Improving the Quality of Research in Developing Country Universities

by

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Abstract

The paper discusses the role of scientific and technological research in developing countries. It emphasizes the importance of research training, both for the efficient adaptation and use of modern technology and for proper environmental management. A number of common misconceptions in connection with the purpose and nature of university research are discussed, and the importance of research output monitoring and of provision of individual incentives for active research is stressed. The role of scientific publications for the improvement of the quality and international status of scientific research in the Third World is emphasized. The effects of different research policy strategies are illustrated by two university research support projects in Indonesia.
Acknowledgement

In January, 1990, Clifford Gilpin, AS5PH, asked me to write a short discussion paper on how to improve research quality, for use in connection with the preparation of the Second Higher Education Project in Indonesia. The paper helped focus the discussion on university research policy in the country, and several suggested that a more general paper on the subject might be useful for Bank staff and borrower country administrators, working on research support projects. The result is the present paper, which, in particular, attempts to identify policy measures that may improve the productivity of individual researchers.

I am grateful to Dr. Jajah Koswara, Director for Research and Community Service in the Indonesian Ministry of Education, for valuable discussions of research policy in developing countries, to Dr. Makin and others from the IUC Project in Indonesia, and to many of my colleagues in the Bank for useful suggestions. In particular, Adriaan Verspoor, Sachi Takeda, and Tom Eisemon provided valuable comments on the first draft of the paper.
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Executive Summary

The technological development and the increasing internationalization of industrial and commercial activities present both new opportunities and risks for developing countries. Today, scientific progress is transformed much faster than before into new, superior products, and the average life-time of products has been drastically shortened. Products and production methods are increasingly global, and higher technical skills in the labor force are providing more of a competitive edge than low costs. In order to compete in the international market and improve the quality of life for their citizens, countries must at least be able to evaluate, adapt, and modify increasingly advanced imported technology. They must also be able to monitor environmental developments and to define and enforce environmental policies.

In order to satisfy this range of demands, countries must ensure a minimum of scientific and technological capability. Manpower with research training is essential, both for the effective modification and use of advanced technology and for providing up-to-date undergraduate and graduate education in the fast developing scientific and technological fields. Each country and each period in time has its own comparative advantages; earlier successful models, e.g. in the South East Asian NIEs, are useful to study, but should not be copied directly.

How can developing countries satisfy their increasing need for scientists and engineers with research based training? Most countries can not rely solely on research training abroad. It is expensive, may not be targeted to national needs, and may lead to costly brain drain. Therefore, a national research capacity must be established in basic science and engineering fields. In order for the research activities, particularly the research training, to be worthwhile, they must be efficient and of good quality. If this is not the case, the contribution to the development process is likely to be very limited. But even outputs of good and efficient research are often not used for economic development; incentives for practical use, e.g. through university-industry cooperation must also be provided.

Policy towards scientific research has often been influenced by misconceptions. This may lead to inefficiency and waste. Strengthening of research quality and efficiency must be guided by a clear understanding of the purpose and nature of research. Specifically:
the main purpose of university research is to produce trained manpower, not patents or outside income, although such outcomes may be beneficial in several ways;

the main obstacle to good and efficient research in most developing countries is a lack of proper incentives, not a lack of facilities and equipment, although such shortages often do limit the research possibilities severely;

it is not impossible, or even difficult, to evaluate research quality and efficiency, but it is often not properly done. Measuring research activity by the input alone is a common, but usually misleading practice;

scientific and technological research is not likely to be funded to any great extent by industry in developing countries. Even in the most advanced industrialized countries, industry covers only a tiny fraction of university research expenditures;

science and technology do not advance primarily through the efforts of a small number of brilliant individuals, but rather through a global team effort, within each field, of many researchers. Access to such global, informal networks is essential for the research quality, but many developing country researchers are still outside the networks.

Research monitoring and evaluation is essential, both for the provision of incentives to individual researchers and as a guide for research funding. A number of evaluation methods are reviewed; it is stressed that the choice of evaluation procedures influences the strategies that are likely to be used by researchers. Therefore, certain evaluation methods may be counteractive, while other methods may result in unexpected benefits.

Two examples of research capacity building projects, both from Indonesia, illustrate the proposed strategies. One project concentrated on high cost provision of physical resources for research activities, the other on low cost provision of incentives and guidance for researchers. In the former project, incentives for individual researchers were missing at first; when they were introduced, productivity increased drastically. In the latter, provision of incentives and advice, even without or with very little funding, had a strong, positive effect on the research productivity.
1. The Increasing Role of Science and Technology Research in Developing Countries

Development is likely to be driven increasingly by research based advances in science and technology (S&T). These advances are dramatically changing the relationship between science, technology, and economic growth. This affects all developing countries, even the lowest income countries. There are four main reasons for this:

a) New, advanced technologies are often low cost, flexible, and dependable. Some, such as information technologies, are already widely used in developing countries. Progress in fields like biotechnology, new materials, information technology, and natural product chemistry is changing the nature of production and consumption. Although this may increase competition, for example through the creation of new products, which compete with traditional natural products from the tropics, or high technology production methods, which compete with low cost labor, it will also create new opportunities in developing countries.

b) The industrial applications of breakthroughs in basic scientific research are rapid and pervasive. There are numerous examples, such as the fast increase in the use of lasers, which both leads to completely new products, from CD players to surgical lasers, and affects manufacturing technologies. New developments in molecular biology may have implications for both products and production methods in agriculture, pharmaceuticals, and many other fields. These developments have changed the rules of the game, and even recent experience may not apply to the present challenges. To adjust sufficiently fast to the changing technological opportunities, as well as risks, even developing countries must build up a minimum capacity in scientific and technological research and, particularly, research training. They must also create a system that ensures use of this capacity. This is essential for both the development of the flexible and well trained manpower needed, and for creation of a knowledge base that allows selection, modification, and
adaptation of key technologies. In some cases, it may also make it possible to develop needed new technology locally.

c) The mobility of capital, as well as manufacturing activities, has been increasing in recent years. The availability of a skilled labor force is a key factor in attracting external investments in high value added industries. Taiwan and Singapore provide compelling examples of successful implementation of a human resource base development strategy. Other countries may be able to follow equivalent strategies, although the initial advantage in the form of low cost labor may be reduced, as development becomes increasingly technology driven. An added opportunity may come from the development in some large, industrialized countries, which foresee a severe shortage of well trained S&T manpower. Other countries may be able to attract the fast increasing research and development (R&D) activities, which are mobile, if the needed manpower is available, and at the same time usually are highly attractive because of their high value added.

d) Environmental concerns are today of high relevance and have an increasing impact on the choice of economic growth strategies, not only in industrialized, but also in developing countries. Proper assessment and monitoring of environmental conditions require scientific research experience, and formulating and managing national environmental policies require a considerable amount of well trained S&T manpower.

There are thus several reasons for developing countries to make careful investments in research based S&T development. The potential impact of a determined S&T policy can be seen in the industrial development of Japan and the South East Asian Newly Industrialized Economies (NIEs), where emphasis was placed on human resource development, rather than on production of research results (as in "big science" and research for military purposes). Human resources in S&T at various levels were developed on a large scale and used in the build-up of the industrial and, eventually, the research capacity (Wu,
Although both the timing and certain aspects of the traditional cultures in these countries may have provided a particularly beneficial background for their industrial success, the technological development leaves little doubt, that without well designed S&T policies, few, if any, countries will prosper in the coming decades. But each country and each time require their own solution; in particular, today's investments in research capacity must be designed to satisfy future needs and opportunities, rather than being attempts to catch up with lost opportunities. While the strategies for establishing basic research capabilities only change slowly with time, the actions required to make use of such capabilities in the development process are changing much faster with the technological development. A key area for the promotion of such applications is university-industry cooperation, which will be discussed in detail in a forthcoming paper (Parker, 1992). Recent examples from the NIEs can be found in Wu (1992a,b,c).

In several Central and East European (CEE) countries human resources in S&T were available, but the absence of market driven competition and the resulting lack of incentives for improving products and production methods insulated the most highly skilled part of the S&T work force (those with research training) from the needs of industry. This situation became increasingly damaging during the 1980s with the growing importance of innovations and research based production in almost all industrial fields. The lack of innovation in CEE industry is illustrated, for example, by the fact that the high technology component of Polish industrial production is around 2%, compared with 14% in Japan, 13% in the former West Germany and more than 11% in the US (Thulstrup, 1991), and while Poland in the 1980s produced 2-3% of all articles in mainstream journals on polymer and materials sciences, it produced less than 0.1% of the patents in the field of plastics.

Most developing countries face an even more difficult challenge, because of a severe shortage of qualified S&T personnel, including researchers. Table 1 illustrates this situation; it is interesting to note that the global increase in the number of S&T manpower is strong in all regions. The relative increase is the same for all regions, except Latin America, where it is much lower.

When using data like those given in Table 1, it is important to realize that such quantitative information alone is often misleading. Definitions of skills are often different in different countries. Specifically, in some Third World countries, the production of engineers is relatively high in numbers, but research and graduate training in the engineering fields are
almost nonexistent. This usually indicates that the engineering education is not up to date, that the educational quality in general is poor, and that the engineers, who are produced in the system, will be unable to contribute effectively to the development process. A situation with a shortage of qualified engineers together with a high unemployment among poorly trained engineers is therefore not surprising in such countries. Another bottleneck may be the ability of industry to take advantage of highly trained human resources. Typically, East European countries did not use well educated university graduates with research training to renew industrial practices; therefore, they benefitted little from their research and training capacities.

Table 1.

Estimates of Scientific and Technical Manpower per Million Population.

