation trends proved to be more optimistic for the period of recent 5 years. 1990-1995 were marked by the increase in business trips abroad, e.g. from 13 to 59 persons of the institute concerned. It should be noted here, that the number of persons, who left for long-term trips in 1994, reached 27% of the total trips number. In 1994 the institute held 12 joint projects with institutions from 8 countries, e.g. 4 times more, than in 1990. As for the spectrum of partners, it was broadened and included the institutes of the academies of Poland and Slovakia, S&T institutes from Britain and Germany, firms and companies from the Netherlands, the USA, Switzerland, Germany. Geographic area of cooperation has altered too. Earlier it had been held within the framework of All-Union programmes, international CMEA programmes. Now it is aimed at penetration into S&T markets of Central Europe, the USA, Japan, Canada. Contacts with CIS countries are shrinking due to financial and transport (communication) problems.

During the most recent years on account of grievous conditions observed in Ukrainian science system the number of visits by foreign colleagues has been decreasing considerably, possibilities to host international conferences which is previous periods had been taken for granted, are becoming more and more limited. Anyway, visiting of our institutes by foreign colleagues and business people is uncomparable with the outflow of our specialists abroad. The process of joining the international scientific community by Ukrainian scientists may be described in the following way.

Removal of various obstacles and constraints to cooperation was an important factor contributing to scientists' inclination and stimuli to set up close international contacts, whereas in former periods these conditions had been regarded as strongest barriers for that. Many experts observe, that during the most recent years scientists "got their hands untied". Barriers associated with secrecy of S&T projects, which contributed to defence potential this or that way (sometimes it happened, that such contribution was so negligible or uncertain), were particularly strong. Their removal resulted in vigorous efforts to publish scientific results in foreign periodicals and participation in international conferences and symposia.

Opportunities to take part in competitions for funds, held by various foreign foundations et up with the purpose to promote S&T activities, became the second factor in the list of those making the greatest positive impact on international cooperation progress. But, according to experts' estimation, grants given by international and foreign foundations (average number of such grants in each natural sciences or engineering institute is 5-10) cannot replace national system designed for science promotion, although they in fact stimulated extension of publications abroad and enabled our scientists to take part in international symposia, conferences, meetings on a much more considerable scale (if compared with previous period). It should be noted, that earlier participation of our scientists in international scientific forums was quite limited, and "nomenclature" aspect of participants selection procedure played here one of the most important roles.

One of valid factors was quite considerable extension of publications in foreign and international periodicals. In table 2 there given the data on publications in journals, for two institutes.

As for the first one (chemistry division), there has been observed consistent growth of publications along with slight decrease of their number in local scientific journals. As for the second one (Physics division), its publications abroad

accounted for 1/2 of the total number of those in local S&T media, but during the most recent 5 years their number has decreased by 1.5. In all the institutes there was observed the decrease in the number of published monographic works, which was caused not only by shrinkage of publishing capabilities and facilities in the Academy, but also by the growing number of unique results and the need to perceive them more deeply and thoroughly before their publication. The total number of publications of the Academy of sciences of Ukraine have decreased for the period 1990-1995 almost 40%, the numbers of monographs, collections and articles dropped to 1994, but in 1996 they grew up once more (see table 3).

Table 2. Number of Publications in Journals (*for two Academy Institutes*)

Years	Total Number of publications	Including in foreign journals	Total number of of publications	Including in foreign journals
1990	160	12	370	58
1991	162	23	317	48
1992	156	23	330	70
1993	135	44	356	94
1994	143	45	320	125
1995	157	52	295	147

Table 3. The Number of Scientific Publications of the Ukrainian Academy of Sciences

	1990	1992	1994	1996
Monographs	437	407	264	277
Collections	305	175	148	191
Articles	15063	15390	12752	12799
Articles for 1 scientist	0.9	0.9	0.8	0.8
Monograph for 1 scientist	0.04	0.04	0.03	0.03

But the number of articles published abroad has increased in total value of articles by 25%. According data from the Science Citation Index, 17% of all Ukrainian collaboration papers in 1996 are done together with the Russian scientists, 12% - with USA scientists, 11% - with Germany scientists.

The growth of publications abroad is observed along with their decrease in Russian journals, which earlier were regarded by our scientists as those embodying international scientific community as a whole.

Experts interviewed in the institutes observed, that while entering the world scientific community via publication channels Ukrainian some scientists come across such barriers, as "language one", others find, that some researches are not ranked in the world as ones possessing critical importance and significance, still others find, that long experience of working on "secret" (defence) projects causes a sort of a trouble for them too. Scientists welcome their publications in English and Russian in local scientific journals, which also promotes the process of informing the world scientific community on the progress in Ukrainian science.

The survey by way of questionnaires revealed, that among the whole set of factors and methods of international cooperation preference was given

to publications in international and foreign journals, information exchange, correspondence and personal contacts during conferences. Those quested opine, that international scientific relations make considerable positive impact on the level and quality of research projects being done in the institute (70% of total number of quested), on the uniqueness and ambitiousness of their ideas (45%), research projects effectiveness (40%), social involvement of researchers (54%).

Below we are going to give estimates, indicating significance of such factors.

i) Each scientist has the right to work elsewhere, if there would be the best conditions there, which could enable him to apply his capabilities in the best possible way, whether it would be in his native country or not — 64%.

ii) A scientist must regard promotion of science in his own country as his first and foremost duty — 59%.

iii) One needs training abroad, but in his own country he needs to apply acquired knowledge for the benefit of national economy — 54%.

iv) I regard the practice of inviting scientists from one country to any other one by any possible means, often quite dishonourable and unworthy ways and methods, as immoral one — 10%.

v) As for science system and researches, universal criteria are applied here : the most talented scientists are to be provided by modern equipment and best working conditions, because progress of science is expectation of the whole humanity — 74%.

vi) Scientific and economic assistance for poorly developed countries is moral responsibility of all the scientists, in whatever country they are working now — 21%.

Besides, many scientists can see very distinctly excesses and adverse aspects of international scientific cooperation at its present stage, when Western science centres and businessmen, in order to profit from grave conditions of post-soviet science, are striving to get for nothing any "crude" intellectual resource, which is available and can be pocketed quite easily. Present migration of scientists from CIS countries is much more transforming into the process, promoting strengthening and progress of S&T capabilities in foreign countries.

Many scientists realise, by way of their own working experience in some foreign countries, that this process is in fact nothing, but "pumping" our national intellectual resources to the West[7]. To forward this process along civilized path, to turn it in such a way, so as the national S&T system too could has profited from it, is very important task for Eastern European and CIS countries, which is not easy to solve in a moment.

4. Conclusion

Sociological study revealed contradictory state and image of international scientific cooperation in the period of transformations within S&T system. During the most recent period there has been observed the process of giving up major intergovernmental S&T programmes (within the framework) of the former socialist countries), which generally involved participants of the academy institutes, on the one hand, and the notice activation of individual contacts, on the other, entering the world scientific community by our scientists by the way of their own initiative and efforts, e.g. through publications abroad, participation in projects competitions, conferences and symposia. Such "personalisation" of international scientific cooperation is one of new prominent features, which will be gaining forth in the future. It's beyond any doubt, that present boost of publications abroad will be replaced by some recession, because poor conditions in science are now hindering the further progress, and, therefore, the most recent scientific results are based on those, which had been got before the coming of post-socialist era. Such stocks of the past are not ever-lasting and being gradually exhausted . The boost of publications abroad (along with their decrease in local journals) is stimulated by and aimed at getting grants from abroad, but as for new unique scientific results, this aim and object is not assigned priority rank here, and, hence, no correlation was observed between the former (publications boost) and the latter (uniqueness of results).

As for applied science, is future progress and ways to outcome the crisis are seen in the perspec-

tive of economy recovery and extension of the scope of contracts with firms, enterprises, etc., whereas basic science prospectives are, anyway, seen in the perspective of approaching world science foreposts, which would be possible only by way of activation of the variety of international cooperation forms. While bearing all this in mind, it's difficult to over-estimate those first steps in that direction, which have been done during the most recent period, and, it their turn, caused many problems for our science. Along with informing the world scientific community on the progress of our sicnce, all forms of cooperation mentioned above tend to remove so- called "uneasiness", instinctively and mindfully felt by our scientists at that very moment of time, when they find themselves to be on the threshold, opening them the new, much more immense science domain. Work in laboratories abroad, carrying out of joint projects enable to do such researches, which are quite often impossible to do at home using local facilities, which are becoming much more out-dated, but not only this. It's promoting the progress of projects renewal, giving preference to those which match researches done by foreign colleagues. All mentioned above, while taken together, promotes removal of various kinds of "curtains", e.g. those which were vices of the soviet era, and contribute to the future breakthrough of our science.

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Citation Histories of Most-Cited Articles From Turkey

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I have studied 37 highest-impact articles from Turkey that were published between 1980 and 1989 and cited upto 1995. These are in a very select group of articles (in the 95th percentile) that ISI processed during the 1980s. The articles received a total of 2016 citations from 1980 to 1995 inclusive, averaging about 4.5 citations per article per year. On average, the citations to 15 biomedical articles reached a maximum four years after publication whereas the remaining 22 articles (included in the group called "sciences") attained their maximum in three years after publication. We found that citation lifetimes ranged between 14 years for biomedical articles and 15 years for "science" articles. The citedness of articles seems weakly correlated (linear corr. coeff. r = 0.48) with the number of bibliographic references they contain.

1. Introduction

Publishing and referencing behaviours of Turkish physicists, and astronomers have been studied extensively in recent years[1-4]. However, previous work has not examined how long typical, or most-cited Turkish articles are cited. Are they cited for only a few years, or do articles have an impact for years? Is there a relationship between the readership of articles and the number of references they contain?

We attempt in this work to answer these and other similar questions based on the analysis of highly-cited articles coming from biomedical sciences, and from physics to astrosciences in Turkey. These are the articles that were published from 1980 to 1989 and cited upto 1995.

2. Data and Method

I considered the 37 articles that were identified as most-cited in the Integrated Citation Files (ICF) of ISI- data base, and presented at a symposium in Istanbul in 1991[5]. These are the articles that listed author all from Turkey, or the first authors's address from Turkey.

Citations to these articles starting from the year of publication upto and including 1995 were counted from SCI on CD-ROM to yield their citation histories. I classified these articles into two broad areas : The biomedical sciences, and "sciences" because of the differences in citation customs of authors in these areas. Including self-citations I counted 718 citations to 15 biomedical articles, and 1298 citations to 22 "science" articles in 16 years to give average of about 48, and 60 citations per article respectively.

We note that

(1) the "effective" number of years an article has been out between 1980 and 1995 is really less than 16, and to first approximation, it is calculated to be about 12. This is the mean number of years 37 articles can be considered to have been out in the period 1980-1995.

(2) even the most recent articles, e.g., those appeared in 1989 have been out long enough to enjoy their citation peaks since this happens when articles are 3-4 years old[6].

