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A MEASURE OF THE SOCIAL RETURNS IN ACADEMIC RESEARCH

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Abstract:

Generation of new knowledge is one of the important aspects of academic research. The knowledge so obtained is embodied in publications and higher degree dissertations, which are thus recognised as products of research. The award of a postgraduate degree confers on the recipient a social recognition which is reflected in the higher remuneration offered in the labour market. A postgraduate degree resulting from a research programme is thus considered a value-added product of determinable value.

Similar valuations could be assigned to scientific publications which measure up to the standard of a higher degree. These concepts can be used to compute the social value of new knowledge generated in research.

In the present study, data from a research grant scheme in Sri Lanka are used to construct a conceptual framework and demonstrate a significant relationship between investments in research and social returns. This study showed that the social returns for different disciplines computed on this basis, was more or less the same and ranged from 12.5 to 16.2 per cent per annum for the investment made. Although there are some limitations, this method provides a useful basis for the quantitative evaluation of research.

Introduction

The growth of scientific activity during the 18th and 19th centuries, often referred to as the "scientific" or "research revolution" resulted in the demand for statistical measurement of resources devoted to new science and technology. It is said that until about the middle of the last century apportioning of funds specifically for scientific research was occasional and small, and any that was allocated resembled the favoured patronage to an art. However, the birth and rise of professionalism in scientific activities during the latter half of the 19th century, led to the establishment of a few industrial research laboratories in Europe and the United States. Since then there had been a fairly sharp increase in resources devoted to scientific and technological research, resulting simultaneously in a demand for better methods for evaluation and measurement of the final outcome of research.

An important outcome of scientific research is the generation of new information. Components of this information flow are systematized and embodied in scientific papers and patents, which are thus recognised as products of research. Over the past few decades, counts of these output components have been used not only for the measurement of productivity, but also to compare the research performances of different countries[6 7 8], universities, institutions and laboratories[4 10 11 12] of individuals or groups of researchers[1 3 10 14] and also between fields of study[4 7 10]. Other measures of research output include counts of citations[1], patents, inventions and innovations[13]. The prospects for the use of such measures as indicators of science and technology have been discussed and reviewed recently by Freeman[9]. In the present study, no attempt will be made to review literature, or to discuss the various approaches for evaluating scientific research.

However, many of the productivity measures used have an elitist outlook with emphasis on scientific eminence and elegance rather than on social relevance. Science planners in developing countries therefore need to look for other parameters which could not only measure productivity in terms of publications etc., but also evaluate research in terms of social returns. A conceptual framework for such a quantitative evaluation of scientific research was proposed by Byatt and Cohen[2], which was probably not followed up with a factual study. The present study attempts to evolve a methodology in which the "factors of production" in academic research are shown to deliver output products of determinable value.

Source of Data

The material for this study was collected from the research grants scheme conducted by the National Science Council of Sri Lanka (NSC). The scheme which was initiated in 1970, continued to function in its original form under the Natural Resources, Energy and Science Authority of Sri Lanka, which replaced the National Science Council in June 1982.

Under this scheme grants for research in the fields of agricultural sciences, biology, chemistry, medicine and veterinary sciences, physical and engineering sciences, and social sciences are awarded annually. Applications for grants are invited by advertisement in national newspapers annually during the month of June for grants to be awarded from the 1st of January the following year. Applications received are screened and evaluated by specialist committees appointed for each of the above subject areas. These committees which are constituted as statutory working committees, function for a period of 2 years.

The grants awarded are monitored regularly through progress reports submitted at half-yearly intervals. Once the research programme is completed, a final report is submitted by the grantee, which is evaluated by the specialist panel giving qualitative rankings such as excellent, very good, good, satisfactory, etc. The evaluation takes into account any postgraduate degrees awarded to personnel associated with the project and also the papers that have been published, or presented at scientific gatherings.

In awarding research grants regularly, the National Science Council and its successor the Natural Resources, Energy and Science Authority had as their main objectives, (a) providing opportunities for Sri Lankan scientists to engage in both applied and curiosity-oriented "expedient basic research"* in any field of science, (b) the enhancement of research capability, both of the recipient and of his laboratory and (c) providing opportunities for promising young scientists to obtain postgraduate degrees and be in productive employment. Accordingly in evaluating the research output, consideration has to be given to the extent to which the primary objectives have been achieved. It has to be commented that although this organisation's contribution amounts to less than 5 percent of the total research budget in the country, it is the key scientific organisation which supports curiosity-oriented research in all scientific disciplines, including social sciences. This grant awarding scheme with its non-restrictive and open-ended policy, thus has the potential of providing valuable data on the research orientation of the country's viable research community.