<table>
<thead>
<tr>
<th>Region</th>
<th>1980</th>
<th>1985</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>2,600</td>
<td>3,500</td>
<td>35%</td>
</tr>
<tr>
<td>Asia</td>
<td>8,900</td>
<td>11,700</td>
<td>31%</td>
</tr>
<tr>
<td>Europe (incl. USSR)</td>
<td>35,700</td>
<td>48,600</td>
<td>36%</td>
</tr>
<tr>
<td>Latin America</td>
<td>9,800</td>
<td>11,800</td>
<td>20%</td>
</tr>
<tr>
<td>Northern America</td>
<td>96,000</td>
<td>126,000</td>
<td>31%</td>
</tr>
<tr>
<td>Developing Countries</td>
<td>6,300</td>
<td>8,300</td>
<td>32%</td>
</tr>
<tr>
<td>Developed Countries</td>
<td>52,800</td>
<td>70,500</td>
<td>34%</td>
</tr>
</tbody>
</table>

Source: UNESCO (1991)

Also the research output is low in most developing countries. While the production of research papers per million population in industrialized countries is several hundred per year (for further information, see Table 4), it is less than half a dozen per year in the leading producer of research in the Third World, India, and lower in the other major producers, China and Brazil (Gaillard, 1990). Even the best universities in many developing countries have a low research productivity among the staff, at least when measured with the yardsticks
commonly used in industrialized countries. There are many reasons for this; some can only be overcome if additional funding becomes available, while others can be dealt with at no cost. Often, the availability of new funds for research, for example through a World Bank loan, presents a unique chance for provoking a change of habits among less productive researchers, primarily through provision of new incentives. This may often be of greater value than the direct benefits of the investments. Generally, it is true that investments in research made without a sound policy background are likely to fail. Similarly as production of S&T graduates is of little effect, unless the education is of good quality and relevant to national needs, research investments must be an effective part of a consistent, national research policy in order to be useful.

2. Defining Research Quality

The criteria applied to define and measure research quality must be defined according to the type of research in question. In product research and development, quality will be closely related to the commercial potential or social benefits of the product, which can be easily measured, at least after it reaches the market; in basic research, quality will refer to scientific excellence, which today can also be measured, at least roughly. The majority of research activities lies between these two extremes. However, fundamental scientific qualities must always be present, not only for basic but also for applied research: Environmental monitoring, medical laboratory tests, or product development will be worthless if measurements are not performed properly, data treated correctly, and conclusions drawn in a logical way. Only if the quality on this (first) level is satisfactory, will the social or economic relevance of the results (the quality on the second level) be of interest (Thulstrup, 1990).

Even among research activities of high quality on the first level, assigning priorities is an important activity. While breakthroughs in the understanding of hieroglyphs academically may be as exciting and qualified as designs for reproducible fusion processes inside a cold palladium electrode, it is clear that "cold fusion," if it can be realized, will have a much larger impact on the future of humankind. It is common practice in most countries to give highest priority to research activities which may support the development of methods or products of considerable social or economic importance. If well designed, such activities
will not only add to the body of scientific knowledge, but will also provide valuable, high-
level training in key areas.

The policy of supporting research selectively often goes quite far in the direction of
support of basic research in a broad base of physical, biological, and engineering sciences.
A strong foundation in fundamental science is needed both for high level training and for
essential applications in the fields of industry, agriculture, environment, and health, and for
technology evaluation. Research activities are essential for the creation of such a base and
for keeping it up to date. Without research activities in a broad area of basic natural
sciences, the standard of higher education in engineering, medicine and science will easily
deteriorate (see, for example, Wolff, 1991). Among the industrialized countries which spend
the largest share of their national products on R&D (around 3%), typically one tenth of the
total is spent on basic research. For developing countries and other countries with relatively
lower research expenditures, a larger, or much larger, share is required to satisfy the needs
for basic research activities, especially the important research training. For a discussion, see

Creating and preserving a national base in the fundamental sciences is, however, not
enough. It is equally important that those areas in applied sciences, which already are, or--
since creation of a scientific research base takes time-- are likely to become essential for the
national development, are supported selectively. Finally, it must be kept in mind, that
without ability to and incentives for constructive use of research based knowledge and
trained manpower in industry, contributions to social or economic development will be
minor, as illustrated by the industrial failures in the CEE countries during the 1980s. Other
examples may be found in India, Argentina, and Brazil.

It may be noted, that in part of the literature on the subject, predictions of what may
become key technology areas for development tend to emphasize electronics and
information technologies (see, for example, Castells, 1991). However, interdisciplinary fields
between biology and chemistry may be even more promising for most tropical developing
countries, primarily because of the special comparative advantages of these countries, for
example the uniqueness or abundance of certain natural product raw materials. Among 87
research projects, supported by the Office of the Science and Technology Board in Thailand
in the late 1980s, 47 were in the biosciences, 22 in materials science (including natural
product chemistry), and only 10 in electronics and informatics (The Science and Technology
Although it is tempting and in several ways relevant to use the NIEs as role models for other developing countries in their industrial development (Dahlman and Brimble, 1990), it should be kept in mind, that each period in time and each country has its own comparative advantage.

In summary, the global trends, including the technological development, makes it necessary for national research policies to satisfy three main concerns:

(i) the quality and efficiency of the fundamental scientific "infrastructure" must be adequate,

(ii) the quality and efficiency in strategic, applied areas must be selectively strengthened, and

(iii) the ability to apply existing knowledge and human resources constructively in the development process must be promoted.

When evaluating contributions of the first kind, the purely scientific excellence of the research is of interest. When the two latter contributions are considered, it is not only scientific quality, but also the potential, direct contributions of the research to economic or social development, which must be counted in any evaluation of research and research policy. OECD has recently given a comprehensive survey of how the choice of priorities in S&T is made in a number of industrialized countries (OECD, 1991).

In order to effectively design policies and projects that deal with research in science and technology, it is important to understand the incentive systems which encourage scientists to be productive, which promote quality and relevance in the research, and which ensures that the results of the research efforts, both in the form of training and new knowledge, contribute towards the development process. Although such systems to a large extent follow what common sense would dictate, their use is limited because of a series of fairly widespread misconceptions. In the following, we will take a closer look of the most serious of these.
3. Myth Number One: University Research is Important Because It Leads to Scientific Discovery

The spectacular breakthroughs in scientific research, which have led to new technologies of great economic impact, have fascinated many. Universities, which account for a substantial part of the research spending in most countries (Table 2), especially in developing countries, are therefore often asked to justify their research activities by producing results of commercial interest, for example in the form of patentable innovations or income from industrial services. By doing this, it may be overlooked that the main purpose of universities is to produce well trained graduates, partly through research and research training activities.

Table 2

<table>
<thead>
<tr>
<th>Country</th>
<th>% of GNP on R&amp;D</th>
<th>Universities</th>
<th>(Other) Public Institutions</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt (1982)</td>
<td>0.2</td>
<td>78%</td>
<td>4%</td>
<td>18%</td>
</tr>
<tr>
<td>Jordan (1986)</td>
<td>1.0</td>
<td>68%</td>
<td>26%</td>
<td>6%</td>
</tr>
<tr>
<td>Chile (1988)</td>
<td>0.5</td>
<td>39%</td>
<td>4%</td>
<td>57%</td>
</tr>
<tr>
<td>Thailand</td>
<td>0.3</td>
<td>30%</td>
<td>7%</td>
<td>62%</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.9</td>
<td>26%</td>
<td>14%</td>
<td>60%</td>
</tr>
<tr>
<td>Canada</td>
<td>1.3</td>
<td>24%</td>
<td>22%</td>
<td>54%</td>
</tr>
<tr>
<td>Denmark</td>
<td>1.3</td>
<td>24%</td>
<td>21%</td>
<td>55%</td>
</tr>
<tr>
<td>Rwanda (1984)</td>
<td>0.1</td>
<td>21%</td>
<td>69%</td>
<td>10%</td>
</tr>
<tr>
<td>Norway</td>
<td>1.8</td>
<td>21%</td>
<td>17%</td>
<td>63%</td>
</tr>
<tr>
<td>El Salvador</td>
<td>1.5</td>
<td>20%</td>
<td>49%</td>
<td>31%</td>
</tr>
<tr>
<td>Japan</td>
<td>2.9</td>
<td>20%</td>
<td>14%</td>
<td>66%</td>
</tr>
<tr>
<td>France</td>
<td>2.3</td>
<td>15%</td>
<td>26%</td>
<td>59%</td>
</tr>
<tr>
<td>Hungary</td>
<td>2.7</td>
<td>15%</td>
<td>21%</td>
<td>64%</td>
</tr>
<tr>
<td>Korea, Rep. of (1988)</td>
<td>1.9</td>
<td>10%</td>
<td>21%</td>
<td>69%</td>
</tr>
</tbody>
</table>

Source: Unesco (1990); NSF (1991)
The importance of the training aspects of research is reflected in the data given in Table 2. Countries which spend a large share of their GNP on research may satisfy their research training needs by carrying out a fairly small fraction of the research in universities (20% in Japan, 10% in Korea, which, however, in addition performs much research training abroad, see below). Other countries, which spend a small part of their resources on research, must carry out a much larger share of it in universities (68% in Jordan, 78% in Egypt). When comparing educational strategies, it is often overlooked, that some developing countries, including several of the successful South East Asian countries (Korea, Taiwan, Singapore, and Malaysia, among others), for many years have performed a large part of the needed research training abroad, by sending graduate students overseas. This often results in high quality training and it gives international exposure for the students, but it is also expensive, it may give less emphasis to problems of particular national interest, it does not, at least not directly, support capacity building at home, and it may lead to costly brain drain. A general discussion of the status and issues in overseas higher education has been given by Selvaratnam (1992).