3. Distribution of Articles by Field and Institution

The distribution of 37 articles by field and institution is given in Table 1. Some of the highlights that can be found from an inspection of the table are —

(1) A subset (four biomedical, and seven "science") of articles account for at least half of the citations in their areas.

(2) Three of the four biomedical articles deal with various aspects of ataxia telangiectasia, an hereditary multisystem disease, which may be one of the most common genetic disorders of mankind. The condition is more prevalent in the Mediterranean countries, and spreads across the Middle East to India, Thailand, and China[7].

(3) The most-cited article (176 citations) is a review article in "science" describing the plate tectonic evolution of Turkey. The second, and the third most-cited articles are on neutron stars, and quantum mechanics of H-atom. It is interesting to note that the Nobel laureate physicist Philip W. Anderson is a co-author of the paper dealing with neutron stars[4]. More than 50% of the biomedical articles goes to a single address, Hacettepe University in Ankara, whereas Bosphorus (Bogazici) University in Istanbul, and the Middle East Technical University (METU) in Ankara, taken together, account for about 55% of the most-cited articles in "science".

Table 1. Distribution of Articles by Two Broad Fields, and Institutions

Broad field	No. of articles	No. of citations	No. of articles (subjects accounting for 50% of citations)	Name of the Institutes listed in articles
Biomedicine	15	718	4 (hereditary multi-system disease, trigeminal system, and gene)	Hacettepe Univ (9)* Cumhuriyet Univ. (1) Dicle Univ. (1) Aegean Univ. (1) Gulhane Mil. Acad. (1) Istanbul Univ. (2) Tubitak (1)
Science	22	1298	7 (plate tectonics, neutron stars, ethyl acrylate networks silicon surfaces, path integrals	Istanbul Univ. (1) Bosphorus Univ. (3) Dicle Univ. (1) Ankara Univ. (1) METU (2) Istanbul Tech. Univ. (1)

*The figures in the parenthesis give the number of times the institution's address is listed in the articles.

3.1 Citations Histories

The citation histories for biomedical articles, "science" articles, and all articles are shown in Figure 1. We observe that the biomedical articles reach a maximum of 6.3 citations per article per year four years after publication. The maximum for "science" articles is 5.5 citations per article per year three years after publication. It is surprising to observe that both biomedical and "science" articles have lifetimes not longer than 15 years. This is estimated to be about half of the lifetime of a good astronomical article published in the two high-impact journals : The Astrophysical Journal (ApJ), and the Astronomical Journal (AJ) in the 1960s and 1970s[8]. Nevertheless I should point out that in this comparison I have not taken into account neither the publishing and referencing dynamics in science in general nor the growth of the ISI's data-base over the time span of more than two decades.

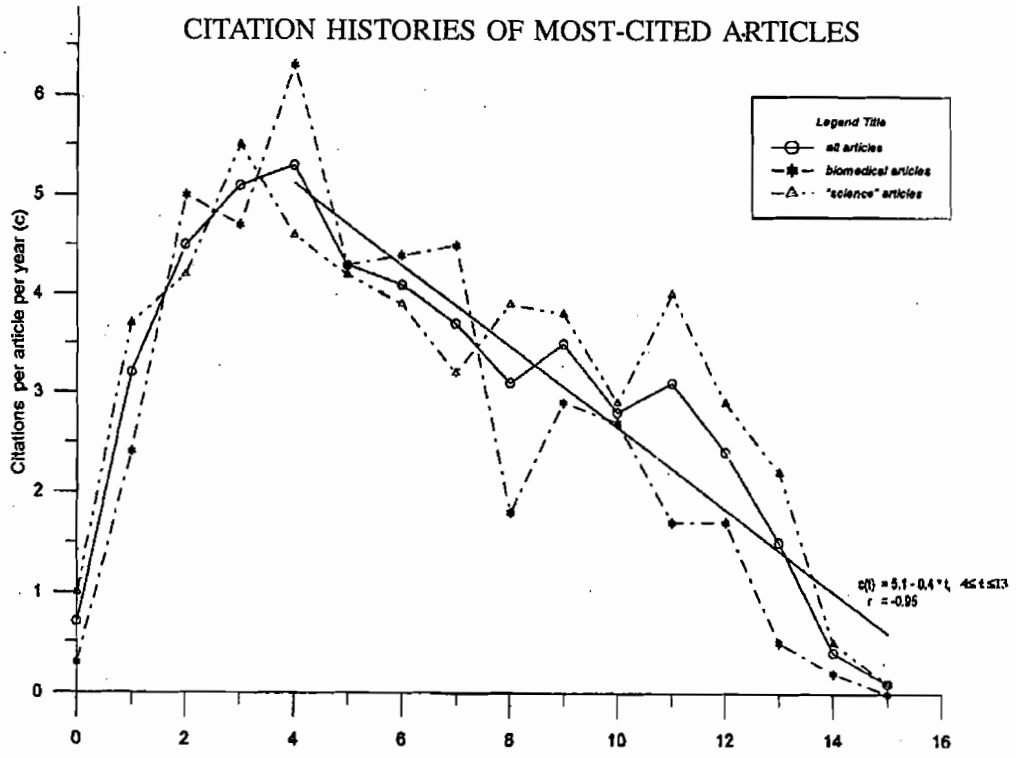

Fig. 1. The Mean Number of Annual Citations Per Article for Biomedical, "Science", and All Articles

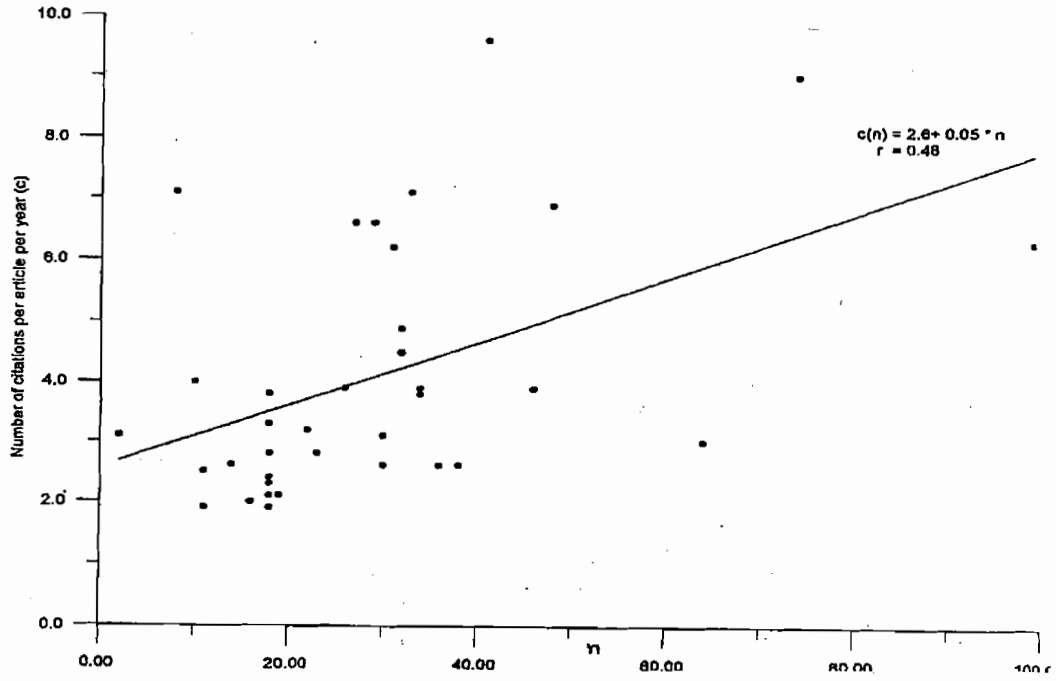

Fig. 2. Average Number of Citations Per Article Per Year Containing n References, and the Number (n) of References the Articles Contain, 1980-1995.

It is worth also noting that the curve for "science" registers rather capriciously a secondary maximum of 4.0 citations per article per year eleven years after publication. This can be attributed mainly to a new surge of citations, to the article on place tectonic evolution of Turkey, around 1992. Just as interesting to note that one of the series of International Conferences of the International Association of Volcanology and Chemistry of Earth's Interior (IAVCEI) held at METU in Turkey in 1993. Certainly, more work is needed to put forward any relationship between scientific meetings and the rate of citations to articles in a field. A final note is that the decline after maximum for all articles is linear (with r = -0.95) with a rate of -0.3 citations per article per year, implying a half-maximum that occurs eleven years after publication. This coincides, accidentally, with the secondary maxima of the articles included in "science".

2 *Citedness of Articles and the Number of References They Contain*

The relationship between the numbers of citations articles receive and the numbers of references they contain is probably the least studied in the content of bibliometrics. We know one classic paper[9] conjecturing very small correlation between the number of times a paper cited and the number of bibliometric references it contains.

Figure 2 shows the number of citations per article per year containing n references, and the number (n) of references the articles contain. The single review article on plate tectonics which contains 203 references is an outlier and it is not included in this graph. The linear fit, with r = 0.48, exhibits relatively low but still significant correlation between the number of times the set of 36 most-cited articles are cited and the number of references they contain. The fit shows that for every 10 references the number of citations per article per year increases by a factor of 0.5. There are, however, a few articles of which the number of citations per year shows large deviations from the line of best fit. One of these is the article containing 41 references, and co-authored by M. A. Alpar and P. W. Anderson on vortex creep and the internal temperature of neutron stars. This article has an average of 0\9.6 citations per year comes from biomedical sciences (pharmacology) on tracheal epithelium releasing a vascular muscle relaxant by M. Ilhan et. al. At the other extreme there is an article from chemistry that contains 64 references but receives only 3.0 citations per year.

4. Conclusion

In conclusion, the results of this paper show that the most-cited Turkish biomedical, and scientific articles have significant impact on research for about 15 years. However, without adjusting for publishing and referencing dynamics of researchers, and with similar reservations, we can say that the lifetime o 15 years is about equal to only half-life of a good article published in a high-impact journal like the Astrophysical Journal, or the British Medical Journal. Another finding is the apparent imbalance in the institutional affiliation of authors of the most-cited articles : Hacettepe University in Ankara appeared 9 times in the address list of the medical authors, whereas the second most frequent address is the Bosphorus University in Istanbul appearing only 3 times. A final finding is the linear correlation of r = 0.48 between the number of times the articles are cited per year and the number of bibliographic references they contain.

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Citation of Publications of Latvian Scientists - Comparison of Two Periods : 1986-1990 & 1991-1995

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The present work gives general data on the citation of the SCI publications in the field of natural sciences during 1986 - 1995, as well as the citation of different publications of Latvian authors. Two periods (1986-90 and 1991-95) have been compared in order to assess the impact of the transformation process in Latvian science connected with the restoration of the state independence and the change in the economical policy in the publicational activities of scientists and the citation of their publications.

Keywords :Publications, citation, transformation processes.