Results and Discussion

Productivity

The data presented in figure 1 illustrates the manner in which funds have been allocated to the major subject areas over the period 1970-1983. Physical and engineering sciences have been omitted because the number of grants awarded has been small over this period. No attempt has been made to deflate the expenditure to constant prices as comparisons are made between subject areas over the identical period. It is clear that there has been a progressive increase in the allocation of funds for all subject areas — reaching a peak in 1983.

Table 1 summarizes the status of research grants awarded during 1970-1983. It is to be noted that medical and veterinary sciences which received the highest number of grants (i.e. 34.4 percent of the total) had a financial allocation of only 22.5 percent of the total, as compared to chemical sciences which received 24.6 percent of all grants but enjoyed 31.5 percent of all funds allocated. The reasons for this will be evident later.

*The author in a recent paper[5] proposed that basic (or fundamental) research be divided into two classes, because of the need to draw a distinction between what may be considered a luxury expenditure on "less expedient basic research" (plainly referred to as fundamental research), as against a profitable investment in "expedient basic research" (referred to in simple terms as basic research). Accordingly, expedient basic research was defined as curiosity-oriented experimental and exploratory research which would lead to an increase in the stock of useful basic knowledge which could be utilized in the future. Less expedient research was then defined as theoretical and experimental studies leading to the understanding and discovery of the fundamental laws of nature.

Table 2 shows the productivity and economics of the research grants scheme as demonstrated by the number and cost of production of postgraduate degrees and publications for each of the major subject areas. It is to be noted that although it as been costlier to produce a postgraduate (row 8) in the field of chemical sciences, this field has also been the most productive, with 58.5 percent of the completed grants yielding postgraduate degrees. With a much lesser number of grants, physical and engineering sciences have been placed second, both in respect of productivity and cost of production. The reason for the higher cost of production in these fields is evidently the need for equipment as shown in the data in row 4. This is also the reason for the increase in financial allocation for chemical sciences over medical and veterinary sciences that was seen in Table 1.

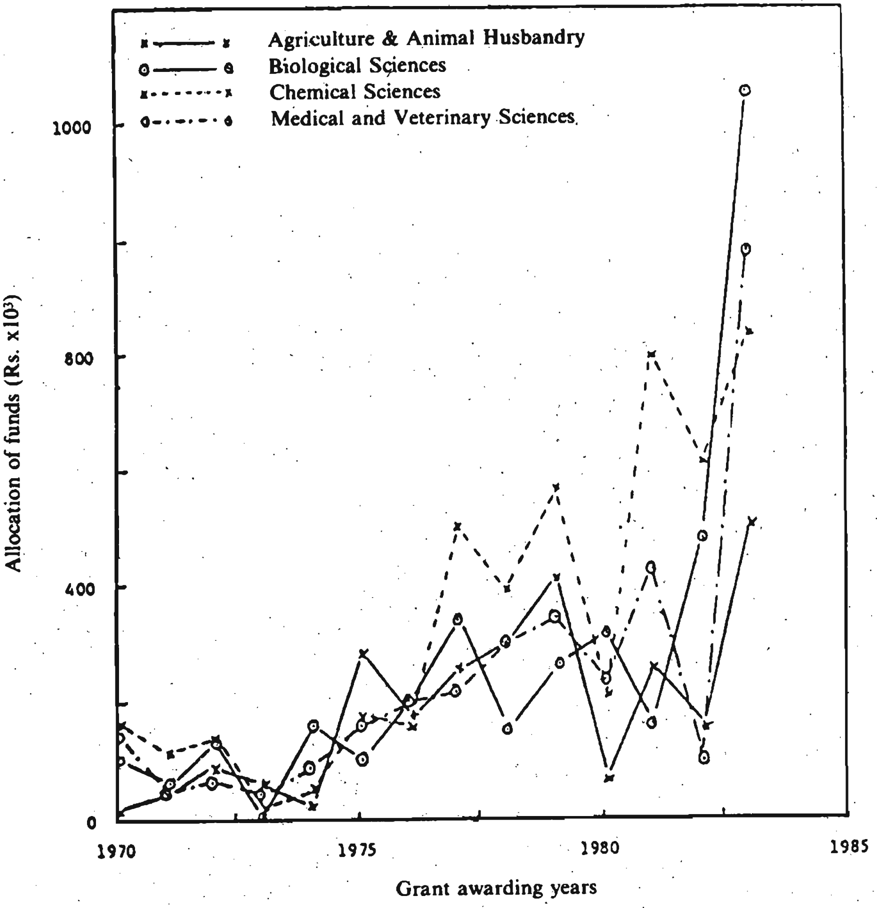

Figure 1. Allocation of funds for scientific research by the National Science Council of Sri Lanka during the period 1970 - 1983