Some of the countries, which earlier emphasized industrial research, may now be reconsidering their policies with respect to university research. This is true in countries, which traditionally have carried out extensive research training abroad. But it is also true in Japan, which performed a major assessment of university science in 1990. Based on this, the Japanese Government has now concluded that university research, particularly in the natural sciences and engineering, must be strongly upgraded in order for the country to preserve its international competitiveness. One particular goal is to improve the ability of Japanese universities to attract foreign talent in S&T to Japan (Nakanishi, 1991). In an interesting development, the Japanese Ministry of Trade and Technology, which for many years successfully supported applications of basic science and technology development in industry, is now planning to start supporting basic science research and training at Japanese universities. This is probably a combined effect of the increasing demands for research based technology and a rising fear of a future shortage of research trained manpower.

Emphasis on educational and training aspects of university research does not prevent graduate schools from working on projects of commercial interest. On the contrary, giving students insight in the needs of industry and the commercialization process is an important part of the training, especially in fields like engineering. This process is one of the main outcomes of cooperation between universities and industry. It may therefore often be
worthwhile for governments to provide special incentives for university/industry cooperation. One possibility, which is being examined in connection with a World Bank project in Jordan, is to give government sponsored vouchers to small and medium sized industries for R&D services provided by universities. However, in the general case, the results of university research activities should not be measured on their commercial success, but in the quality and relevance of the training they provide. If creation of income becomes the main purpose, training needs may easily be overlooked. This may create long term problems, even in those industries, which were supposed to benefit from the emphasis on commercial activities.

Quality in university research and research training is important for industry, not only in connection with the development of new technologies or the creation of scientific and technological breakthroughs, but to an even larger degree for providing a basis for the efficient and innovative use of up to date technologies. It is often overlooked, that proper introduction and adaptation of new technologies, as well as major changes in existing technologies, today are necessary, but difficult components of successful industrial management. The new ideas may have been created in the industry itself, but more often they are brought in from the outside, for example in the form of patents. In almost all cases, proper adaption and continuous modification of the technologies and their application are required, in order for the technology changes to become successes. These incremental improvements are, in a sense, as important as the technology changes. For a number of international examples, see Mody (1991).

What decides whether industries will be able to carry out the incremental improvements well? This requires a solid knowledge of the field in question, good analytical skills, and the ability to think independently and logically. These are exactly the qualities, which good research training is likely to develop. Therefore, a main purpose of university research remains the training of researchers who can adapt and modify technology.

There are other educational benefits of quality university research, which may be equally important. In particular, the fast development of many fields in science and technology requires constant upgrading of the subject matter which is taught in science and engineering, also at the undergraduate level. This upgrading takes place most effectively, if at least some of the university teachers in each S&T field are engaged in research, together covering a sufficiently wide range of subjects. It is also important that undergraduate students, through at least some of their professors, experience the scientific enthusiasm and
global perspective, which often results from active research, especially when combined with participation in international research cooperation, for example through international networks.

Research activities may also have a negative influence on the teaching. If the university reward system only emphasizes research, teaching duties may be neglected. Even worse, if the research is weak and the researchers passive, providing time and facilities for research may have a negative effect on the work climate and student attitudes, which are being formed during the studies. A compromise solution, in which real research work by university teachers is replaced by the concept, which sometimes is referred to as "scholarship" (a small allowance of time to follow the development in a specific field), may provide some savings compared to active research. But at least one flaw of this solution is, that the possible results of "scholarship" work are hard to measure and reward.

It is important to note, that scientific university research often is efficient compared with other public sector research. A comparison of the number and quality (based on dissemination channels) of research papers in chemistry, produced in Polish universities and public sector research institutions (without teaching obligations), showed that researchers in the three best university chemistry departments were producing as many (or more) quality papers per professor as their counterparts in the best Research Institute in the field (Thulstrup, 1991). Both the latter Institute and the top university chemistry departments have won considerable international recognition. The equally high production in the universities happened in spite of the fact that the Research Institute was better equipped and that its staff was full time researchers, while the university staff used more than half of its time on teaching. The main difference between the two types of institutions is the teaching duties. The students, on the one hand, demand time and attention from the researchers, but, on the other, pay them back in the form of intellectual stimulation and possibly also by providing continuous quality control. At the same time, universities have a considerable advantage in their access to select their own research students. This way, educational activities become almost as important for the research as research is for university education.
4. Myth Number Two: The Main Obstacle to Good Research is Insufficient Physical Facilities

In projects providing support for research, it has often been assumed that researchers, particularly natural scientists, respond to an inner drive do research when physical conditions allow it, and that the most common obstacles to research productivity, especially in developing countries, are lack of laboratories and modern equipment, computers, and library facilities. This assumption has been the background for much of the support for developing country research, including some of the support given through World Bank loans (Muskin, 1991), even at a time - the last twenty years or so - when most industrialized countries had realized, and many had taken into account in their policies, that the assumption did not hold.

The reality is different from the traditional assumptions, also in developing countries. It is hardly surprising, that researchers do active research when it serves their personal interests, both monetary and non-monetary. More than most other groups, researchers are independent-minded, intelligent, and respond more effectively to reward systems than to orders. When incentives are missing, many researchers, even talented ones, become easily absorbed in other activities. When incentives are strong, researchers may overcome considerable practical difficulties, and may, for example, perform relevant, or even outstanding, work with outdated or primitive equipment.

Incentives for active research may in its simplest form be provided by a monitoring and evaluation process, which gives recognition to researchers, who have performed well. It is surprising, how often even this basic motivational mechanism is missing in research management systems. More effective incentives may come in the form of rewards for good research: Improved research opportunities, promotion, better pay, travel opportunities, intellectual stimulation, especially through interaction with other researchers, and, maybe most of all, fame and honor. Research teamwork may have a similar importance, at least as long as the project is limited in size and is successful. With the fast growing development of small, international networks in specialized fields, such teamwork may take on a global dimension, which becomes particularly stimulating through the fast electronic communication (e.g. on Bitnet), which today is common among industrialized countries.
In many industrialized countries, a research funding strategy is today widely used, which combines sound investment practice (financing researchers and research activities that have a record of high productivity) with the provision of incentives to researchers. In this model, research support is provided on the basis of the quality of proposals submitted by eligible researchers and based on the researchers' past performance. This way, it is ensured that research funding is given, where the chances of success are best; at the same time, researchers are aware that their research performance matters. In particular, it will determine their chances for future support. Research support in such systems is usually very attractive, it is a form of recognition, and it may include a salary component, travel funds, funds for new and improved equipment, or research time (funds for hiring staff to relieve the main researcher from other duties).

In developing countries, such competitive research funding systems are less common. Often research funding is spread out, not only in the form of research time, also as travel funds, equipment, etc. Often a small share is given to everyone above a certain rank in the system. This kind of research funding does not ensure effective use of the resources, often each share is too small to matter, and, worst of all, the system does not provide the needed incentives for active research. For an example of the effect of research incentives in a developing country, see Annex 1.

5. Myth Number Three: Research Quality and Efficiency Cannot be Evaluated

The quality of research, including the quality on the second level: its local applicability, and the research productivity are key quantities in research management. Effective management of research requires that both the input and the output (in terms of quality and quantity of research and research training) is monitored. This is often not done. The excuses are usually that the research output is too difficult to measure. What is usually considered easy to estimate is the input in research. The largest single input usually comes in the form of manpower (salaries), which in most systems should be easy to estimate. Nevertheless, it is often not properly done in university evaluations: Sometimes, the research time of the faculty is not counted at all, at other times each university teacher is counted as a full time researcher. More realistic estimates of research time for university staff with
research obligations will usually be between 20% and 50% of full time. Some other major inputs into university research are physical facilities, including equipment, which in S&T takes an increasing share of the budget, libraries, and travel funds.

The lack of ability and willingness to measure output has lead to a widespread, unfortunate practice, in which the productivity of research communities and the quality of the research outputs are replaced by a listing of research input measures. For example are international comparisons of research potentials often performed on the basis of input measures alone (usually data on the number of researchers per million population, or research expenditures in % of the GDP, Table 3), in spite of the fact that research efficiency, the amount of new knowledge and research training obtained for a given amount of money, often vary strongly between countries.

Table 3

<table>
<thead>
<tr>
<th>Country</th>
<th>per capita GDP in US$</th>
<th>%R&amp;D of GDP</th>
<th>R&amp;D Manpower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korea, Rep. of (1988)</td>
<td>3,600</td>
<td>1.9</td>
<td>1,320</td>
</tr>
<tr>
<td>Japan</td>
<td>16,000</td>
<td>2.9</td>
<td>5,000</td>
</tr>
<tr>
<td>India (1986)</td>
<td>300</td>
<td>0.9</td>
<td>100</td>
</tr>
<tr>
<td>Philippines (1984)</td>
<td>590</td>
<td>0.1</td>
<td>90</td>
</tr>
<tr>
<td>Denmark</td>
<td>15,000</td>
<td>1.3</td>
<td>1,900</td>
</tr>
<tr>
<td>Spain</td>
<td>6,000</td>
<td>0.6</td>
<td>500</td>
</tr>
<tr>
<td>Finland</td>
<td>14,000</td>
<td>1.7</td>
<td>1,900</td>
</tr>
<tr>
<td>Norway</td>
<td>17,000</td>
<td>1.8</td>
<td>2,800</td>
</tr>
<tr>
<td>Hungary (1980)</td>
<td>2,200</td>
<td>2.3</td>
<td>2,300</td>
</tr>
</tbody>
</table>

Source: The World Bank (1989); OECD (1990); UNESCO (1990)
Information of the kind presented in Table 3 is an unsatisfactory substitute for a measure of the true research potential, activity, and output of a country. Drastic differences in research productivity may be illustrated by many concrete cases on both local, national, and international levels. For an example, see Box 1.