1. Introduction

In 1990, the restoration of independence in Latvia posed a necessity to evaluate the potential of our science and technology thoroughly. The organisational structure of the research and development in the former Soviet Union was a strongly centralise, hierarchical system. That is why there was no necessity of assessing the potentials of separate regions. The overall contribution of the USSR scientific output to the world science did not allow to assess the science potentials of its constituent regions, and among them that of Latvia. Studies of the bibliometrical indices of the science of Latvia, Lithuania and Estonia, as well as citation of the Latvian authors were started in the 80s by J. Kristapsons[1], and continued in his works with collaborators[2].

Science in Latvia, that has earlier been a constituent part of a large country's science, is gradually being transformed into the science of a small country. One of the advantages of a small country is a possibility (and even a necessity) to follow all the activities of the scientists and to assess the contribution of each scientist, as well as each scientific school, team or institution, to the common scientific potential of a country.

In order to assess the scientific potential in general and that of every researcher or the institution, such indicators are used : the number of SCI publications an the citations of publications. It is true that the "quality" of scientists and their achievements cannot be quantified, and every estimate is subjective. However, on the aggregated level of a scientific branch and for the comparison of the results of scientific teams and institutions these indices are still reliable. According to E. Garfield "...When a work is cited, it generally indicates that it is taken as being relevant to the citing author's research. Citations are thus, in a sense, also actually an indicator of productivity as well as impact..."[4]. It is true that citations are one of the many statistical indices, not sufficient for the use while forming the country's science policy. Yet, in this case the analysis of the citations of publications of Latvian authors is of interest for the scientific community in this country and can serve as the indicators (though relative) of the efficiency and the recognition of a scientist or a scientific

school among the colleagues. This is particularly important in the present period, when the transformation of the Latvian science system has not been completed yet, but the citations together with the total number of publications can be use as one of the possible criteria while distributing the scanty budgetary financing of science. The present work gives general data on the citation of the SCI publications in the field of natural sciences during 1986-1995, as well as citation of different publications of Latvian authors. Two periods (1986-1990 and 1991-95) were compared in order to assess the impact of the transformation process in Latvian science connected with the restoration of the state independence and the change in the economical policy on the publicational activities of scientists and the citation of their publications.

2. Methodology

Our study is based on the information from the Science Citation Index (SCI)[4]. We have done all the necessary work by hand, using the printed issues and databases on CD-ROM produced by the Institute for Scientific Information (Philadelphia, USA)[5]. The process in question differs very much from that of the large automated systems used to investigate the science of large countries[6]. However, the small volume of science in Latvia enables us to follow the dynamics of Latvian science both in general and in particular while assessing the activities of the researchers.

3. Results

The articles published in the journals covered by the Science Citation Index give a sufficiently true picture of the state of science in this country. To answer the question of how the citation of the SCI publications from Latvia (and for comparison with Estonia and Lithuania) have changed after the restoration of independence in 1990-91, we have counted the citations of publications of 1988-1989 in 1990 and of 1992-93 in 1994 (according to the Impact Factor definition), as well as the relative citation rates (RCR) according to the methodology of A. Schubert and T. Braun[7] (Tables 1, 2, 4).

In spite of the fact, that since 1989 more than 75% of employees have left the science system (especially auxiliary workers and researchers in Engineering sciences)[8], the number of SCI publications from Latvia has remained practically the same, at an average of 250 per year[9]. It might be expected that the number of SCI publications would decrease in the course of the transformation of science, because of the reduction in funding and in the number of scientists. However, this has not happened so far. One of the explanations is that the results, accumulated during the previous years, are now being published, and the second explanation might be related to the same authors of the SCI publications. There are very few new authors.

In 1994 the citation of SCI publications from the Baltic states increased 1.5 times for Latvia, 2 times for Estonia and 3 times for Lithuania (Table 1). The RCR values have grown, too (Table 2). Therefore, as previously, in all the three Baltic states the calculated values of RCR < 1, that indicate that the papers are, on the average, less cited than it had been expected[7]. The similar picture has been observed earlier.

Table 1. Citation of SCI Publications From Baltic States

	Total no. of SCI publications		Share of cited publications, %		No. of observed citations			
					per SCI-Publ.		per cited publ.	
	1988+ 1989	1992+ 1993	in 1990	1994	1990	1994	1990	1994
Estonia	441	503	28	41	0.64	1.16	1.32	2.84
Latvia	536	529	19	31	0.35	0.57	1.80	1.85
Lithuania	573	495	15	33	0.25	0.96	1.67	2.91

Table 2. Relative Citation Rate RCR

	Total no. of citations of SCI publications				RCR	
	expected		observed		1990	1994
	of 1988+89 of 1992-93		of 1988+89 of 1992+93			
	in 1990	in 1994	in 1990	in 1994		
Estonia	453	732	284	585	0.63	0.80
Latvia	376	528	185	301	0.49	0.57
Lithuania	356	639	145	475	0.41	0.74

The increase in the citation of SCI publications may be explained by the following factors. The re-orientation of scientists from the scientific area of the former USSR to the science of the whole world has taken place. The reasons of the re-orientation are as follows : the freedom in choosing and establishing scientific contacts, compared with the previous times; many researchers have the opportunity to implement their desire to maintain contacts with Western scientists. Latvian researchers have practically ceased publishing their articles in journals of the former USSR (with low Impact Factor IF values), and now they publish their articles in Western journals (with higher IF values).

The IF values for each year between 1986 and 1994 were calculated for Latvian, Lithuanian and Estonian SCI publications[9]. The period from 1986 to 1990 is characterised by relatively constant IF_{av} values for Latvian and Lithuanian publications, and there is slight increase for Estonian publications. Since 1990 in Lithuania and Estonia, and since 1992 in Latvia, the IF_{av} has started to grow considerably[9]. The changes in 1990-1992 coincide with the restoration of Latvia's political independence and the elimination of restrictions on the publications of papers abroad (as it was in the case of the former USSR).

The global tendency of increase international collaboration and international coauthorship[10] has also been observed as regards to Latvia. The international contacts with western scientists have been growing rapidly, including the participation in conferences, training sessions and the co-operative work in various scientific centres during different time periods.

The expanded contacts led to the increased number of joint publications with foreign authors. Before 1990 Latvia's scientists had has 16 joint publications a year with foreign authors (beyond the USSR); in 1995 this figure rose to 107[9]. As it is known, such joint articles, especially if written in English, are being cited more often[11], which has also been proved by our results, obtained by comparing the authorship of the cited SCI publications (Table 3). In 1990 7% of the articles published in 1988-89 with Western authors were cited. But the number of the citations of the publications of 1992-93 with foreign authors in 1994 increased to 37%. The number of joint articles with Russian scientists decreased from 22% to 8%.

Table 3. Authors of Cited SCI Publications

	% of cited SCI publications	
	1990	1994
Only Latvian authors	71	55
Latvian with USSR and former USSR authors	22	8
Latvian with authors from Western countries	7	37

The distribution of the citations has changed. The Russian scientists cite Latvian SCI publications a half less, and simultaneously the number of citations have increased in articles published by Western scientists and in joint articles of Latvian and Western authors (more than 70% now) (Table 4).

Table 4. Who Cited Latvian SCI Publications

	Total no. of citations	Self	In-house	Citation, % SU and former SU	Foreign	Joint In-house and foreign
1990	185	23	11	16	50	0
1994	301	16	3	7	43	31

Among the researchers chosen for the citation analysis were the leading scientists of Latvia, including the members of the Latvian Academy of Sciences, the leaders of the local scientific schools of different research fields, the authors of SCI publications. This selection was carried out on the basis of studies of scientific reports and publications in local scientific journals taking into account the representation of the main scientific directions developing in Latvia. Also, this selection highlighted the so-called "small country effect", which provides a good opportunity for the citation analysis of each Latvian researcher during different time periods.

The selection of such a great number of researchers for the citation analysis of their publications has been done in order to collect the statistical data on the citations of Latvian researchers, because similar data have never been received before.

While counting the citations, all publications, both SCI and "non-SCI", were registered, as the latter constitutes a greater part of every researcher's scientific output, and they should not be omitted.

The citation search has been done using the name of the first author of the publication, as ISI Science Citation Index contains the data of the citations only for the first author, and the data of the citations for the second, third and the rest of the authors are not recorded. We realised that counting the citations taking into account only the first author leads to the reduction of the total number of citations of that author. Nevertheless, we have decided to confine ourselves to those data.

We have collected information on the citations of publications more than 800 Latvian researchers during 1980-1995; besides, we have noted the absence of citations (i.e. in 1990 approximately 200 authors had no citations at all). The information for the period of 15 years (1980-1995) has been collected for the most often cited leading scientists and for the period of 10 years (1986-1995) for 150 researchers. The information on the citation for the period of 2-3 years (chosen at random) has been collected for 600 researchers.

The tables were drawn containing the data of the 100 most often cited scientists of Latvia in 1986-1990 (including the authors having more than 10 citations during a 5 year period), and the dynamics of the changes in their citations after 1990 (1991-1995) was assessed. For the comparison two 3-year periods were chosen : the first one prior to the transformation of science (1987-1989) and the second one relating to the recent time (1993-1995). Such a choice was due to the fact that in 1987-1989 the articles of the previous period were cited, while in 1993-1995 the results of recent changes in Latvian science could be observed. Table 5 presents the result of different science fields.

From the list of the 100 most often cited scientists in 1986-90 the authors having less than 10 citations for the second 5-year period (1991-1995) have been excluded. According to Tables 5, 78 researchers have maintained the previous level of citation. Eleven researchers have been listed for the first time additionally, mainly those under the age of 40.

The total number of citations during both periods has not changed considerably (there were 21 citations per one researcher, and now there are 28). However, the proportion of science fields and the distribution of the citations have changed. The citation of the publications in life sciences has decreased 1.5 times (due to medical sciences), and they have increased to about the same amount in the field of physical sciences (due to publications in solid state physics). The citations in chemistry has increased a little. The decrease of citation in

medicine can be explained by the effect of "ageing" of scientific personnel and the lack of young scientists in the field. On the other hand, the solid state physics and organic chemistry have always been well developed in Latvia (it can be proved by the fact that there were 25 researchers from the field of solid state physics and 21 researchers from the field of organic chemistry among 100 most often cited authors). The researchers of these fields have recently received more funding if compared with other science fields. Being more active in maintaining scientific contacts with their foreign counterparts they have managed to involve more young researchers and to use the possibilities to work together with foreign scientists abroad. As a result of this scientific co-operation, the number of joint publications with western scientists has increased (Table 3), there appeared more publications in most often cited scientific journals.