(At current costs)

TABLE I

SUMMARY INFORMATION ON THE NSC RESEARCH GRANTS SCHEME
(1970 - 1983)

Subject Area	Total No. of grants allocated	As percent of total No. of grants	Total sum allocated Rs. (×10³)*	As percent of total for 1970-1983	Average allocation per grant Rs. (×10³)*	Total No. of grants completed	Percentage of grants completed
1. Agricultural and Animal Husbandry	77	14.9	2,779	17.8	36	42	54.5
2. Biological Sciences	109	21.1	3,718	23.9	34	62	56.9
3. Chemical Sciences	127	24.6	4,900	31.5	39	53	41.7
4. Medical and Veterinary Sciences	178	34.4	3,494	22.5	20	62	34.8
5. Physical and Engineering Sciences	26	5.0	674	4.3	26	15	57.7
	517	100	15,565	100	—	234	—

* Computed on current costs. (Note: US $ = Rs. 27.5 in January 1986)

TABLE 2

POSTGRAUDATE DEGREES AND SCIENTIFIC PUBLICATIONS IN MAJOR SUBJECT AREAS
(1970 - 1983)

Subject area / Parameters	Agriculture & animal husbandry	Biological sciences	Chemical sciences	Medical & vet-erinary sciences	Physical & engi-neering sciences
1. Number of completed grants	42	62	53	62	15
2. Total expenditure (Rs. x10^3)*a, b*	1,213	1,371	2,441	1,280	344
3. Expenditure on equip-ment (Rs. x10^3) *b*	156	140	460	172	79
4. Percentage spent on equipment	12.9	10.2	18.9	13.4	22.8
5. Master's degrees	5	17	30	6	5
6. Doctorates	Nil	2	1	2	Nil
7. P.G. degrees as a per-centage of the No. of grants	11.9	30.7	58.5	12.9	33.3
8. Overall cost of a postgraduate degree *a, b*	37,213	30,189	51,585	26,815	40,910
9. Publications in inter-national journals	7	10	31	8	2
10. Publications in local journals	14	25	18	27	6
11. Publcations as per-centage of the No. of grants	50.0	56.5	92.5	56.5	53.3
12. Mean overall cost/ publication *b*	12,973	15,544	20,530	10,228	18,484
13. Scientific communica-tions	18	46	71	30	5

a Excludes wages of grantees

b Current costs (Note: US $ = Rs. 27.5 in January 1986)

In respect of papers too, productivity (rows 9, 10, 12) has been very high for chemical sciences, as compared to the other fields of sciences. It is also significant that while in chemical sciences the majority of publications (row 9), had been in international journals, in the other fields it has been in local journals.

A study of the type of research carried out in these subject groupings shows that, while in chemical sciences the major effort has been in the direction of basic type of research relating mainly to geochemistry and natural products chemistry, in the other fields it has been mainly of an applied nature. This could also mean a better access to the prestigious journals in the fields of chemistry. Evidently researchers in the field of chemical sciences desired greater visibility, and in fact were successful in receiving the patronage of international journals.

Rate of return

Unlike investments in productive or development enterprises, investments in scientific research and experimental development projects are not easily amenable to a cost-benefit analysis. The obvious reason for this is the lack of an acceptable measure to determine quantitatively the outcome of scientific research. As mentioned earlier, although some types of simple measures or counts are available for output measurement of research, their social impacts are not discernible.