**Box 1: Is Research Input and Output Related?**

In 1987, the three countries, Denmark, Finland, and Norway, spent, within a few percent, the same amount on research in the natural sciences (Unesco, 1990). Still, among these three neighboring and very similar countries, with similar research systems, there were large differences in the scientific research output. Norway, with 0.08% of the World population, produced 0.45% of the World's total of articles in mainstream science journals, Finland produced 0.6% and Denmark 0.7% (Luukkonen, Persson, and Sivertsen, 1991). Both the latter countries have close to 0.1% of the World population. However, the number of scientific papers is not a measure of research output that is simple to use. It should never be used directly, but only as background material for a closer study of research efficiency. There is thus, at least initially, no reason to blame Norwegian researchers for being unproductive, or to praise Danish researchers for their high productivity. Part of the explanation may be that Denmark spent more on scientific research than Norway before 1980, which would account for some of the higher production ten years later, since scientific research requires time to become established and productive. There are also other possible reasons, which may give clues to constructive research policy inputs: University researchers are better paid in Denmark; Danish competition for research grants may be harder, etc. Irrespective of the reasons, the example illustrates the severe weaknesses in using input measurements alone, when research capacity and activity is being measured. For further illustrations of output measures, see Table 4 below.

The primitive input measures often used should not conceal the fact that it is possible to measure research quality and productivity; in particular, methods have improved considerably during the last 15 years (see the discussion below). While it still may be difficult to select Nobel Prize winners, it is easy to distinguish between active and inactive researchers, between local and international research, and between well disseminated and poorly disseminated research. The information given in Table 4 includes research publications as a quantitative, and citations of such publications by other researchers as a
qualitative measure (see below). This kind of information is much more useful than the
normal listing of input, as in Table 3, since it illustrates the real research capacity and
efficiency of national research systems. It must be added, that the output measures used in
Table 3 do not predict the usefulness of the research beyond the academic quality control.
An widely applicable set of indicators for predicting social or economic benefits of research
does not yet exist.

Table 4.
Total Research Input, Output, and Efficiency in Some Industrialized Countries.

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English Speaking Countries:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>15,000</td>
<td>1.4</td>
<td>7,400</td>
<td>5.0</td>
<td>37,000</td>
</tr>
<tr>
<td>UK</td>
<td>10,000</td>
<td>2.3</td>
<td>7,200</td>
<td>5.7</td>
<td>41,000</td>
</tr>
<tr>
<td>US</td>
<td>19,000</td>
<td>2.9</td>
<td>7,100</td>
<td>6.6</td>
<td>47,000</td>
</tr>
<tr>
<td>Non-English Speaking Countries:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switzerland</td>
<td>21,000</td>
<td>2.9</td>
<td>10,200</td>
<td>7.3</td>
<td>73,000</td>
</tr>
<tr>
<td>Sweden</td>
<td>16,000</td>
<td>3.0</td>
<td>8,900</td>
<td>6.8</td>
<td>60,000</td>
</tr>
<tr>
<td>Denmark</td>
<td>15,000</td>
<td>1.4</td>
<td>7,700</td>
<td>6.1</td>
<td>47,000</td>
</tr>
<tr>
<td>Finland</td>
<td>14,000</td>
<td>1.7</td>
<td>5,600</td>
<td>5.0</td>
<td>28,000</td>
</tr>
<tr>
<td>Norway</td>
<td>17,000</td>
<td>1.8</td>
<td>5,500</td>
<td>4.9</td>
<td>27,000</td>
</tr>
<tr>
<td>Belgium</td>
<td>11,000</td>
<td>1.7</td>
<td>4,300</td>
<td>5.3</td>
<td>23,000</td>
</tr>
<tr>
<td>France</td>
<td>13,000</td>
<td>2.3</td>
<td>3,900</td>
<td>5.2</td>
<td>20,000</td>
</tr>
<tr>
<td>Japan</td>
<td>16,000</td>
<td>2.9</td>
<td>2,500</td>
<td>4.3</td>
<td>11,000</td>
</tr>
<tr>
<td>Italy</td>
<td>10,000</td>
<td>1.2</td>
<td>1,900</td>
<td>4.2</td>
<td>8,000</td>
</tr>
</tbody>
</table>

Source: The World Bank (1989); OECD (1990); The Economist (1992). See also the
discussion in Box 1 and 2.
of experienced researchers. A summary of research evaluation methods is given below.

In reality, evaluations of research quality are performed, and have for many years

In some Industrialized Countries

Box 2: Research Output and Efficiency

The information in Table 4 is separated into two groups: English and Non-English Speaking Countries.
In good universities, application for local research support may also lead to an evaluation, both of the past research performance of the applicant (ex-post evaluation), which is often given greater weight, and of the scientific value of the proposed research project (ex-ante evaluation). In many countries, universities apply such evaluations when several kinds of research resources are distributed, but not when research time is given. Often university teachers have a standard amount of their time available for research (20-50%), irrespective of how productive they are. Rewarding good research through provision of research time, and punishing poor productivity by removing research time, may be a useful way of providing incentives without additional resources. In practice, research time includes time for provision of research training; this way, good researchers are given better opportunities to provide research training than less efficient researchers.

University researchers are often required to produce research publications in order to be promoted. A major advantage of this practice is the self-evaluation, which usually takes place when research papers are written. If the papers are submitted to good, refereed journals, an additional important evaluation will occur. Such evaluations are by some researchers viewed as obstacles for their projects. In reality, if they are performed well and the results are expressed in a constructive way, they may provide the most valuable guidance for the authors, and are the key to improved research quality. Other research institutions often do not have the same traditions for frequent evaluations built into their systems.

One important strength of many of the evaluations, which traditionally take place in good universities, is that the purpose and the consequences are clear (should the degree be awarded? who should have the job? should the grant be given? should the paper be published? etc.). Evaluations are time consuming, often for both the evaluators and those, whose work is evaluated. They are rarely successful when the purpose is not clear for the parties involved, or when the evaluations have no clear purpose; unfortunately this is sometimes overlooked, particularly in large-scale (nationwide) evaluations.
6. Myth Number Four: University Research Can be Funded by the Private Sector

It is tempting to assume that because of the considerable interest the private sector has in scientific and technological research, in particular research at universities, which also provides industrial access to the best students and graduates, university research may to a considerable degree be funded by industry. This is, however, not the case in any industrialized country today. In the US, for example, industry, including foreign industry, particularly Japanese, provided around 7% of all university research funding in 1991; this may be compared with federal support covering more than 56% of the university research expenditures, and with support from state and local governments accounting for most of the rest. It must be noted, however, that the industrial contribution to university research in the US has grown steadily during the last decade; in 1980 it was only 4%.

The situation in other industrialized countries is not much different; if there is a difference, it is in the direction of less industrial support for university research. Table 5 shows a comparison of data for 1989 for four countries. In the two of those, where industry in recent years has been most successful, Italy and Japan, it provided 1% and 2%, respectively, of the university research funding. In addition to the direct government contribution to university research, indirect public support frequently occurs through tax deductions for donations, etc. from private sources to university research.

Table 5
University Research Funding by Source

<table>
<thead>
<tr>
<th>Country</th>
<th>Industry</th>
<th>Government</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>1%</td>
<td>98%</td>
<td>1%</td>
</tr>
<tr>
<td>Japan</td>
<td>2%</td>
<td>51%</td>
<td>47%*</td>
</tr>
<tr>
<td>UK</td>
<td>7%</td>
<td>74%</td>
<td>19%</td>
</tr>
<tr>
<td>US</td>
<td>7%</td>
<td>86% **</td>
<td>7%</td>
</tr>
</tbody>
</table>

* Most of the 47% is universities' own support for research
** Support from federal (60%) and state + local government (est. 26%)
Source: Parker (1992)
Compared with the modest industrial support of university research, the US federal government is very generous in its support for research in industry. In 1960, 60% of all research in US industry was financed by the federal government. The number fell to 43% in 1970 and 31% in 1980. It has not changed much during the 1980s and is expected to be 31% for 1991. In many countries, also indirect government support for industrial research through tax incentives is substantial. This is part of the reason for the very high share of the total research activities, which takes place in industry in some countries, for example Korea (Table 2, see also Wu, 1992c).

In most developing countries, governments sponsor little industrial research, and industry sponsor even less university research. To expect that it might be possible to convince developing country industries, which are generally much weaker than those in industrialized countries, to sponsor substantial parts of university research, outside a few specialized areas, is hardly realistic. The best possibilities for generation of income from industry in the Third World may come from research-based course activities for industry staff. The need for such training activities is often great, and they are likely to promote university/industry cooperation. But they are not likely to become a major funding source for research.

The modest opportunities for industrial financing of university research do not reduce the importance of university/industry cooperation. It is important that both teaching and research training in relevant subjects at universities reflect industrial needs. It is equally important that industry has easy access to active researchers in universities, who can keep it informed about the latest developments in key areas. Finally, it is important to maintain a dialogue which ensures that new graduates, especially those with research degrees, are properly placed in industry. Incentives for universities to take part in such cooperation may require rewards in the form of industrial support for both research projects and individual researchers. In many developing countries, such support may be urgently needed in order to keep highly skilled researchers in key areas from leaving the universities for better paid jobs in industry.

The role of industry in this area is complicated. It is clear, that industry often can benefit greatly from recruiting good researchers from universities. On the other hand, only by ensuring that a sufficient number of qualified teachers and researchers remain in their university positions, will it be possible to ensure a steady flow to industry of graduates with relevant, high quality research training. If salaries, other benefits, and career opportunities
are unsatisfactory in universities, there is an increased risk of brain drain to industry. The risk is highest for researchers in fields, such as S&T, which develop fast and are particularly relevant for industry. If such brain drain limits or even prevents advanced training efforts in key industrial fields, it may hurt industry severely. In some countries, industry is aware of this risk, but in most, governments must try to limit such damages. Another common risk is that public sector career systems may force successful researchers out of active research, in order for them to obtain a promotion. Some countries, for example the Philippines and the US, have recently taken steps to reduce such damage, by improving conditions and career opportunities for active researchers in the public sector.