Table 5. Most Often Cited Latvian Scientists

	19871989						1993-1995					
	No. of Scientists	Number of citations					No. of scientists	Number of citations				
		Total	Self	SU	In House	Foreign		Total	Self	SU	In-House	Foreign
Life Sciences	**25**	**463**	**60**	**262**	**22**	**119**	**19(16)**	**315**	**28**	**78**	**10**	**199**
Medicine	15	268	24	215	8	21	9(9)	109	10	57	1	41
Biology general	6	92	26	25	10	31	5(4)	61	2	11	4	44
Mol.biol.& biotech	4	103	10	22	4	67	5(3)	145	16	10	5	114
Physics	**41**	**842**	**105**	**288**	**60**	**389**	**37(32)**	**1191**	**154**	**281**	**73**	**683**
Solid st. physics	25	526	76	211	45	194	22(19)	821	127	190	68	436
Theor. physics	6	197	9	49	8	131	6(6)	189	2	41	2	144
Astronomy	3	28	6	3	0	19	4(2)	38	5	11	1	21
Chemistry	**25**	**705**	**128**	**298**	**53**	**226**	**26(23)**	**923**	**119**	**242**	**35**	**527**
Organic chem.	21	633	124	250	50	209	22(20)	868	113	207	32	516
Math & Comp. Sc.	**4**	**54**	**2**	**27**	**4**	**21**	**3(3)**	**54**	**6**	**3**	**3**	**42**
Engineering	**5**	**79**	**1**	**51**	**-**	**27**	**4(4)**	**50**	**1**	**18**	**0**	**31**
Total	100	2143	296	926	139	782	89(78)	2533	308	622	121	1482

The increase in citation was observed with those scientists who have joint publications or grants with western researchers, attend international conferences more often or have been working in some other research centres of the world. The analysis of the most often cited Latvian scientists proves the tendency that the re-orientation of scientists from the Soviet scientific area to that of the world science has taken place. Scientists of the former USSR cite Latvian authors 1.5 times less, but western scientists - 1.9 times more. It can be concluded that along with the policy shift towards integration into the western science, a parallel process is taking place - the recognition of Latvian science by international scientific community.

Twenty most often cited publications of Latvian authors have been found (since the time of the publication upto now). The physicists are leading here also. This list contains 10 papers in physics, 6 in chemistry, 2 in molecular biology, one in biology, and one in medicine. Among them articles, monographs and reviews published in English have more citations. These articles are cited by foreign authors (except the countries of the former USSR) upto 75-90%. The monographs and the publications printed in Russian are mainly cited by Russian authors.

A number of applications using our bibliometric investigations for the Latvian science community can be mentioned here. For instance, the

Latvian Council of Science used some of the statistical data, the analysis of the character of the citations and the publications of Latvian scientists. The Council of Science has recently mentioned some factors that will influence the evaluation of the scientific activities of Latvian researchers. While allocating the grants, the projects whose authors have publications in the SCI journals will be given preference. The Council of Science has recommended that the degree of doctor habilitatus be conferred only on those scientists who have publications in the SCI journals.

4. Conclusions

The increase of the citation of the publications of Latvian authors took place in the period of 1991-95 as compared with 1986-90. This can be proved by the changes of the observing indices. The value of the Related Citation (RCR) and the total number of citations has increased. The number of the citations in western journals has increased, but the number of citations in ex-Soviet journals decreased.

The reasons of an increase of the citations of Latvian publications could be explained to a certain extent by political and economical process taking place in Latvia in 1990-92. Regaining the political and economic independence by Latvia in 1990-92 caused the changed in the publication policy of Latvian authors, as well as in the citation of their works. The scientific ties with the scientists of the former USSR have loosened. The general political development in Latvia is directed towards the co-operation with western countries.

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Mapping Oncological Research

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In this paper an attempt has been made to identify key authors in the field of Oncology and the pattern of collaboration among them. Key author clusters have also been developed and analysed to examine changes in them.

1. Introduction

Increasing specialization and complexity of scientific research and its increasing inter-disciplinary nature have been both the result and cause of collaboration in scientific research. Several useful tools and methods have been developed and adopted for understanding the nature of research in scientific disciplines. 'Collaboration' between two of more scientists can be taken to be an indication of the interaction between the areas of specialization of the scientists collaborating and/or between the two institutions/countries that they are working for. As such analysis of authorship pattern of papers in a scientific discipline or subdiscipline may provide useful insights into the nature of the discipline or subdiscipline.

Chambers Twentieth Century Dictionary defines the term 'Collaborate' as "to work in association with". According to Vidal and Villarroel[9] collaboration can be of different forms : e.g., collaboration

(a) on scientific publications
(b) on scientific projects
(c) on research contracts with businesses
(d) on patents, and so on, as well as collaboration depending on the institutions, countries, scientific areas etc [9].

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This area has attracted the interest of Sociologists of Science and in the recent years there have been quite a few studies on the subject. These studies have dealt with diverse aspects of authorship pattern and collaboration. With the objective of quantifying the findings of such studies many statistical tools have also been proposed to identify and analyze patterns of authorship and collaboration.

Price and Beaver used co-author relationships to investigate social structures and influence in science, and more specifically, communication networks[7]. The patterns of co-authorships have been examined by Stokes and Hartley and they have determined ways to identify the influential scientists in a field[8]. Balog and Broad have noted an increase in multiple authorship/collaborative research in several fields[2, 3]. Porter and Chubin have indicated the importance of collaboration[6]. Diamond has also stressed the importance of collaboration. He found that multi-authored papers received, on the average, more citations than single authored ones[4]. Peters and Van Raan applied co-author analysis to create clusters of collaborating researchers (faculty) in the field of chemical engineering. They found the co-author clusters to be meaningful with respect to the identification of research groups.

2. Objectives

The present study is an attempt to identify key

authors and to analyze the co-authorship pattern in the field of Oncology. This study is confined to published English language journal articles.

The objectives of the study are to :

(i) identify key authors in Oncology;
(ii) analyze the productivity pattern of key authors;
(iii) study collaboration among key authors;
(iv) generate co-author clusters in Oncology.

3. Methodology

For this study, bibliographic details of all English language journal articles published in the field of Oncology were downloaded from Medline CD-ROM for four sample years, viz, 1985, 1988, 1991 and 1994 and analyzed.

Table 1. Publications in the Study

Year of publication	1985	1988	1991	1994	Total
No. of publication	3434	3639	4810	4141	16,034

These 16,034 records formed the database for this study.

3.1. Operational Definitions

Following are the definitions of terms used in this study :

Key authors :

An author who has published ten or more number of journal articles in at least one of the sample years studied.

Co-author :

An author who has produced three or more articles with a key author.

Cluster :

An aggregation of a key author and all his/her co-authors during a year.

Equivalence Index (EI) :

A statistical measure of the linkage/association between two authors in a cluster. *EI* for a pair of authors (a key author and one co-author) has been calculated by using the formula :

$$Eij = (C(ij)/C(i)) * (C(ij)/C(j))$$

where $C(i)$ and $C(j)$ are respectively the frequencies of concurrence of authors *(i)* and *(j)* and $c(ij)$ is the frequency of co-occurrence of the authors *(i)* and *(j)*.

Centrality :

A statistical measure of the intensity of the linkages/associations for a given cluster with other clusters. This has been computed by adding the square of *EI* for all the links forming a cluster.

Density :

A statistical measure of the strength of the links that tie the authors making up a cluster. This is indicated by the mean value of *EI* values of all the links uniting a cluster.

The methodology adopted in this study was to use these concepts in order to map oncological research. In other words these indicators were computed for the data downloaded from MEDLINE database and inferences drawn.

4. Identification of Key Authors

In view of the large number of authors associated with the items downloaded from the database, it was necessary to restrict further analysis to items involving key authors only. In order to identify the key authors an author frequency file was created. For this purpose the records downloaded from the CD-ROM were uploaded into a CDS/ISIS database specially designed for the purpose and using this the author frequency table was generated. Further analysis was limited to the key authors and their co-authors. Twenty seven key authors were identified. K. Sugimachi was found to be the most productive author with 66 publications constituting about 0.41% of the database and over 10% of publications if only publications of key authors were considered. Y. Shimosato was the second most productive key author with 33 papers, followed by S. Hirohashi and M. Mori with 31 papers each, S. A. Rosenberg (29 papers), L. J. Old (22 papers) and W. M. Mendenhall (21 papers). These were five key authors who had published 20 papers during the period of study. Among the 27 key authors only 18 had published papers in all the four sample years. In the year 1991, all the twenty seven key authors had published papers. The number of key authors who published papers during the other

sample years is : 1985 (20 key authors); 1988 (25 key authors); 1994 (26 key authors). The production pattern of key authors during the sample years is presented in graph - 1.

***Key Authors**

1. K. Sugimachi
2. Y. Shimosato
3. S. Hirohashi
4. M. Mori
5. S. A. Rosenberg
6. A. K. el-Naggar
7. I. Miyazaki
8. H. Takahashi
9. R. R. Million
10. L. J. Old
11. W. M. Mendenhall
12. Y. Hayashi
13. Y. Maehara
14. M. Noguchi
15. H. Watanabe
16. M. Yamamoto
17. J. Y. Ro
18. H. Suzuki
19. M. Herlyn
20. H. Kobayashi
21. H. Kprowski
22. P. G. Natali
23. H. Kimura
24. W. H. Lee
25. J. E. Pontes
26. Y. Yonemura
27. T. Kobayashi

5. Collaboration Pattern Among Key Authors

Maps of pattern of collaboration among key authors were developed. These maps indicate two large groups with a concentration of eight and five key authors respectively. The other four groups identified were much smaller. The largest group comprising of eight key authors was found to be dominated by the pair, Y. Shimosato and S. Hirohashi (17 papers) and the pair I. Miyazaki and Y. Yonemura (15 papers). The second group with five key authors was found to be dominated by the pair, K. Sugimachi and Y. Maehara (23 papers) and the pair, K. Sugimachi and M. Mori (18 papers). The other key author pair that was found to have made significant input was that of W. M. Mendenhll and R. R. Million that contributed 18 papers. However this pair did not have any common links with the other groups.(Figure 1)

6. Formation of Clusters

Clusters (a key author and his collaborators) were developed to examine the patter of collaboration in the different sample years. (Table 2).

Table 2. Clusters

1985	1988	1991	1994
Herlyn M	Lee W. H.	**el-Naggar A K**	**el-Naggar A K**
Koprowski H	Mendenhall W M	Hayashi Y	Kobayashi H
Old L J	Million R R	Hirohashi S	**Mori M**
Pontes J E	Simosato Y	Kimura H	Rosenberg S A
	Sugimachi K	Kobayash T	**Sugimachi K**
		Miyazaki I	Watanabe H
		Mori M	Yamamoto M
		Natali P G	
		Noguchi M	
		Ro J Y	
		Sugimachi K	
		Takahashi H	
		Yonemura Y	
4	5	14	8 = 31

Thirty one clusters headed by key authors were identified the cluster headed by K. Sugimachi was found to occur in three of the four sample years - i.e. 1988, 1991 and 1994. Clusters headed by A. K. el-Naggar and M. Mori have appeared only during 1991 and 1994. Other clusters were comprised of new key authors. Two major observations may be made from these clusters. First, no cluster occurs in all the four sample years. The cluster headed by K. Sugimachi is the only cluster that has occurred during three of the four sample years. This suggests the formation of many new clusters in each sample year in the discipline rather than a continuation of the clusters formed during the earlier years. Secondly, there were three clusters that had occurred in more than one sample year. Even here when examined it was found that the internal structure and composition of these clusters had changed over the years with entry of a number of new co-authors.