However, the increase in research capacity that follows the turn out of postgraduates, and their higher utility value in society can be lookd upon as a direct social benefit. The award of a postgraduate degree not only implies the acquisition of new and advanced knowledge, but also confers on the recipient a higher status in his profession and career. Associated with this recognition is a leap in remuneration and other benefits. In institutes which perform R & D, or carry out specialized activities such as teaching or servicing of research, advanced training and postgraduate qualifications for its scientific personnel are pre-requisites for improving career prospects. Here therefore is seen the "value-added" concept for a product of scientific research. In Sri Lanka like in most other poorer developing countries the price that is paid for this value-added product is very low by standards available in the developed and newly rich countries. Nevertheless it could be used as a measure of the social return for the new knowledge gained as a result of scientific research. This is the philosophy that is advanced in this study to evolve a measure for a quantitative evaluation of an output component in academic research, ie. production of new knowledge.

It has to be clearly noted that production of postgraduates is only one output component of scientific research, which can in most situations be of minor significance. Hence production of new knowledge and production of postgraduates are not necessarily equivalent. However, in this particular research grants scheme, promotion of postgraduate training is a primary objective that deserves special merit. Therefore its outcome has to be taken into consideration in any evaluation, since most of the new knowledge would be associated with the higher degree.

Hence if "I" is the investment on research proportional to the effort required for the production of a postgraduate, and "R" is the wage increase (on an annual basis) for obtaining a postgraduate degree then the social return on this investment is given by the ratio R/I. In order that this ratio would be comparable, and hence used as a partial indicator of research output, the determination of values for 'I' and 'R' should be according to a standardized procedure as will be explained later.

In Sri Lanka, the wage structure of the state sector is relatively uniform with the minimum and maximum wages payable being determined by government. This also applies to the state-controlled higher education sector. It is therefore possible to determine the official recognition given to a person, for obtaining a higher degree in a post, where acquiring such a qualification is an absolute necessity to enhance career prospects. Such is the case in the institutes of higher education, research institutes and other associated scientific organisations.

The universities which turn out postgraduates and also employ such persons appropriately should ideally establish the standards of remuneration appropriate to the level of education. Hence, in this study, the data relating to wage increases offered to holders of postgraduate degrees by these institutions, are used as the officially recognised valuation for new knowledge gained by such degree holders. Since in government service a distinction is not made between master's and doctoral degrees insofar as wages and other monetary benefits are concerned, the value added will be considered identical for these two higher degrees. Here therefore is an anomalous state, since for a higher investment and a superior output the return remains the same. This is an unfortunate situation, since it tends to limit the validity of this evaluation technique. One method of avoiding this is to compute the investment for a PhD as for a Master's degree which though technically incorrect, would satisfy the condition for equivalence in investments. This has not been done in this study as only a little over 7 percent of all the postgraduates (Table 2) are PhD.s.

The above concepts were used to formulate the following guidelines for the computation of ratios:

i. The differences in the initial of the salary scales payable to a fresh recruit (assistant lecturer grade) and to the holder of a postgraduate degree (lecturer grade), computed on an annual basis, was used as the monetary value given to new knowledge gained in obtaining a postgraduate degree.

ii. Any supplementary allowances such as professional allowances given additionally at any given time, in recognition of the postgraduate qualification were included in the computation of returns.

iii. The value of "R" as determined by (i) and (ii) was at current prices applicable to the year in which the higher degree was awarded but it varied in accordance with the periodic salary revisions.

iv. Since the period of the research grants varied from one to five years, the proportion of the grant (at current prices) equivalent to 2 years for a master's degree and 3 years for a doctoral degree were used to compute the investment "I" of the grant relevant to the higher degree. (The values of "I" as computed above are not identical to the values given in Table 2 for the overall costs of postgraduate degrees).

The use of ratios as computed above, eliminated the need to use *ad hoc* type of deflators to transform values to constant prices. The values for "R" used here are as follows

1970 — 1976 — Rupees 2,400 per annum
1977 — 1979 — Rupees 3,600 per annum
1980 — — Rupees 4,500 per annum
1981 — — Rupees 9,045 per annum

1982 — — Rupees 7,500 per annum

The values given above show a progressive increase from 1970 to 1980, reflecting in a way, the successive governments' efforts to compensate for inflation. The sharp increase in 1981 was due to the grant of a so-called "professional allowance" for scientists with postgraduate degrees. Although this was a move to curtail migration of scientists, it still reflects a type of official recognition for holders of higher degrees. The drop in the wage increment in 1982 was due to an overall change in the wage structure which resulted in the absorption of the professional allowance. It has to be noted that these changes have, in general, been applied uniformly to all scientific personnel in the State Sector.