7. Myth Number Five: Research Results are Produced Primarily by a Small Number of Brilliant Individuals

Institutions like the Nobel Foundation and press coverage of breakthroughs in research tend to give the impression that research results are produced by a few brilliant individuals. While this is occasionally true, it is often overlooked to what extent research efficiency is related to teamwork and extensive communication between researchers. Most productive scientific and technological research is today performed by teams. Sometimes, the immediate reason may be that the major equipment, which is often needed for such research, can only be afforded if it is shared by several researchers. Another, more important reason is that team cooperation between researchers, for example scientists specializing in different aspects of a common research field, tends to be very efficient. However, in the team cooperation, brilliant individuals are still important driving forces.

A similar situation, promoting research cooperation, exists on a larger, global scale. Research results and methods in all basic and some applied scientific research (for example often within the pharmaceutical field) is published openly and is available for the usually modest price of research journal subscriptions to anyone with the ability to read and understand the papers. This creates a global communication, and often also cooperation, in which even researchers, who have never met, are able to learn from each other. There is little doubt that this free exchange of ideas is a major cause for the fast progress in natural science research in industrialized countries.
For research communities in the Third World, the tradition of free, global communication between researchers in a given field presents special opportunities, but for both practical and cultural reasons, developing country researchers are often found outside these specialized, informal, international networks, and they contribute in general little to the mainstream scientific literature. When attempts are made to strengthen research in developing countries, it should be a main priority to establish strong ties with the international research communities in each field. Long term twinning arrangements between university departments are more likely to accomplish this than even large amounts of scattered technical assistance (Danida, 1992).

Many developing countries have invested heavily in overseas research training by sending students abroad on degree programs. This has been successful in those cases, where many of the graduates have returned home to proper employment (Japan, Korea). In other cases it has led to brain drain, either with severe consequences (India, The Philippines, see Gonzales, 1992) or with much less severe effects (Taiwan, see Wu, 1992b), or returning graduates have obtained a specialization, in which they were not able to continue their research after the return (e.g. at some Outer Island universities in Indonesia). Degree programs of the sandwich type, where the home university in cooperation with an overseas university defines a research program, are much more likely to contribute to a strengthening of local universities and to promote research of local importance.

Today, much of the global communication between researchers in any given S&T field takes place through electronic networks, and much of the discussion between specialists in a field may have occurred in this form before publication of a research paper. However, this has not reduced the role of scientific journals, it has rather modified it. A new division of tasks between local (national) journals and international journals seems to be appearing: International research journals provide not only wide exposure, but also quality control, of the research, while local journals provide dissemination of methods and results to local users.

Publication of research results in good, international journals is still thus considered a necessary activity, of particular value for less experienced researchers. Describing a research project and its results in a concise, written form is a highly constructive exercise for the author. It often reveals weak points in the collection and treatment of data and in the final conclusions. Good scientific journals provide referees who are usually experienced researchers within the field of the paper submitted. Good referees will not only point out problem areas in the research work and the description of it, they will often also suggest
improvements. Thus, regular submission of research papers to good, international journals does not only serve the dissemination of research results, but may also provide a continuous guidance in the research work. Developing country researchers are often at a disadvantage in this connection, since they generally publish little in leading research journals, partly because of a lack of facilities (equipment, research journal subscriptions, etc.), partly because of traditions, lack of practice in scientific writing, language problems, etc.

A second important advantage connected with the regular publication of research results in scientific journals follows from the exposure, it gives the research. Good international journals are often read by essentially all researchers in the given field, far outside the small, specialized networks. An immediate result of the publication of a research article is often comments or questions from other researchers working on similar projects. Again, this provides valuable guidance to the author and it promotes cooperation between researchers, which often leads to better results and faster progress in the research projects. The free transfer of research results to other researchers, as well as to a wider group of users, through scientific journals may still be the most important mechanism in the dissemination of all fundamental research. Therefore, the journals used for publication must preferably have a circulation as wide as possible, where the research is of interest. This will often be the whole world.

In order to ensure effective dissemination to a world-wide audience, the language used in original research publications should be understood by as many researchers in the field as possible. In natural science and engineering, the language favored today is English, and knowledge of English is almost a necessary condition for high quality work in these areas. This may change as other languages become more important. Still, in any field, most languages, even French, German, Japanese, Spanish, and Russian, provide communication with a research base, which is so limited, that publication of research results in these languages often does not provide sufficient quality control.

For the often extremely important dissemination of research methods and results to local users, in particular local industry, conditions are usually quite different. Local language is often preferable; in particular, regular local language reviews of selected S&T research fields may be very useful in helping industry keep up with the recent development in research areas of particular interest for them.
In many developing countries, the foreign language ability among researchers is still so limited that a wider use of local language journals may be relevant (for an example, see Annex 1). In such cases the journals should satisfy as many of the quality demands for good, international journals as possible (such as the widest possible circulation in the language region, good referee and editorial support, foreign language abstracts, short publication times, etc). For a detailed discussion of the language issue in higher education and research, see Eisemon (1992).


The most frequently used evaluation methods have recently been discussed by OECD in a useful booklet (OECD, 1987). Examples of application of these and other more exotic methods are abundant; they are frequently studied and reviewed by international organizations, including the European Community (1984), the Nordic Council (1987) and OECD. Although the literature in the field is extensive, one important aspect is often overlooked: the effect the evaluation has on the work and attitude of individual researchers. Another weakness is that evaluation methods have been developed in industrialized countries and often assumes an administrative infrastructure and research activity database which are usually not present in developing countries. In the following, a short summary of some of the most important methods will be given.

The traditional and still dominant method for evaluating scientific quality is the peer review method. It can be used in several forms, but common for most is that a group of qualified and experienced researchers try to reach a judgement on the quality of research work already performed (ex-post) or proposed (ex-ante) by others. The method has several weaknesses. First of all, it is not always easy to ensure complete impartiality of the peer review group. While strong, traditional research projects, as well as very weak projects, are usually easily recognized, there is often a large group of projects in between, on which peer reviewers tend to disagree. When the purpose of the peer review is resource allocation, such cases may give rise to claims of bias: Old researchers are often claimed to be favored over young, men over women, and routine projects over the untraditional, etc.

Studies by the National Science Foundation in the US of its own practices showed no indication of significant bias (NSF, 1982, 1983). However, the US represents a very large human research base; bias may be much harder to avoid in small countries (or rather, small
scientific communities, which are found in almost all developing countries, even some of the largest). In such small communities, the number of evaluators with sufficient knowledge is often very limited. This was one of the major problems in connection with a major research grant project in a large developing country, Indonesia (Annex 1), but such problems have also been encountered in industrialized countries. In a series of major research evaluations, initiated by the Swedish Natural Science Research Council, the quality was strongly dependent on the availability of foreign reviewers. Unfortunately, hiring foreign reviewers is not always a realistic solution: language problems, travel expenses, and other costs may often limit the supply of suited experts severely. Sometimes, regional sharing of reviewers may help solve these problems; in addition it may promote other kinds of constructive cooperation. For example, during the 1970's a large number of Nordic scientific research journals were transformed into a much smaller number of strong, international journals through regional cooperation (Sievertsen, 1989).

It is of extreme importance that the fairness and competence of the reviewers are accepted by the researchers, whose work is being evaluated. It is even more important that the evaluation is seen as a positive process by the individual researcher; it should provide guidance and advice on how to improve the research quality, efficiency, or relevance. In developing countries, where researchers often must cope with numerous practical problems and often are far away from other researchers in their field, such guidance is of particular importance. Providing guidance is a time-consuming addition to the work of peer reviewers, but if it is not done, a unique opportunity, of special importance in emerging research communities in developing countries, is wasted. The guidance may be very specific in relation to each individual project; in addition, it might also promote constructive general attitudes among researchers by emphasizing true scientific quality as a long-term investment, which is much more valuable than purely formal goals (the fast production of many short scientific papers is one common example of the latter, see below). But it should be kept in mind, that in order for a research evaluation to become a constructive exercise, it requires proper funding, typically from a few percent of the cost of the research up to ten or twenty percent.

Many variations of the peer review method exist. Among these are some which include exchanges of views between the reviewers and the researchers, and some which separates the evaluation of scientific quality from the evaluation of social and economic importance. In developing countries, the main concerns must be the availability and selection of qualified reviewers and the transformation of the evaluation process into a constructive exercise, promoting guidance towards improved scientific quality and productivity.
have been used among the more serious methods are publication counts and citation counts. These bibliometric
scores tell us which is being emphasized in each the procedure has reached the total scientific production, which is being emphasized in each the procedure has
met a certain level. As a scale is available, if a method exists in more or less advanced forms. The simplicity it has achieved is
promising methods are based on the assumption that research results are more
and may sometimes reflect the social organization of the scientific community more than
factors, such as financial support, visibility, and the impact on future research. These metrics are used to evaluate long past performances
scientists are encouraged in terms of prestige, influence, or prestige conferences, research
and may sometimes reflect the social organization of the scientific community. It is
is helping for peer reviewers to seek qualitative data which can help them in

9. Indirect Peer Review Methods: Bibliometrics

Box 3: Rewinding Westfall Research
For many reasons, such as dissemination of results to users, quality control, feedback to the author, and identification of new partners for research cooperation, frequent publication of research results is an important activity for researchers. It is therefore not surprising that publication counts, or even page counts, have been widely used as a measure of research productivity and, to some extend, quality. This method has some very severe drawbacks. First of all, some journals do not perform the quality control needed or do not provide sufficient exposure for the research. As a result, publication in them may be useless, and counting such publications would give a false measure. In some fields, "grey literature" is becoming widespread. Such literature is not published in regular, widely read journals, but appear as local university proceedings, departmental discussion papers, etc. It is often not subject to proper quality control (referee evaluation). Results published as grey literature are often not noticed by other researchers, and may therefore not contribute to progress in the field. This does not prevent it from being useful in other respects.