The contribution of different clusters was assessed by computing the centrality and density for each cluster. It was observed that the mean centrality values fluctuate to a great extent thereby indicating that there has been no progressive integration in the theme of clusters headed by key authors in the last decade. A similar fluctuation has been identified in the density indices also indicating that the clusters display diversification rather than coherence overtime. (Table 3).

Table 3. Mean Centrality & Density Indices of Clusters

	1985	1988	1991	1994
Mean Centrality	0.1377	0.3375	0.3366	0.0666
Mean Density	0.3712	0.4487	0.4843	0.2249

Collaborators of Key Authors

Key Authors	Number of Collaborators											Total
	0	1	2	3	4	5	6	7	8	9	>9	
Sugimachi K	-	-	1	7	17	17	16	6	2	-	-	66
Shimosato Y	-	-	2	1	10	1	9	5	1	3	1	33
Hirohashi S	-	1	1	3	7	4	4	7	1	2	1	31
Mori M	-	-	-	2	10	5	6	5	2	-	1	31
Rosenberg SA	3	2	2	2	4	4	2	4	1	3	2	29
El-Naggar AK	-	1	2	6	7	3	4	1	1	1	-	26
Miyazaki I	-	-	-	1	1	9	5	2	3	3	2	26
Takahashi H	-	-	3	1	4	4	5	3	1	1	4	26
Million RR	-	2	1	2	9	5	3	1	-	-	-	23
Old LJ	-	-	1	-	4	8	1	5	1	1	1	22
Mendenhall WM	-	1	2	2	7	5	2	2	-	-	-	21
Hayashi Y	-	-	1	1	1	3	3	5	2	3	1	20
Maehara Y	-	-	1	1	2	5	7	3	1	-	-	20
Noguchi M	-	-	-	1	8	3	4	2	1	1	-	20
Watanabe H	-	-	2	1	1	2	4	3	4	-	3	20
Yamamoto M	-	1	2	3	4	4	2	3	-	1	-	20

Contd....

Ro JY	-	1	1	3	4	4	2	3	-	1	-	19
Suzuki H	-	-	-	3	3	3	2	3	1	3	1	19
Herlyn M	-	-	2	2	3	5	2	1	1	1	1	18
Kobayashi H	-	-	1	1	2	5	4	2	1	2	-	18
Koprowski H	-	-	1	3	2	6	3	-	1	2	-	18
Natali PG	-	-	1	2	6	5	1	1	-	-	-	16
Kimura H	-	1	1	2	2	1	-	1	2	2	3	15
Lee WH	-	3	3	2	2	2	-	2	1	-	-	15
Pontes JE	2	-	2	2	1	3	4	-	1	-	-	15
Yonemura Y	-	1	1	-	-	5	-	1	3	2	2	15
Kobayashi T	-	1	-	-	2	1	3	2	1	1	1	12
Total	5	15	34	54	122	122	98	73	33	33	24	614

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7. Conclusion

This analysis has been able to identify the most influential authors (key authors) in Oncology and analyze their productivity pattern and to study the collaboration among them. The study appears to suggest both, the emergence of new clusters as also changes in the composition of the few clusters that continued over the period of study.

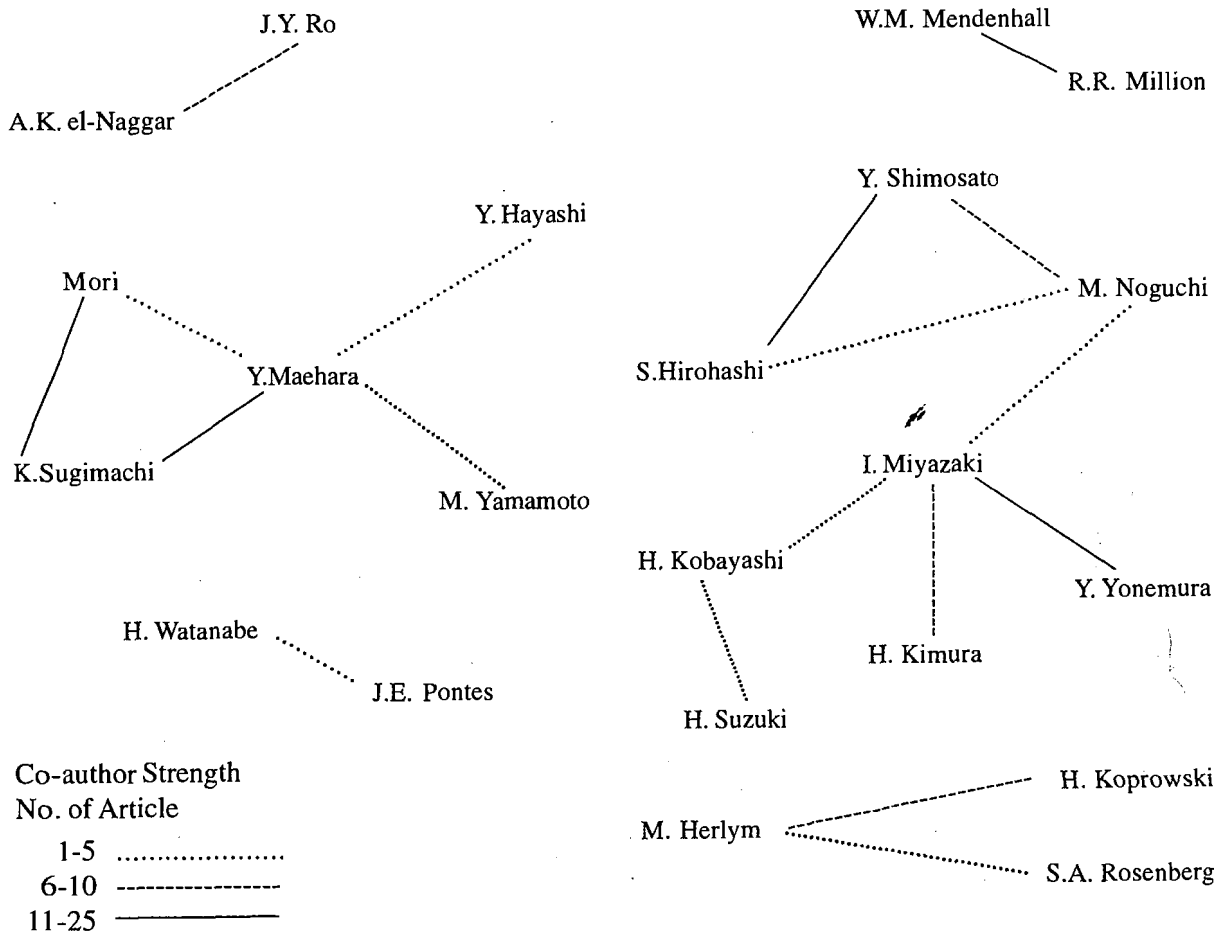

Fig. 1. Collaboration Among Key Authors

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Bibliometric Indicators for Publication Productivity Analysis of an Individual Scientist

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Recently, lot of Bibliometric, Scientometric, and Informetric Studies, all over the world, have focused attention on evaluation of contributions of an individual scientist or his/her research group. Present paper attempts to bring together the productivity indicators for analysis of one of the most famous Indian Scientists. So that such studies will emerge as guidelines for evaluation of contributions of contemporary scientists, which may help in identification of present talent in the country, so that it can be nurtured further and latent potentials can be harnessed.

This case study analyses Dr Vikram Ambalal Sarabhai's publications by year, domain, collaboration pattern, channels of communications used, and distribution of articles among channels, and keyword frequencies appeared in the titles of publications. He had 160 publications in the domains *Cosmic Rays* (89), *Science Policy and National Development* (57), and *Management* (14) to his credit. His highest collaboration coefficient was 1.00 during 1947-53, 1955-56, and 1961. His productivity coefficient was 0.58 indicating his consistent publication activity through-out his scientific career. His most prominent collaborators in number of papers were; G Subramanian (14), G L Pai (11) and K N Nair (11).

Core journals, with papers to which he had contributed were : *Physical Review* (8), *Proceedings of Indian Academy of Sciences* (8), and *Nature* (6). Bradford multiplier was 2.44. Publication density was 1.30, and publication concentration was 2.86. His high frequency keywords in the titles of the articles were : *Anisotropy* (18), *Daily Variations* (18), *Cosmic rays* (14), *Galactic cosmic rays* (14), *Geomagnetic field* (14), and *National development* (11).

The results indicate that the temporal publication productivity and the nature of the research activities were such that he is eminently qualified to be taken as a *role model* for the younger generation to emulate.

1. Introduction

Vikram Ambalal Sarabhai was born on August 12, 1919 at Ahmedabad. He had his early education at a private school at Ahmedabad. He then went to Cambridge and obtained his tripos in 1939. He worked in the area of cosmic rays under the guidance of Sir C V Raman, the Nobel Laureate in Physics for 1930 at Indian Institute of Science, Bangalore.

His craze for physics was formed early and remained intense as ever throughout his life.

He worked at the Meteorological Department, Poona as early as 1942.

He was awarded the Doctorate for his thesis *Cosmic ray investigations in tropical latitudes* by the Cambridge University in 1947.

Sarabhai was responsible for the establishment of Physical Research Laboratory (PRL) in Ahmedabad in 1947 and personally directed till 1971, and founded the Ahmedabad Textile Industry's Association (ATIRA) in 1947 and was an Honorary Director till 1965. Sarabhai also founded Indian Institute of Management (IIM) in Ahmedabad in 1962 in order to cater to the

demands for professional management skills of high order in India and was its Honorary Director till 1965.

He was a pioneer in space research in India and was responsible for taking up major steps like setting up of the Space Science and Technology Centre (SSTC) near Thumba and the establishment of an Experimental Satellite Communication Earth Station (ESCES) at Ahmedabad. Sarabhai's major achievement with which he was closely associated is the famous Satellite Instructional Television Experiment (SITE).

Sarabhai's pioneering efforts could enable India to launch its first Scientific Satellite Aryabhatta named after a great Indian Astronomer and Mathematician into space by Soviet rocket carrier only after three and half years of his untimely death in 1971.

He had several positions in different capacities and received many honours and awards in recognition to his contributions in the fields of space research and Atomic energy.

(a) Professor of Cosmic Rays Physics (1947-65).

(b) President, Indian Science Congress Physics Section (1962).

(c) Chairman, Indian National Committee for Space Research (INCOSPAR) (1962).

(d) Bhatnagar Medal (1962).

(e) Fellow of the National Science Academy (1963).

(f) Director, Physical Research Laboratory (PRL) (1965-71).

(g) Secretary, Department of Atomic Energy (1966-1971).

(h) Chairman, Atomic Energy Commission (1966-1971).

(i) Padma Bhushan (1966).

(j) Member, International Council of Scientific Unions (1966).

(k) Chairman, Panel of Experts and Scientific Chairman of the UN Conference on the *Exploration and Peaceful Uses of Outer Space* (1968).

(l) President, 14th General Conference of the International Atomic Energy Agency (1970).

(m) President, Indian Geophysical Union (1970-71).

(n) Vice-President, Fourth UN Conference on Peaceful Uses of Atomic Energy (1971).