In this study, the principle used for quantifying and placing a monetary value for new knowledge gained in academic research, was also extended to scientific publications. Scientific publications in prestigious journals are sometimes subjectively equated to postgraduate degrees. This is based on the assumption that the stock of new scientific information conveyed by papers accepted for publication in such prestigious journals were adequate for the award of a postgraduate degree (refering usually to a master's degree).

An attempt is made in this study to determine the returns from scientific papers using these concepts. In order to do this, two basic assumptions are made. Firstly, there is the presumption that the material presented in two scientific publications in refereed journals of which at least one is an interntional journal, is equivalent to that required for a master's degree. Secondly, the production of two such publications is considered to cost the same amount as for a master's degree, as given in clause (iv) of the above guidelines. Then a grant qualifying under this requirement would be awarded a return (R^-) equivalent to a master's degree as in guidelines (i), (ii) and (iii). Grants in which a higher degree has already been awarded, availability of two such publications does not qualify for further reward, as the material contained in such papers would have already been incorporated in the higher degree dissertation. There were however, few grants of 3-5 years duration, which resulted in the award of post graduate degrees and also produced more than two publications per grant. In such instances all papers over and above those accounted for higher degrees, qualified for evaluations provided they met the conditions specified under the first assumption above. Thus in a few such instances, for the same investment,social benefits accrued both from the higher degree and publications for new knowledge gained in scientific research. The ratios for social returns in these took the form $R + R^-/I$ where R^- is the return for scientific publications.

The ratios computed in this manner show that the overall means for the different subject areas vary from 0.125 to 0.162, but the differences are not significant. This means that the social returns as computed above for different subject areas are more or less the same, and ranges from about 12.5 percent to 16.2 percent of the investment for a given year.

This finding may appear unusual since already it has been observed that in the field of chemical sciences, the investments have been high and consequently the cost of producing a post graduate was also higher than in the other fields. The answer to this is found in the productivity of publications, wherein it was shown that in the field of chemical sciences, not only was there a much higher output of publications, but also a higher proportion of publications in international journals. Thus the higher investments in chemical sciences have resulted in higher productivity and possibly a better quality output.

Figure 2 shows the manner in which the social returns changed over the period 1970 to 1983. Ignoring the odd value for 1973, the graph shows a regular form in which the ratio declines steadily from 1970 reaching a minimal level in 1976 and then picking up to rise sharply to a maximum level in 1981. The reason for this is not immediately clear and needs further study.

Figure 3 is a plot of the mean social return against the average investment in research for different years. The investments here refer to the expenditure (in current costs) proportional to the effort required to produce a postgraduate. The positive correlation ($r = 0.7$) noted here, is an indication that the social benefits as determined by this method are proportional to the investments. That is, an increase in the investment on scientific research would result in the production of an output of greater value. The relation obtained here is statistically significant (at P. = 0.01). This could be a finding of importance because it provides a provisional basis to evaluate quantitatively the output of research. The value of 'R' and also of the ratio, could be used as indicators of the recognition bestowed on scientists for new knowledge acquired from scientific research.

The method no doubt has several limitations and needs further refinements if it is to be used for international comparisons. Three of the major problems that require careful study are (a) the lack of a satisfactory method for computing the real costs of research in terms that would enable international comparisons, (b) the subjective nature of the basis for determining the quality of journals, and (c) the parity valuation given for postgraduate degrees.