If the evaluation of research is based on a simple publication count, it will be tempting for researchers to publish grey literature, or to submit papers to journals, which provide a published paper for the count without time-consuming quality control and pressure for improvements. At the same time, the paper may be well "hidden" from experts in the field and may therefore avoid later criticism. Such publication habits are destructive, especially for beginners in a field. They prevent the researcher from receiving the quality guidance which should be the main reward for producing a research paper. A different risk, connected with publication counts, is that researchers may divide material on the same subject between different articles, often with substantial repetition. This increases the number of publications in the list, but is harmful to the scientific literature. If evaluation procedures, especially in connection with promotions, grant applications, etc. are based on simple publication counts, they encourage such practices, are counteractive, and should be changed.

Publication counts have been refined. Pages have been counted instead of papers and grey literature has been discounted. Better methods are based on a grading of the journals the paper appear in. International journals may be given a much higher weight than national or local journals; this is done in Korea with some success. In a further refinement, journals may be rated according to their global impact, which for leading journals can be measured by advanced bibliometric methods. Such modifications in publication counts may have a significant, positive effect on the publication practices of researchers, but are still, for several of the above reasons, not satisfactory.
Another quantitative method, which has several additional advantages, is the citation count. Here, the assumption is made, that the number of times a scientific paper is cited represents its impact on science and represents a measure of its quality. The measure is not perfect, but it is better than simple publication counts. Most importantly, it encourages scientists to publish in a way that makes other scientists read and comment the work. Self-citations which might be irrelevant can easily be excluded from the count, but do not seem to change to result of evaluations much in the general case. The problems and virtues of the technique have been discussed intensively (see, for example, Luukkonen, 1990).

Citation data are published for the 3,000 most important international journals (around 10% of the total number) in "Science Citation Index" (SCI). It seems to have a bias towards the English language, a slight bias towards the natural sciences, and it does not cover developing country journals well, see, for example, Eisemon and Davies (1989). Still, it represents essentially all journals with a measurable impact on the fields of science; if research results are not quoted in any of the 3,000 journals, they are not likely to have any major impact on the field, at least in the short term. For a recent survey of the unsatisfactory inclusion of developing country scientists in the international databases, see Gaillard (1992).

There are many special advantages connected with the use of citation counts as an input for evaluations. When evaluations are based on citations, it will increase the researchers' awareness of who are quoting them. Information on citations by others of one's own work is a gold mine, especially for scientists without frequent contacts with colleagues in the field elsewhere. This kind of information will help researchers locate other groups working on similar problems, i.e. identify unofficial networks in the field, and will thereby help promote scientific contacts and cooperation which may be of immense value for the progress in the research field.

Citation analysis can be used in much more advanced forms. For practical use in evaluation of weak research environments in developing countries, they are presently often of more limited interest. What is important, is to encourage scientists to publish in a way that leads to constructive criticism and increased, international cooperation. Even if the initial purpose of more visible publication strategies is to ensure extra citations of a researcher's work, there will be a higher reward in the form of a quality assessment and consequent improvement of the research. This can be accomplished only if researchers are aware that the evaluation method used places high emphasis on the reputation of their work.
in the specific research field, expressed through a high citation count. Generally, a high count follows from quality research and good publication habits. For developing country researchers, it is important to stress that by submitting work for publication in refereed, international journals, free services are provided, both quality control (constructive criticism) and, if the paper is accepted, free exposure of the work to other researchers in the field. Most leading research journals, which normally ask authors to pay publications fees, do not expect such fees to be paid by developing country researchers.

In spite of the considerable positive effects of the use of citation counts on the behavior of researchers, it would be risky to use them directly, especially by people (politicians) who do not understand the nature of scientific research. This is the major reason for the widespread opposition among even good researchers to systematical research evaluations. The proper application of bibliometric evaluations remains the use as input for peer reviews or as background material for research policy work (Persson, 1987).


The bibliometric methods do not always give full credit to work which, in addition to academic qualities, is particularly important for other reasons than the purely academic. In some fields, (industrial and military research, etc.) the freedom to publish is, for various reasons, limited. This does not mean the results are less important, sometimes the contrary may be true. Part of the problem is solved by the fact that much applied research can be measured in the commercial success of the resulting products on patents. This still leaves the problem of predicting the social and economic impact of more basic industrial research, or even of applied research in its early phases. For this, there seems to be few obvious alternatives to a peer review method, although several other interesting techniques have been tested, including computerized programs in which the probability of scientific and commercial success of an R&D project is estimated from evaluations of a large number of simple parameters (Thulstrup, 1984).

The situation for peer reviewers in estimating social or economic impact of research is not hopeless. Research related to specific national problems in health, education, environment, agriculture, and industry is likely to be important, as long as the academic quality is good. Similarly, research on local raw materials and in fields where extensive technology import is likely to take place must also be given high priority. The choice of
priorities, based on predictions of social and economic benefits in a number of industrialized countries, has recently been reviewed by OECD (1991).

Finally, work which informs scientists and engineers in industry and government about new scientific and technological developments should be given special credit in evaluation systems. The import of valuable information through, for example, scientific journals is usually free. Based on this information, local researchers may make important contributions to local dissemination in the form of review articles. In these, the recent development within a specific research area is described. Laboratory and theoretical work, as well as conclusions by different research groups are compared and a literature survey and publication list are given for the area. Review articles are of considerable importance for newcomers in a field and researchers in neighboring fields. And, most of all, they are very efficient in transferring knowledge from basic research to places where it is applied, for example in industry. Thus, review articles in "local" languages (even those which have been directly translated from a major language) are often particularly useful in developing countries, and a national, systematic effort to produce review articles in key areas may be very worthwhile. A common problem in industrialized countries is that although production of reviews takes a long time, they are often not given much credit in peer evaluations, compared with papers describing original research. Thus incentives to produce reviews are weak, and there is a global shortage of good, international reviews. The only exception to this reward system is citation studies, where reviews often do well. This may be an important reason for including citation counts as part of the background material for extensive evaluations.

11. Conclusions

University research, particularly in S&T, can make substantial contributions to national development, in developing as well as industrialized countries. Usually, the most valuable contributions come in the form of research training and support for other kinds of training, but in some cases, specific research results may become of great importance. For all purposes, research must be both efficient, of good quality, and related, directly or indirectly, to national needs in order to contribute effectively to the development process.
Part of the training effort should aim at giving students an insight in how research is carried out efficiently. There are large differences between the efficiency of research activities in different countries and different research groups. It is important, that research training takes place in environments, where not only quality, but also efficiency is high. This can only be achieved if proper incentives are provided for high quality and efficient research. In order to do this, it is mandatory to monitor university research continuously. Both academic quality, efficiency, and relevance to national needs should be evaluated. It is important, that such evaluations are viewed as constructive exercises by the researchers being evaluated, since one of the main benefits of evaluations may be that they change inefficient habits. Unproductive researchers may become active as a result of evaluations; if not, the evaluation may provide a starting point for reassignments of their duties.

Research capacity should be measured by the output and not, as is common, by the input. Cost/benefit ratios are much more useful than the costs alone. Output and efficiency measures provide essential information for the design and monitoring of national research policies. All countries must define such policies, if they do not exist. New research initiatives should support the intentions of national policies. It is important, that these policies emphasize not only research quality, but also promote the application of research based knowledge into useful support of the national development.

The lack of qualified S&T research activities in the higher education sector, both in their own right and as support for training, is a major obstacle to economic development in many countries. How can countries build up quality and applicability in research and advanced training under the difficult financial restraints, which today are common in the Third World? There are several key strategies, which might help, but these are not as widely used in developing countries, as one might expect. The reasons for this include the misconceptions in connection with university research described above. Although the situation in each country is special, the following common sense strategies may help strengthen research quality and efficiency in most systems, if they are included in the national research policy:

a) Use universities as centers for quality research and research training, by providing them with the incentives and resources needed. The latter will often be modest. This will result in a double benefit: Research results and research based training. Make sure that universities stay true to their main mission:
providing quality and up-to-date training, including research training, at the highest level. In the long run, this will be the best support universities can give to development of both national scientific infrastructure and industry.

b) Provide (i) individual incentives for active research to all researchers, and (ii) secure sufficient resources to the efficient and qualified researchers, so that they both see an interest in, and have a possibility for concentrating on productive research of high quality and relevance for national development. Such incentives and support will strengthen university education at all levels, and will be the best foundation for production of research results and training. Provide special incentives for university/industry cooperation, primarily in order to increase the applicability of the teaching and research training. Such incentives may even take the form of free vouchers to industry for R&D services provided by universities. Change public sector career systems that force productive researchers into purely administrative positions.

c) Introduce monitoring of outputs and cost/benefit evaluation systems in public research, and let the evaluation results influence the distribution of research funding. This will ensure that resources are concentrated in productive activities, and that researchers not only realize that their constructive efforts are noticed, but also feel that they are rewarded. This provides incentives for productive research. Keep in mind, that the evaluation procedures may strongly influence the researchers' behavior, and design them so that they encourage constructive research and dissemination practices.

d) Identify unproductive researchers. In many countries, a large part of the total research funding is tied up in facilities, services, and, in particular, salaries to researchers, who produce very few or no results, and who therefore set poor examples for students and have a negative impact on attitudes among researcher
community. Give such unproductive researchers the intellectual or financial support they need in order to become more productive, or, if this does not work, encourage them to take up other duties.

e) Strengthen research publication habits (i) by providing support for a system of national research journals, when appropriate, (ii) by including specific requirements to publish, together with financial support for dissemination in all research support schemes, and (iii) by particularly supporting international dissemination, without overlooking the needs for local language research reviews.

f) In general, promote internationalization of research activities. This is particularly useful in S&T, since these subjects are universal; the basic sciences are the same in all countries, and often only slight modifications of their applications are needed for local use. Regional cooperation within specific fields may be very useful for small research communities. Specialized equipment and libraries may be more affordable if they can be shared by researchers from several countries in regional research centers. Cooperation with industrialized country research communities may provide useful and inexpensive support in important fields, such as instrumentation services, up-to-date information through scientific journals or informal networks, reviews and quality control, etc. If access to these services can be gained, developing country researchers can benefit from them in many ways. Therefore, promote proper university (department) twinning between developing and industrialized countries, rather than one-sided technical assistance programs. If overseas research training is supported, encourage domestic university involvement, e.g. by supporting degree programs of the sandwich type.
References


Annex 1: University Research in Indonesia

A 1.1 Support for University Research in Indonesia

Indonesia has expanded its higher education system strongly during the 1980s. In the second half of the 1980s most of the expansion took place in the private higher education sector. From 1986 to 1989 alone, enrollment in private universities increased from 750,000 to 1,010,000, compared with a slowly increasing number of public university students, presently close to 600,000. It has been very difficult for the higher education system, particularly the private universities, to improve, or even maintain, the quality standards during this fast expansion.