(o) Padma Vibhushan (Posthumously) (1972).

In 1966, after tragic death of Homi Jehangir Bhabha, Sarabhai was asked to take up the Chairmanship of the Atomic Energy Commission. He threw himself whole-heartedly in to the work with boundless energy and Space Research Organisation (ISRO) into even closer contact.

Vikram Sarabhai put India on the space map of the world. He was inducted into the International Space Hall of Fame at the Space Centre, Alamogorodo, New Mexico, at an impressive ceremony on October 2, 1993. He is the first Indian Scientist to be honoured by the Americans in recognition of his contribution to the Indian Space Programme and in applying space technology for the welfare of people. His work has been well documented [1-8].

2. Objectives

Objectives of the present study were to highlight quantitative aspects of research publications of Vikram Sarabhai such as authorship, pattern, domainwise contribution, author productivity, core channels of communications used, distribution of articles among channels, documentation of keywords from titles of publications, Bradford multiplier etc.

3. Methodology

Scientometric analysis is usually based on the utilization of several independent data like publications, citations, experts opinions, content analysis, etc. which together permit to enlight various sides of the development of a definite science field.

Publication and citation counting techniques have been used in the assessment of scientific activity for atleast fifty years. During the half-century of this activity the main thrust of interest seems to flow along two connected parallel paths : the bibliometric path of publication and citation counts as tools for the librarian, and an evaluative path using these same tools to illuminate the mosaic of scientific activity [9].

Evaluative bibliometrics shows that there are

large differences in influence among scientific journals; few scientists would deny this. Evaluative bibliometrics shows that our great scientific institutions are in fact publishing large numbers of highly cited papers in highly influential journals; few scientists would dispute this. Evaluative biblometrics shows that scientific activity is related to Gross National Product (GNP), and that, as the economic might of the United States and the Soviet Union have grown over the last 50 years, so have their measured positions in the scientific world; few would question this. Clear evidence emerges that the productivity of individuals varies widely, and that the truly creative scientists publish often, are heavily cited, and contribute to the progress of science in an amount which is many times that of the average scientist. Few would object to this observation [9].

The choice of unit of analysis and of the initial set has a strong influence on the measures and results of any bibliometric study. Generally speaking authors are used when the study focuses on the influence of individuals, articles are used to study the particular idea as embodied in the article, key terms are used to follow an idea over time as it crosses disciplines and journals when the study focuses on the institutional embodiment of a discipline [10].

Bibliographic details of all publications of Vikram Sarabhai were documented on cards and sorting was done as per requirement to extract various data.

Normal count procedure [11] was followed. Full credit was given to each author regardless of whether he happens to be the first or the last author. It is widely recognised that scientists all over the world look at their own papers exclusively in that way. Similarly titles of the articles were analysed and one score was alloted for each key word, subject, journal etc.

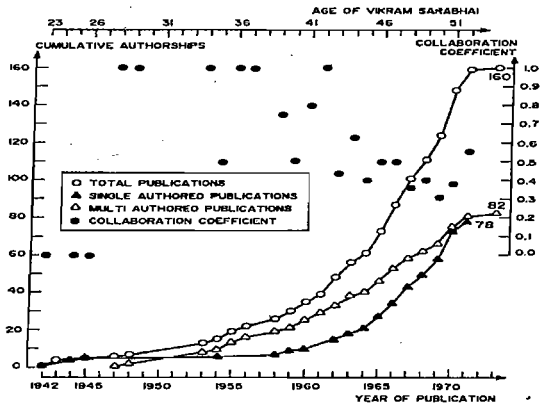


Figure 1. Yearwise Publication Output of Vikram Sarabhai.

The degree of collaboration [12] in a discipline was defined as the ratio of the number of collaborative research papers to the total number of research papers published in the discipline during a certain period of time.

Vinkler [13] defined Publication Density as the ratio of the total number of papers published to the total number of journals in which the papers were published, and Publication Concentration as the ratio in percentage of the journals containing half of the papers published to the total number of journals in which those papers were published during the period under study.

Sen and Gan [14] defined Productivity Coefficient as the ratio of 50 percentile age to the total productivity age.

Frequency of keywords from the titles of the articles were recorded. Data obtained from above study were presented in tables and figures.

4. Results And Discussions

During 1942-1973 Vikram Sarabhai had published 160 publications in the domains *Cosmic Rays* (89), *Science Policy and National Development* (57), and *Management* (14).

Yearwise publication output of Vikram Sarabhai is shown in Figure 1. His highest Collaboration Coefficient was 1.00 during 1947-53, 1955-56, and 1961.

His productivity coefficient was 0.58 which is clear indication of his consistent publication productivity behaviour throughout his research publication career.

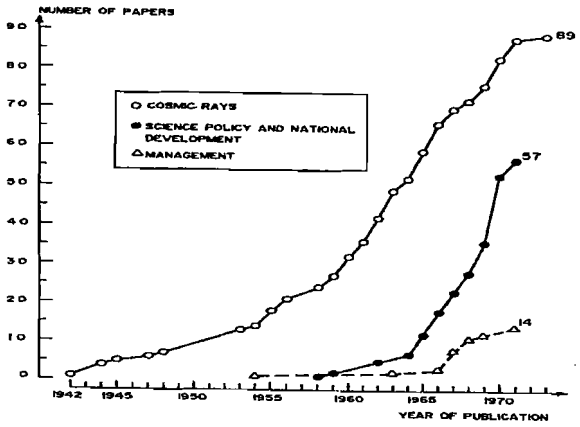
Vikram Sarabhai had 78 single author publications and 82 multi-author publications to his credit. He was first author in 46 multi-author papers.

His first paper was published in 1942 in *Proceedings of Indian Academy of Sciences* at the age of 23.

Vikram Sarabhai had single authored papers in various domains as *Cosmic Rays* (15), *Science Policy and National Development* (52), and *Management* (13).

His domainwise cumulative number of publications is depicted in figure 2.

Table 1 shows author productivity and distribution of author in various domains. The research group of Vikram Sarabhai has the credits of number of authorships in various domains : *Cosmic Rays* (194), *Science Policy and National Development* (75), and *Management* (15). Total number of authors in the research group were 39. Researchers and their authorships in collaboration with Vikram Sarabhai in chronological order of their association (in first publication with Sarabhai) are depicted in Figure 3. Most active researchers and their contributions with Sarabhai were G Subramanian (14), G L Pai and K N Nair (11) each. Other active collaborators with Sarabhai were U R Rao (7), U D Desai, R P Kane and D Patel (6) each. Other collaborators having four papers each were four, three papers each were four, two papers each were four and single papers each were 17. P D Bhavasar, E V Chitnis had collaborated with Sarabhai in the domains *Cosmic Rays* and *Science Policy and National Development* whereas K Choudhary had collaborated only in the domain *Management.*



Figre 2. Domainwise Growth of Publications of Vikram Sarabhai

Domainwise collaboration of Vikram Sarabhai with his 38 collaborators and their status of authorship in various domains is provided in Table 2.

Table 1. Author Productivity and Distribution of Authors in Various Domains

No. of authors	Domainwise Authorships			No. of authors	Total authorships	Prominent Collaborators
	A	B	C			
1	6	10	1	17	17	
2	6	2	-	4	8	
3	6	6	-	4	12	
4	16	-	-	4	16	
5	10	-	-	2	10	Nerurkar, N. W. and Pathank, P. N.
6	18	-	-	3	18	Desai, U. D.; Kane, R. P. and Patel, D.
7	7	-	-	1	7	Rao, U. R.
11	22	-	-	2	22	Pai, G. L. and Nair, K. N.
14	14	-	-	1	14	Subramanian, G.
160	89	57	14	1	160	Sarabhai, V.
Total	194	75	15	39	284	

A = Cosmic Rays B = Science Policy and National Development C = Management

Communication channelwise scattering of publi-cations of Vikram Sarabhai is provided in Table 3. He has published eight papers each in *Proceedings of Indian Academy of Sciences* and *Physical Review*, six papers in *Nature*, four papers each in *Indian and Foreign Review*, *Journal of Geophysical Society of Japan*, and *Planetary and Space Science*, and three papers in *Proceedings of Royal Society*.

In addition to 69 publications in 32 periodicals,

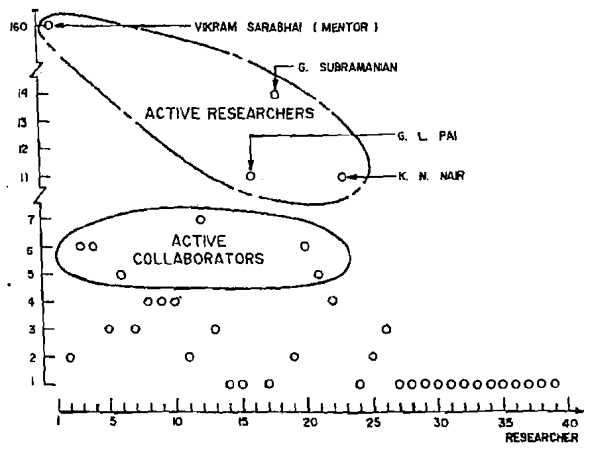


Figure 3. Researchers Association in Chronological Order and Authorships

he had 91 papers to his credit in various conferences, symposia etc.

Average Bradford multiplier was 2.44 publication density was 1.30 and publication concentration was 2.86.

The channelwise frequency and cumulative number of papers published is depicted in Figure 4.

The keyword frequencies in the title of the papers were provided in Tables 4 and 5. High frequency keywords were *Anisotropy* (18), *Daily variations* (18), *Cosmic ray intensity* (14), *Cosmis rays* (14), *Galactic Cosmic rays* (14), *Geomagnetic field* (14), and *National Development* (11).

These keywords indicate his wide spectrum of interest, materials, methods, instruments used and subjects addressed to in the course of his 24 years of research papers publishing life span.