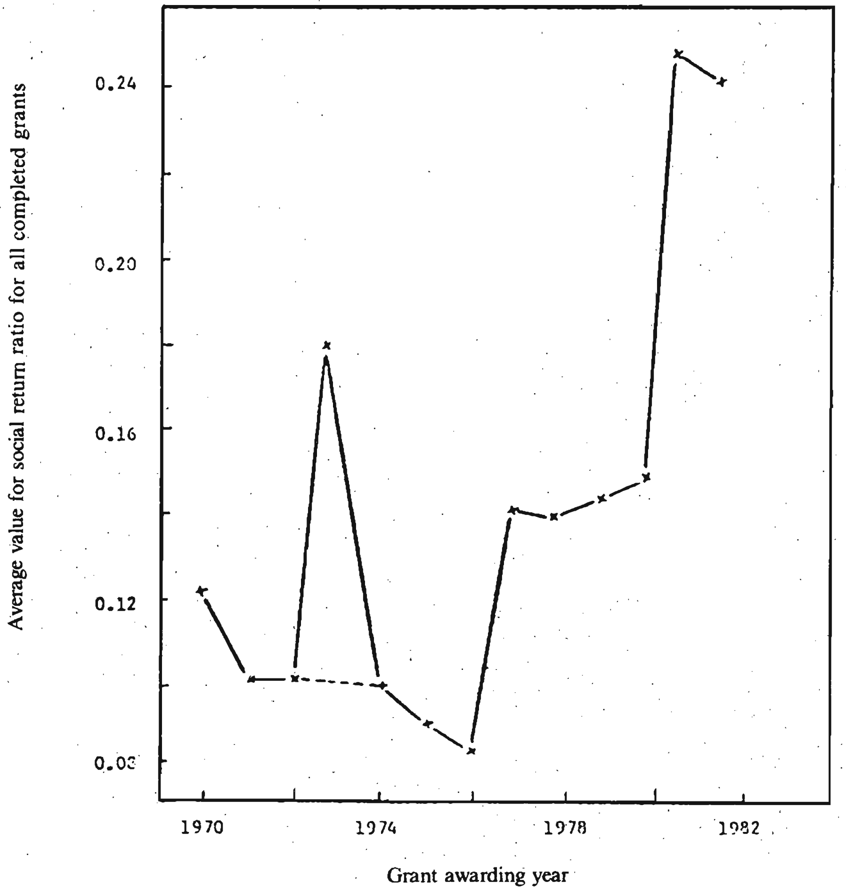

Figure 2. Change in the social return ratio with time for grants completed during 1970 - 1983.

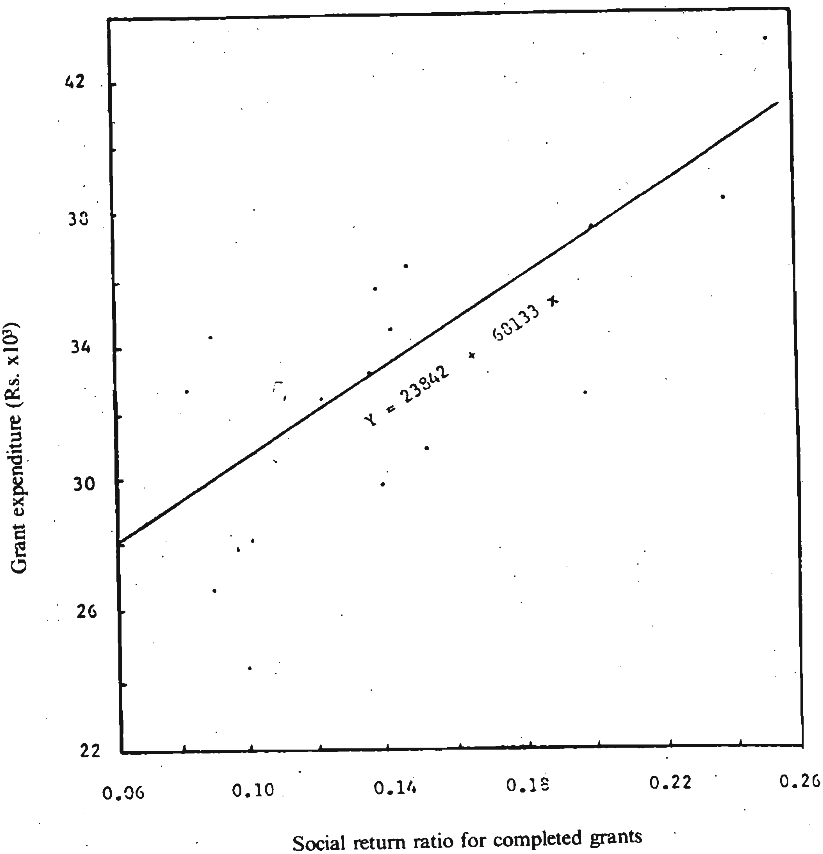

Figure 3. Relationship between research expenditure and the social return ratio.

The costs of research vary considerably among different countries. Thus for example, industrialized countries producing most of their own scientific equipment,would possibly spend less on procurement and servicing of capital goods than less developed countries. On the other hand, third world nations with relatively cheap scientific and technical manpower would spend less on labour than richer industrialized countries, where labour costs are very high. Costs of research are also strongly influenced by inflationary trends of different countries. There is therefore a need to evolve a system of costing research which would facilitate international comparisons meaningfully.