Improving the quality of higher education is now a major concern of the Indonesian Government. In this connection, it is of overwhelming importance that research quality and productivity are improved at all universities, especially the public, which are expected to be quality leaders. Active researchers and quality research must become the driving forces in the modernization and improvement of university teaching, while inactive researchers and poor quality research, which have a negative effect on the teaching in general and on student attitudes, must be reduced or eliminated. In particular, unproductive research is harmful for students working on research projects and looking for role models. It will also have a negative effect on the university faculty development and on the reputation of individual departments and universities. Finally, it will not provide any useful scientific support for industry, agriculture, health, and the public sector in general.

In connection with work on the Second Higher Education Development Project, an analysis was carried out in late 1990 of the actions needed to ensure that Indonesian researchers were given full opportunities to use their potential for quality research. It was concluded that the following elements of a support system must be in place:

a) Each researcher should be accountable for her/his performance, and rewards, such as promotion, research support, or increased pay, should result from quality research. Evaluation methods should encourage proper research and publication habits.
b) When needed, researchers should be offered help with their research problems. In particular, constructive criticism should be provided. National, as well as international, cooperation with other researchers should be encouraged. Workshops and national meetings in specialized fields should be supported, in particular for the benefit of young researchers. The mobility of researchers within the country and internationally should be increased.

c) Laboratories and equipment should be of a standard which encourage researchers. Grants for improving physical research conditions should be available to researchers giving high priority to quality. Adequate library and computational facilities should also be ensured.

d) Quality research usually demands both time and concentration. Without sufficient research time, researchers will never excel. Since normal salaries at Indonesian universities are insufficient compared with normal living costs, many university researchers hold second jobs. Replacing these with honoraria for quality research work will not only improve the research output, but also the teaching standards.

A 1.2 The Inter-University Centers

Earlier World Bank projects in the Indonesian higher education sector had primarily addressed the facility problem, and had only attempted to address the widespread need for research guidance. This is best illustrated by the World Bank supported Second University Development Project, which established the Inter-University Centers, 16 centers for research and research-based education in strategic fields, placed at the leading campuses in Indonesia (all of them in Java). The centers have received much support in the form of buildings, laboratories, equipment, grants for degree studies at the IUCs and their host universities and at overseas universities, technical assistance for the management of the program, and in the form of visiting scholars, and considerable research funds for operation and maintenance.
In the fall of 1990, the first assessment of research conditions and output was carried out. It was clear, that far from all planned equipment had been delivered, and many graduate students under the scholarship program still had not returned to Indonesia, but research funds were being spent as planned and had been available for one to five years at the IUCs. It therefore seemed timely to proceed with a first evaluation of the research performance at the IUCs, in order to obtain information needed for their further development.

The questions asked were the following: Are the new buildings being used as well as possible? Are the instruments purchased of the right kind and, in particular, are they being used? Did the graduate students go to the best suited research groups in Indonesia and overseas? Did they perform well during their studies and after their return. But the most important question of all was: Has the university research at the IUCs become sufficiently effective, and, if not, was anything missing in the design of the research policy for the IUCs?

A summary of representative outputs for the 15 research active IUCs (the 16th primarily produces teaching materials) are shown in Table A1.1. It is clear that the educational efforts have been considerable; many students had been trained in short courses in addition to the training provided under degree programs. But, in general, the research accomplishments seemed disappointing. The major documentation for research at this stage would be publication of research results. But some IUCs, with an average staff of more than 40, had not published any research papers at all, and no IUC had published much in reputable, international journals. An average of less than two papers published in international research journals per IUC over their lifetime, often several years, did not seem to justify the costs and the number of staff. In particular, it did not correspond to the large number of Ph.D. students, on the average ten per IUC, including an average of three already graduated. The research output seemed unsatisfactory, not only in quantity but also, based on the low number of papers in international journals, in quality.
Table A 1.1 Research Productivity in 15 IUCs 1985-90 (1990-91).

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<th>Table A 1.1 Research Productivity in 15 IUCs 1985-90 (1990-91).</th>
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<td>Graduates:</td>
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<td>S2</td>
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<tr>
<td>Biotechnology IUCs (3)</td>
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<tr>
<td>Life Science IUCs (2)</td>
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<tr>
<td>Food and Nutrition IUCs (2)</td>
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<tr>
<td>Engineering IUCs (2)</td>
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<tr>
<td>Info. Technology IUCs (2)</td>
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<tr>
<td>Economics IUCs (2)</td>
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<tr>
<td>Social Science IUCs (2)</td>
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<tr>
<td>Total</td>
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Note: S2 is a Masters level degree, S3 is somewhat similar to a Ph.D.
Source: The Second University Development Project Office, Jakarta.

Did anything go wrong? Was it just too early to expect publishable research results? This was the general opinion among both IUC directors and the "facilitators", paid experts, one for each IUC, provided by a university consortium in the US, which had a large contract for provision of technical assistance to the IUCs under the World Bank project. One problem with this explanation is that dissemination of research, in particular international publication of research results and methods, is a useful path to scientific contacts and a major source for constructive criticism. Scientific publication in good research journals is not only a result of quality research, it is also part of the process to get to the state, where quality research can be produced. An additional problem for the IUCs was, that not only had few papers succeeded in being published internationally, but even fewer had been
submitted for referee comment without being accepted, one of the first, and often very valuable, provision of constructive criticism on a research project.

In this situation it was necessary to look for other problem areas in the IUC research support system. There were several. For example, the extensive technical assistance program, that provided management of overseas degree programs, facilitators, and visiting scholars, very rarely led to useful research cooperation between Indonesian IUCs and universities in industrialized countries. Such constructive cooperation seemed to result with a higher probability outside the technical assistance program. One possible explanation, according to an IUC director, was that the consultant fees paid under the technical assistance program were so high, that researchers were willing to come, although they had no interests in the Indonesian research. Researchers, who came without such incentives, were much more likely to have a serious interest in longer-lasting research cooperation.

There were other problems. Indonesian researchers were paid for their research work at the IUCs, but not so much that they could give up other second (or third) jobs. Therefore, their research efforts were often very much part-time. Most had regular positions at the host university for the IUC, and the relationship between their duties to the two employers was not clearly specified. An additional flaw was that the ample funds for operation and maintenance were distributed without regard to the kind of research, it should support. A social science laboratory was given exactly as much as a biotechnology laboratory, in obvious disregard for the true costs of doing active research.

The main problem, however, was without any doubt the project's lack of quality control measures and individual incentives for efficient and high quality work. The distribution of space and equipment, as well as funds for travel, visiting scholars, operation, and maintenance, was made on the basis of a plan, which was not adjusted according to the activity and performance of individual research groups in the IUCs. This prevented an optimal use of the funds and facilities, and, worst of all, it provided no incentives for active, quality research. Researchers making only modest research efforts were given the same support as hard-working researchers.

Based on the analysis from 1990 and discussions between the Government of Indonesia and the Bank, the procedures used in the IUC project are now being changed in three ways, with considerable support from the IUC management: (i) research plans must
now be evaluated and accepted by independent referees, in competition with other research activities within each IUC field, (ii) laboratory work is given higher support than purely theoretical work, and (iii), most important, researchers are now aware that their efforts are being monitored and that good efforts are rewarded. In the future, most funding will be based on evaluations of individual research proposals and the past performance of the researchers involved. There are already signs that these measures have a positive effect: The research productivity, especially the international publication activity, has been much higher during 1990-91 than before (Table A 1.1). The increase in the number of international papers may also have been influenced by returning graduates, increase in the availability of equipment, and other conditions.

One important reason, that research productivity and efficiency was given so little attention, was the impression, held by the Indonesian managing team, that the Bank’s main interest was compliance with the disbursement plan, and not the real outcome of the research. After an initial hesitation, the new Bank emphasis on research productivity, which was presented in 1990, was accepted with considerable enthusiasm and interest by many of the researchers and managers involved.


An important initiative was taken in the second half of the 1980s by the Directorate General for Higher Education in the Indonesian Ministry of Education and Culture, when a competitive research grant scheme was reorganized and improved in connection with the First Higher Education Development Project. Through a continued dialogue between the Ministry’s Office for Research and Community Service, which manages the grant scheme, and the World Bank, modifications of the initial project component were introduced, based on internationally recognized best practices, with emphasis on competitive research funding, as used in most industrialized countries. In addition, special provisions of guidance for researchers were introduced, based on the experience gained during the lifetime of the project. The grant scheme has recently been increased in size, with support both from the World Bank Second Higher Education Development Project and, starting 1992, through additional funds from the Indonesian Government.
A large number of proposals are now received (Table A1.2). They are all evaluated (an ex-ante evaluation) through a peer review procedure, and details of the evaluation results are mailed to all applicants. Unsuccessful applicants are given the reasons for rejection in a detailed form. A large number of research projects, until now almost half of those supported, have been monitored during visits at the universities involved. The visits were very useful; the monitoring team members were often able to act as consultants for the researchers, and at the same time, they obtained insight in the weaknesses of the research administration and evaluation procedures.