Table 3. Channelwise Scattering of Publications of Vikram Sarabhai

Sl. No.	Journal	No. of papers	Percentage	Cumulative percentage	SCI JCR 1992		Period of journal usage		
					IF	II	FPY -	LPY	Total
1.	Physical Review	8	5.000	5.000	-	-	1944	1960	17
2.	Proc. Ind. Acad. Sci	8	5.000	10.000	-	-	1942	1962	28
3.	Nature	6	3.750	13.750	22.139	5.224	1953	1970	18
4.	Indian & Foreign Review	4	2.500	16.250	-	-	1968	1970	3
5.	J. Geophys. Soc. Jap.	4	2.500	18.750	-	-	1962	1962	1
6.	Planetary and Space Sci.	4	2.500	21.250	1.075	0.259	1964	1970	7
7.	Proc. Roy. Soc.	3	1.880	23.130	-	-	1961	1961	1
8.	Astrophysics J.	2	1.250	24.380	2.931	0.152	1966	1967	2
9.	Ind. J. Person. Adm.	2	1.250	25.630	-	-	1968	1969	2
10.	J. Geophys. Res.	2	1.250	26.880	2.100	0.900	1963	1970	8
11.	J. Sci. Ind. Res.	2	1.250	28.130	0.062	0.033	1962	1971	10
12.	Science and Culture	2	1.250	29.380	-	-	1970	1970	1
13.	Science Today	2	1.250	30.630	-	-	1969	1970	2
14.	Yojana	2	1.250	31.880	-	-	1966	1967	2
15.	Acta Physics	1	0.625	32.505	-	-	1970	1970	1
16.	Ann. Rev. Nucl. Sci.	1	0.625	33.130	4.034	0.400	1956	1956	1
17.	Astrophys. and Space Sci.	1	0.625	33.755	0.325	0.155	1973	1973	1
18.	Can. J. Phys.	1	0.625	34.380	0.461	0.099	1968	1968	1
19.	Cosmic Electrodynamic	1	0.625	35.005	-	-	1971	1971	1
20.	COSPAR Information Bull.	1	0.625	35.630	-	-	1962	1962	1
21.	Gandhi Marg	1	0.625	36.255	-	-	1969	1969	1
22.	IAGA Bull.	1	0.625	36.880	-	-	1969	1969	1
23.	J. Geomag. Geoelec.	1	0.625	37.505	0.333	0.529	1966	1966	1
24.	Link	1	0.625	38.130	-	-	1970	1970	1

25.	Nuovo Cimento	1	0.625	38.755	-	-	1958	1958	1
26.	Opsearch	1	0.625	39.380	-	-	1970	1970	1
27.	Physical Review Letters	1	0.625	40.005	3.375	1.449	1967	1967	1
28.	Proc. Phys. Soc.	1	0.625	40.630	-	-	1948	1948	1
29.	Science & Technology Series	1	0.625	41.255	-	-	1960	1960	1
30.	Space Research	1	0.625	41.880	-	-	1965	1965	1
31.	Space Science	1	0.625	42.505	-	-	1970	1970	1
32.	Times of India	1	0.625	43.130	-	-	1970	1970	1
33. to 123	Conference Proceedings etc.	91	56.870	100.000	-	-			
	Total	160							

SCI JCR = Science Citation Index Journal Citation Reports, IF = Impact Factor, II = Immediacy Index, FPY = First Paper Published Year, LPY = Last Paper Published Year.

So far a very few scientometric studies have been carried out on individual scientist [15-47]. This is an interesting interdisciplinary domain which reveals characteristics of the School of Scientific Excellence, formed around a creative scientist, that results in Synergetic effect of progress in Science and Technology. Hence needs further research so as to get insight into the system of harnessing effectively the potentials in human resources. There is a need to assess the performance on a continuous basis. There are individual scientists doing good work. If we can project image of such scientists, it may be possible to attract talents of younger generation. It is the human intelligence and imagination that is going to build 21st century.

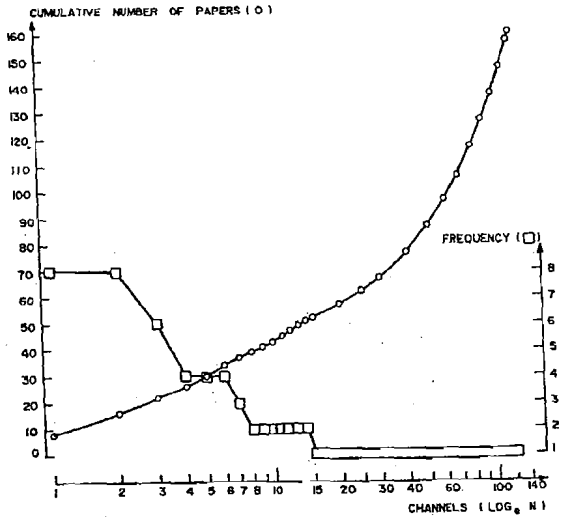


Figure 4. Bibliograph on Publication of Vikram Sarahai

Table 4. Keyword Frequencies in the Titles by Vikram Sarabhai

Keyword	Frequency	Keyword	Frequency
Anisotropy	18	Scientific research	3
Daily variations	18	Solar activity	3
Cosmic ray intensity	14	Solar cosmic rays	3
Cosmic rays	14	Solar wind velocity	3
Galectic cosmic rays	14	Television	3
Geomagnetic field	14	Asymmetry	2
National development	11	Atomic power station	2
Fluctuations	7	Cosmic ray storms	2
India	7	Electro magnetic state	2
Low latitudes	7	Employment	2
Meson intensity	7	Energy	2
Cosmic radiation	6	Extra terrestrial	2

Interplanetary space	6	Galectic cosmic ray density	2
Solar system	6	Geomagnetic equator	2
Time variations	6	Interplanetary plasma	2
Developing countries	5	Leadership	2
Interplanetary magnetic field	5	Mesons	2
Science	5	National goals	2
Magnetosphere	4	Nonviolence	2
Modulation	4	Organization	2
Education	3	Plasma wind	2
Green revolution	3	Security	2
Magnetic storms	3	Semidiurnal anisotropy	2
Nuclear Power	3	Semidiurnal variations	2
		Telecommunication electronics	2

Table 5. Keywords Used Only Once in the Titles of Papers by Vikram Sarabhai

Air showers	Government	Science & Industry
Arms control	Green coronal emission	Sector structure
Asymmetric interactions	Human function	Satellite
ATIRA (Ahmedabad Textile Industries Research Association)	Human values	Short period fluctuations
	Innovation	Shower anticoincedences
Atomic energy	INSAT-A	Social environment
Atomic Energy Commission	Management	Solar and terresterial relationship
Control & Management	Meteorological	Solar anisotrypy
Coronal intensity	Meson component	Solar Cycle
Cosmic ray effects	Mu mesons	Solar equatorial plane
Cosmic ray fluctuations	Music	Solar flare
Density of Solar Wind	Narrow angle telescope	Solar influence
imiliterasation of space	Noise	Solar maximum activity
Dip equator	Non Uniformity	Solar minimum activity
Disarmament	Nuclear Centre for Agriculture	Solar plasma
Electromagnetic conditions	Nuclear Medicine	Solar wind effects
Energy spectrum	Operational research	Space
Environment	Outer space	Space exploration
Equatorial sky	Planning	Space research
Gangetic plain	Polar cap absorption	Temperature effect
Geomagntic disturbance	Pollution	Three dimensional dynamotheory
Geomagnetic effects	Public sector enterprises	Time distribution
Geomagnetic fields	Public sector management	Trivendram
Geomagnetic plasmas	Remote sensing	Unemployment
Geomagnetic variations	Reorganisation	

5. Conclusion

Publication productivity analysis of the successful scientist Vikram Sarabhai, carried out here has thrown light on his pivotal contributions to science and technology. He can be considered as a *role model* for younger researchers to follow. Knowledge is valuable for its own sake and research has cultural values. Desire of being creative is built in our genes. Who knows this effort may switch on genes for creativity in some of those

who happen to read this article. Narrating success stories always has an encouraging effect. It is also important to recognise that excellence in science is not just a matter of a few individual successes, what is required is a wide base of high quality, which would enable peaks to come up more frequently and on a more definite basis. New ways to motivate scientists seem as important to contest outcome as new sources of funds. Science policy makers interested to know about functioning of active research teams as centres of excellence and factors responsible for optimizing, maximising and enhancing outputs may find further interest in scientometrics. As per Indian Scientific Policy Resolution 1958, which our scientists regard as their charter, *to ensure that the creative talent of men and women is encouraged and finds full scope in scientific activity* all must work together with holistic approach.

There is no dearth of ideal role model scientists in India, what we lack is the systematic and continuous studies on such scientists. Hence, the comment *Most of the developing countries lack role models to motivate other scientists* [48] does not hold good at least for India.

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Internet and the Developing World

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Internet will contribute to global democra--tisation and free flow of information. This was the opinion of the Dakar Declaration. Internet is required wherever people live. But this optimism should be tempered by ground realities. Internet or for that inalter, technology does not come without its atendant problems. History has repeatedly shown that technology inevitably enhances already existing inequalities.

Classical sociology of science tells us that science is universal. Anybody, anywhere can contribute to knowledge in the sciences and irrespective of who said it in the new finding, if it is reasonable, it will be accepted or atleast taken seriously by all. That is the basis of the system of information exchange — mediated by journals, current awareness, abstracting and indexing services. In reality though case of access to information differs considerably from place to place.

An outgrowth of Arpanet, internet in other countries was most often installed to allow interconnection of university campuses or the integration of regional government offices. Internet itself exists in multiple conditions. In many North American citiesit is freely accessible to those with the inclination — even children. In other countries internet coexists alongside non-functioning telephones and is accessed by a small elite.

Many countries in the United States subscribe to more than 50,000 serials, whereas not even ten libraries in India receive more than 1000 journals.

Moving over to the electronic means of information transfer; many institutions in the deve-loping world takes a long time to have the techno-logy in place, and does not have the same bandwidth and other capabilities as their counterparts in the advanced countries. Most scientists in the developing world does not have access to electronic journals. The well networked Western scientists are by and large well-informed or atleast can remain well informed with some effort. Scientists of the developing country are handicapped. Many of them are not on the NET, they are out of touch with what is published in journals, and they get to know of what is published a long time after their western counterparts. The transition to electronic publishing from print will widen the gap between the advanced countries and the developing countries, especially those with large populations, do not have the necessary infrastructure and will take a long time to have it in place to be able to take part as equal partners in the worldwide enterprise of knowledge production and exchange. While communication revolution is perceived as a liberating influence, what is more likely to happen is that in many developing countries (including India, I am afraid) scientists and scholars will be among the last to be reached by the revolution and therefore the relative disadvantage they now suffer from (in the matter of access to information and knowledge) will only increase. The number of institutions and individual scholars having access to E-mail and Internet in developing countries and the rate at which this access has grown over time will support this contention.

The transition to electronic publishing will make

it much easier for scientists and scholars in the advanced countries to interact with colleagues and invisible colleges, and most Third World scientists and scholars are most likely to be excluded from this "worldwide" network, not because they are intellectually inferior but because they do not have the technological backu. The already existing gaps in the levels of science and technology performed in the advanced and the poorer countries will be widened further and this could lead to increased levels of brain drain and dependence on foreign aid of a different kind (knowledge imperialism).

Mastery of technology has led the West to dominate the world to such an extent that even in areas where the traditional societies of the poorer countries had a lead of millennia (such as ethnobotany and plant-based medicine), now it is the west which is exploiting this knowledge base and converting it into products (of modern medicine) and profits. What has happened in the area of knowledge production and dissemination (including publishing and patenting).

Most journals and databases are produced in the advanced countries and developing country scientists read articles written by their own countrymen in expensive journals produced by commercial publishers in the West and gain access to the same articles through exhorbitantly priced secondary services produced in the West! Electronic publishing and online access will only make the situation even worse.

Both Chemical Abstracts and Science Citation Index are now availabl on the web at an enormous cost. Accessing through the web offers capabilities that are not possible with the print or CD ROM forms. Hardly any laboratory in the developing world has web access to these databases. How they can be equal partners in the worldwide enterprise of knowledge production?