The computations derived above for scientific publications are no doubt based on certain assumptions, which some may regard as too arbitrary. However, it has to be realized that many educational institutions often award higher degrees entirely in recognition of published work. Hence it could be argued that the measures used here in respect of published work, are better or less objectionable than simple counts of citations and publications, where quality of materials is of no consideration.

Quality-wise ranking of journals can raise many controversial issues. Thus for example, it is claimed that the so-called prestigious journals sometimes strive to retain their prestige by favouring recognised scientific groups without much consideration to the quality of material. On the other hand the lesser known local journals which publish material which are relevant and directly applicable in national programmes, are of higher utility value, and deserve greater recognition. These are problems which certainly need further study.

In respect of postgraduate degrees, it could always be argued that under a given set of conditions, the standards attained in a particular higher degree in any field of study are equivalent, and therefore justifies a parity valuation. Yet conceptually, new knowledge gained has different utility values, which may be reflected by the demand for different specialities. In the present study although a standard valuation based on the recognition given by State is used, this need not necessarily be so. If a free competitive market prevails for the employment of qualified personnel, then based on the demand for specific specialities, appropriate valuations could be assigned to such higher degrees.

Unfortunately in most of the poorer developing countries, the necessity to contain inflationary trends, has resulted in rigid state control of the public sector wage structure. Hence in these countries a free competitive labour market for scientists hardly exist. This is a situation which sociologists and economists of industrialized countries, especially those who have not had an exposure to third world problems may fail to comprehend, and hence view the assumptions made in this study as somewhat mechanistic.

In spite of the above limitations, the method evolved provides a tentative basis for the quantitative evaluations of a component of research output, which may have some applications in reviewing research policies.

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References

1. BAYER, A.E. and FOLGER, J. (1966) (Some Correlates of a citation Measure of Productivity in Science, *Sociology of Education. 39: 381-390*

2. BYATT, I.C.R. and COHEN, A.V. (1969) *An Attempt to Quantify the Economic Benefits of Scientific Research.* Science Policy Studies No. 4 Dept. of Education and Science H.M.S.O. London

3. COLE, S. and COLE, J.R. (1967) Scientific Output and Recognition: A Study in the Operation of the Reward System in Science. *American Sociology Review 32: 377-390.*

4. CRANE DIANA (1965) Scientists at Major and Minor Universities: A Study of Productivity and Recognition. *American Sociólogical Review 30: 699-714.*

5. DE SILVA, M.A.T. (1985) Higher Educational Enterprise and Production of Knowledge as Partial Indicators of Research Output. *Paper presented at the Commonwealth Science Council's Workshop on Science and Technology Indicators for Development,* New Delhi India 21-26 February 1985.

6. DE SOLLA PRICE, DEREK, J. (1967) Nations can Publish or Perish. *Science and Technology, October 1967 34-102.*

7. DE SOLLA PRICE, DEREK. J (1969) Measuring the Size of Science. *Lecture delivered to the Israel Academy of Sciences and Humanities,* 11 February, 1969.

8. FREEMAN, C. (1970) *Measurement of Output of Research and Experimental Development. Statistical Reports and Studies.* ST/S/16 COM. 69/XYI/16A. UNESCO, Paris.

9. FREEMAN, C. (1982) *Recent Developments in Science and Technology Indicators: A Review:* Science Policy Research Unit, Univ. of Sussex, U.K.

10. LIBERT, ROLAND J. (1977) Research-Grant Gettir and Productivity among Scholars: Recent National Patterns of Competition and Favour. *Journal of Higher Education. 48(2): 164-192.*

11. MARTIN, BEN, R. and IRVINE, J. (1980) *Assessing Basic Research: Some Partial Indicators of Scientific Progress.* Science Policy Research Unit, Univ. of Sussex. U.K.

12. MC ALLISTER, P.R. and WAGNER, D. ANN (1981) Relationship Between R & D Expenditures and Publication Output for U.S. Colleges and Universities. *Research in Higher Education,* 15 (1): 3-30.

13. SCHMOOKLER, J. and BROWNLEE, O. (1962). The Economics of Research and Development: Determinants of Inventive Activity. *American Economic Review 52(2): 165.*

14. ZUCKERMAN, HARRIET. A. (1967) Nobel Laureates in Science: Patterns of Productivity Collaboration and Authorship. *American Sociology Review 32: 39-403.*