Internet penetration in the developing world is low at the moment. In Calcutta, total number of subscriber is 1,50,000. However, the internet and its communications standards and protocols now connect millions of lusers around the world through terminals networks and home computers logged over telephone lines to hundreds of thousands of commercial land institutional computers. The internet began amongst an elite of engineers and researchers, but the required equipment, the computer and telecom prices are coming down rather fast and unlike technologia will diffuse much faster.

What happens if this situation comes — A large part of the population gets access to a set of new technology essentially borrowed, and will have very little of their own content. A middle class Indian family denying themselves of all pleasures to buy a computer for the kids ends up with the kids having CD ROM facility ... and other products largely meant for and created by the West, knowing a great deal of Western culture and civilization and remaining quite ignorant about their kown classics. In fact many vendors of multimedia computers give free CR ROM discs, not one of which is India oriented. Every technology has this problem associated with content. Take Gutenbergs printing. It not only helped Martin Luther's religions revolution but has helped generations of his successors in Europe to colonize and convert people in Asia and Africa. What mattered more was the content the technology of printing helped to be disseminated.

Computers replace human brains byte by byte, performing more complicated tasks faster. But the social impact of this new technology and how it has subjugated most of modern humanity are causes for serious concern.

The spread of computers has followed the usual patterns — obsession with the new technology. Powerlooms in the mid 19th cen. automobiles in the 20s and the nuclear power in the 60s. All these new technologies had side effects which were detrimental to the social life.

There is an enormous difference between accessing information from the 3rd World and accessing it from the advanced countries. How can a computer function in a country beset by numerous hazardous problems? Where water supply can be down for days, roads are repared only when dignitaria visit, where rainfall collapses everything. People do not even think of the requirement for repairing. Impatient bus drivers leap frog one another regardless to traffic conditions. Problems of telephone going dead for hours or even days, months. Professor Ganapathy Bhaskaran, one of the world's leading condensed matter theorists had to undergo such chaotic situations. When he had

to move to an official quarters from his rented house, it took several months to shift the telephone and nearly nine months to use the telephone.

About creating Indian contents on the NET, one can put all the classics in the NET, but that doesn't guarantee that they will be read. As Toni Morrison the Nobel Laureate once said, who cares for writing concerning black people. The point is unless what you do in "mainstream", you need not be synical. In recent years, many Indian writers in English have been acepted in the West. Here again, the West wouldn't know that there have been many far more outstanding writers in several Indian languages, who remains unknown forever.

People who went into software-related positions are indeed from institution from where most of our scientists and researchers hail. Once they move into high-pressure software jobs and companies they lose touch with their friends who go into research. A number of our graduates have gone on to become software professional, but not one maintains academic contact with colleagues back home who are in research and teaching.

Regarding scientific know-how in India, there are some world class scientists, no doubting that. But they are rather few considering our large population. We do publish about 11,000 papers annually in the 3,300 or so journals indexed in Science Citation Index. If we take into account other S&T journals — those not indexed in SCI, but still of some value to S&T researchers — then India may account for roughly 16-20 thousands papers a year.

Most Third World governments and people themselves can take advantage of the Internet revolution. Take China and Brazil for example. Both have far better access to Internet than India. Right now, steps are being taken to improve the situation in India, mostly by academics. A few months ago Prof V. S. Arunachalam, formerly Scientific Adviser to the Ministry of Defence at New Delhi and currently a distinguished professor at Carnegie-Mellon University in the USA, was in India and he met several key people including Mr P Chidambaram, our Minister for Finance; Mr Chandrababau Naidu, Chief Minister of the southern state of Andhra Pradesh and the leader of the United Front which governs India; and some technocrats. His primary mission was to provide high bandwidth - at least 2Mbps if not T1 - Internet access to at least the top 25 or 30 Indian cities where much research is being carried out. He is also interested in linking up Indian and American University Libraries. Subsequently, the Scientific Advisory Committee to the Cabinet headed by Prof C. C. R. Rao appointed a three-member subcommittee consisting of Prof Roddam Narasimha, an outstanding aeronautical engineer, as the chairman and two world-class computer scientists - Prof N. Balakrishnan and Dr Vidyasagar - as members to look into improving Internet access in India for academics and researchers. This committee's report is now with the Cabinet, but it may take a long time before the Cabinet will act on it. The Prime Minister and his Cabinet colleagues are constantly embroiled in political crises and fighting for their very survival and Internet cannot be a priority item in their agenda!

In the fight between the mongoose and the snake. Although both are of very nearly equal physical strength, invariably the mongoose emerges victorious. Because it organizes its strategy better. The First World countries are like the mongoose and the developing countries are like the snake! In every transaction - including adopting new technologies - the First World wins!

There is no harm in adopting new technologies as long as you know how to use it to your advantage. If one is mature enough, one can handle these transitions rather well.

Rapid growth of the use of computers enables poorer countries to earn higher incomes.

There are a few stinkingly rich families and business tycoons in India. Similarly, there are some sectors where India has enormous world class quality, and software writing is one of them. In fact, many Indians are performing the key functions in California's silicon valley. [Even so, India's share of the world's software business may be about 1%! While the Indians work, invent and develop, men like Andy Grove and Bill Gates make the money!] The point is there is no real equalization. All we see is exploiting a new set of resources. In the colonial days the European powers occupied much of the rest of the world and exploited their natural

resources and used the territories as their captive markets. When political colonialism became no longer profitable, the economic colonialism took over and the West is exploiting the skilled labour of the developing world to its advantage. The enormous reputation Indian software writers enjoy around the world has absolutely no impact like two water-tight compartments parked in the vicinity of each other. Actually, the intellectual capabilities required to be a first class theoretical physicist or mathematician are of a much higher order than those required to become a Y2K program developer. But today in India, the Y2K programmer gets a US$ 60,000/year job rather easily and gets a visa and flies off to the USA while a mathematician with an FRS to his credit earns around Rs.200,000/ year (about US$ 6,000!). The job market is very skewed.

People who went into software-related professions are indeed from institutions from where most of our scientists and researchers hail. There is a considerable overlap. But once they move into high-pressure software jobs and companies they lose touch with their alma mater and frinds who go into research. A number of our graduates have gone on to become software professionals but one hardly knows of anyone maintaining 'academic' contact with colleagues back home who are in research and teaching. Also, a number of our engineering and technology graduates migrate to management and marketing careers and they also lose 'academic' relations with the rest of us.

BOOK REVIEW

The Challenge of Scientometrics : The Development, Measurement, and Self-Organization of Scientific Communications by Loet Leydesdorff, DSWO Press, Leiden. 1995. 231 Pages.

This volume, in a sense, presents one man's view of the content and direction of the emerging discipline of scientometrics and its place in (or relation to) science studies. It derives from and summarises Loet Leydesdorff's 15 years of work. Trained as a student of philosophy and linguistics, Leydesdorff always had a perspective which is considerably different from that of mainstream scientometricists such as Derek Price, Gene Garfield, Mike Moravcsik, Tibor Braun and Ton van Raam who were all trained as physicists or chemists. Unlike most other scientometricists who are essentially interested in empirical analysis of observed pattern,s Leydesdorff has a penchant for theory and a predilection for philosophical and sociological underpinnings of whatever is subjected to measurement in scientometrics. It is this keen interest in theory which led him, early in his development as a scientometricist, to organize a workshop on 'the relation between qualitative theories in science and technology studies and the use of scientometric methods' [see the special issue of Scientometrics, 1989, for papers presented at the workshop]. His penchant for theory and his quest to unify the worlds of scientometrics and science studies — in particular the sociology of scientific knowledge and philosophy of science and information theory — are evidenced by the authors he chooses to cite often in this book : Theil, Quine, Hesse, Luhmann, Callon, Courtial, Law, Collins, Shannon and Burt, rather than Garfield, Moravcsik or Braun. He has cited, of course, the empirical results of Henry Small, Fran Narin and to some extent those of van Raan.

In this elegantly produced volume, Leydesdorff has essentialy reproduced 15 of his published papers, with some modifications resulting from an attempt to weld them together into a cohesive book. I must say, he has taken full advantage of hindsight in this endeavour. There have been some attempts to bring together quantitative studies of science (especially scientometrics and the science indicators movement) and the desparate studies in the areas of history, philosophy and sociology of science. See, for example, the volumes edited by Ina Spiegel-Rosing and Derek Price (*Science, Technology and Society : A cross-Disciplinary Perspective, 1977)*, Karen Knorr-Cetina and Michael Mulkay (*Science Observed : Perspective on the Social Study of Science, 1983)*, and Sheila Jasanoff *et al* (*Handbook of Science and Technology Studies, 1994)*. Leydesdorff feels that these collections have not really integrated all aspects of the dynamics of lscience and that we actually lack methods of true integration. This slim volume is Leydesdorff's attempt to bring about a true integration. As the blurb on the back cover says, "the various dimensions of the problem of studying the sciences empirically are clarified here in a methodological analysis of theoretical traditions, including the sociology of scientific knowledge and neo-conventionalism in the philosophy of science".

Looking at the study of science as a multi-dimensional problem — where the three core dimensions are cognitions, texts and scientists — Leydesdorff views the sciences as multi-layered and flexible communication systems and hence the dynamics of science to be amenable to 'information theoretic' analysis. His approach differs from that of sociologists of knowledge in that he emphasises the need for rigorous distinction between static and dynamic questions pertaining to socio-cognitive

(inter-) action and the structure of scientific knowledge. For him the meaning and context of these interactions as well as the 'asymmetry' that will necessarily prevail among the social, cognitive and socio-cognitive variations are important. Also, 'information' is more fundamental than 'words' in science, which formed the basis of tools such as the co-word analysis. It is in this context, I thought, Leydesdorff could have benefited from Ranganathan's analytico-synthetic method, which was fruitfully applied by Robert Fugmann (of Hoechst) in heuristic selection of drug molecular structures to be actually synthesized in the laboratory for testing.

Leydesdorff argues both the theoretical and at the empirical levels against a sociological reduction of the multidimensional problem to only the two dimensions of the literary manifestations of the sciences and the perception of local actor groups. In his search for better methods of science studies, Leydesdorff suggests that methods used should allow for the use of qualitative data and dynamic analysis — such as information theory, especially probabilistic reasoning. He demonstrates the use of this method in the static and dynamic analysis of relations among eighteen texts in chemistry. Then he procees to look at irreversibilities in networks and that leads him to second-order systems theory, the theory of self-organization and finally to mathematical sociology of science.

Not surprisingly, the book is Eurocentric. Rarely do we find references to Asian and African researchers. Wu Yishan is referred, just to acknowledge that he told the author that there are two Chinese words for information. Two papers by South Asians working in the USA, viz. Sahal and Shahidullah (co-authored with two others) are quoted in passing. Not one from India is cited. Is there a message for Indian scientometricists?

On the whole, this is an ambitious book, and a book only Leydesdorff could have written. Students of science studies and scientometrics with a theoretical bent to mind will find this book interesting and useful. This book should be read by other scientometricists — who do not venture far into theory — as well.

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