Table A1.2. Grants for University Research in Indonesia

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<tr>
<td>Applications received</td>
<td>925</td>
<td>1682</td>
<td>1876</td>
<td>2067</td>
<td>2664</td>
</tr>
<tr>
<td>Grants awarded</td>
<td>314</td>
<td>547</td>
<td>621</td>
<td>696</td>
<td>~750</td>
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<tr>
<td>Average size of grant (M Rps)*</td>
<td>7.6</td>
<td>5.9</td>
<td>6.1</td>
<td>5.8</td>
<td>~5.5</td>
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* 1 M Rps is around $500 (1992)


Finally, the scheme contains an ex-post evaluation of the research results obtained and their dissemination. Standard forms are used to describe the quality of the different components of the projects. Such information is essential for the researchers, but also in connection with this ex-post evaluation, a more detailed provision of guidance to the researchers was considered a good investment. Under the Second Higher Education Development Project, course activities in research methodology, scientific writing, etc, will now be provided at universities where such activities seem needed, based on proposals and research results under the grant scheme.
Research grants, which are based on proposals for support to individual projects, generally provide valuable opportunities for guidance. Good habits can be rewarded and the grants thus provide researchers with incentives for such good behavior. Although most grants in the Indonesian grant scheme were small (around $3,000 each, see above), they often help solve practical problems for the researchers. An increase in the grant scheme was recently proposed by BAPPENAS, in recognition of the success of the program. It will allow research projects to be supported with larger amounts, e.g. for equipment. A serious weakness remain: Grants covering more than one fiscal year are still not be possible. This is unfortunate, since many research projects require long term planning and work over several years.

The management of the scheme is very demanding, particularly because of the extensive guidance provided. Still, around 80% of the total expenditures are used for grants. The reviewers are paid for part-time work; nevertheless, it has not been easy to find qualified evaluators in all fields. The work of the reviewers is carefully monitored and those who do not perform well loose their assignments.

An important aspect of the grant scheme is that it includes payment for the time used on the projects by the researchers. This is necessary so that they can afford to give up other sources of income which take time away from the research. The results are likely to be higher research productivity and higher quality of teaching, as well as a further strengthening of the incentives for quality research and for submitting research work and plans for constructive evaluation. The present limit for the salary component is, however, very low.

One very important byproduct of the small research grant scheme is, that an extensive database of active university researchers in Indonesia is being built. It does not only contain information on names and research subjects, but also on research quality. So far, almost 10,000 proposals have been classified and evaluated since the academic year 1988/89. The number of applications for research support under the grant scheme has grown steadily from 925 in 1988/89 to more than 2600 for 1992/93 (Table A1.2).

On average, one-third of all applications come from the field of agriculture, and one fifth from education, reflecting the unusually large size of these subjects in Indonesian universities. For 1991/92, the fields of medicine, natural science, and engineering combined only submitted a slightly larger number of applications than education alone, and they did
not together receive as many grants. Increasing the research activities in science and technology is now considered a major task; in the Second Higher Education Development Project, there are special, earmarked grant funds for this purpose.

During the years 1988/89-1991/92, two universities (Gadjah Mada University in Yogyakarta and IPB in Bogor) submitted more than 500 proposals each, while 23 out of 45 public universities submitted fewer than 100 each. However, the participation rate for the weakest public universities has increased up to several times in recent years, partly due to other components of the grant scheme, such as course activities in less active universities on research methodology, formulation of proposals, and scientific writing. Another important feature is the detailed feedback, which is provided to all unsuccessful applicants, and which may contribute considerably towards a strengthening of the research plans.

Also private universities now apply for grants; for 1991/92, proposals were received from 62 of the around 1000 private universities. Six percent research active private universities is still unsatisfactory, and only 15 of the applicants received grants. But since all applicants now are given detailed information on problem areas in the proposed research, unsuccessful application is not a wasted effort. On the contrary, many private university applicants highly appreciate this form of guidance.

The evaluation of proposals is based on strict quality criteria, with some provisions for weaker universities. It is performed by small groups of qualified and experienced researchers. Over the years, younger researchers have received a large share of the grants; university staff with only S1 (Bachelor) degrees receive over one third of the grants. Although 25% of public university staff are women, only 20% of the applicants are. Women also received 20% of the grants.

Successful applicants are required to write a final report and a research paper. These form the basis for an evaluation of the outcome of the project. For the years 1988/89-1990/91, over 60% of the completed projects were classified as good or very good, and only 7% as poor. For comparison, a similar evaluation of 295 research projects supported by local university funds was performed. Most of this support was given without much competition between the researchers. Of the 295 projects, a much smaller share, only 10%, were classified as good, while 38% were classified as poor. The difference may be considered an illustration of the effect of proper evaluation, guidance for researchers, and competitive research funding.
The demand for delivery of a proper research paper, describing the results of each funded research project, contributes greatly to scientific writing in Indonesia. All papers are reviewed and critical comments are submitted to the author. The authors of the best half of the papers are invited to a national seminar, held annually, where they have an opportunity to present their research to an audience of peers.

The final publication of the research papers resulting from the grants presents a major problem, since there is a lack of good, subject-specific national research journals in Indonesia (see below). After the research papers have been edited, they are initially published in a number of subject specific volumes, seven for 1990/91. Some are also offered to local journals, which have the potential of becoming national journals for specific subjects. Under the Second Higher Education Development Project such journals will be provided with funds to cover the costs of publishing the papers, in order to encourage and facilitate their transformation into national journals.

A 1.4 Strong Scientific Journals.

There still is much to gain in the general area of research guidance in Indonesia. Stronger contacts between Indonesian research groups with similar interests and better mobility of researchers within Indonesia are two examples. In particular, researchers from outside Java may benefit from this. Most of all, it would be a major accomplishment if Indonesian research could enter the global scientific community on a larger scale. To do this, an improvement of publication habits and the system of research journals in Indonesia is needed. Other actions may also be taken: Organization of international conferences and workshops in Indonesia, travel support to Indonesian researchers attending meetings elsewhere, strengthening of Indonesian professional societies, etc., but it is through the scientific literature that most can be gained for the least money.

The situation in Indonesia is not unlike that in many other developing countries. There are hundreds of research journals, but most appear infrequently, have long publication times and weak editorial and referee systems. Almost all are using local language (Bahasa Indonesia), and the circulation of each journal is often very limited. The individual journals frequently contain a mixture of local research papers on widely different subjects, which means that the reader may have to pay for pages of French literature, veterinary science and
sociology, if she/he wants to read a physics paper. This is often the case for the "University Proceedings" type of publication.

The costs of producing hundreds of small journals with low circulations are overwhelming, although the real costs are often partly hidden. The journals serve several purposes, but their contributions to the strengthening of science and to the dissemination of research results are often weak. Sometimes, they even help hide results, since they give researchers an excuse for not publishing elsewhere.

A transformation of the many small research journals into a limited number of larger, subject specialized journals, with short publication times and good editorial and referee systems would yield considerable benefits. It may become a key element in the strengthening of the research in the country, as it has, for example in Korea (Eisemon and Davies, 1989). If possible, the new journals should be international, but the vast majority would initially have to be national, with abstracts in a major language, preferably English. They should include review articles for the benefit of local industry, when appropriate, and should, in general, take the needs of the local users of research into account in the editorial policy.

What can be done to support the formation of strong national (or international) journals? If a strong professional society exists in the subject of interest, it may be the natural "owner" and responsible body for the journal, but this is rarely the case in Indonesia. Other possible owners are universities, private publishers, or government offices. The choice of editors is the most crucial. In order for a journal to succeed, the editor must be highly qualified, with a solid knowledge of the field, and with an ability to convince authors and referees to work according to strict schedules. The editor should be given substantial support in the form of (paid) time and secretarial assistance as well as possibilities for improving management skills. Courses and workshops for Indonesian editors of selected research journals might be very constructive. The possibility of establishing a research journal consultancy service under the Office of the Director for Research and Community service has been discussed. It would provide advice on editorial and management matters to journal editors. The employment of an expatriate, experienced editor for this purpose may be needed.
The responsibility of editors for Indonesian research journals should include provision of special support to less experienced authors and relevant services for industry, agriculture, and the public sector. In particular, regular reviews of the international developments in the field of the journal may be very useful. Courses in scientific writing for young researchers may be combined with language courses (English) and even courses in modern library techniques.

Financial support for a new system of strong national (international) Indonesian research journals and for related activities will be needed, at least for some years. Support of this kind is included in the research grant scheme under the Second Higher Education Project, in connection with the funding of dissemination of the research results, obtained under the scheme. Later, strong scientific journals may become self-financing. There is no doubt that this kind of assistance will provide a very cost effective support for Indonesian research.

The transformation of local journals into national journals may be seen as a first step. It will become increasingly important that Indonesian scientists regularly publish internationally, and, whenever possible, Indonesian journals should attempt to become international. One example of a new Indonesia-based international journal has recently appeared: The Journal of Tropical Agriculture, based at IPB in Bogor. In the internationalization process, other national needs should not be forgotten and science writing aimed at local industries, schools, etc., should continue to be a responsibility of Indonesian researchers.

The process of strengthening and internationalizing Indonesian science may be continuously supported by evaluation methods which rewards research projects that expose results and methods openly to the scientific community. Scientific culture, good research and publication habits, scientific openness, and critical self-evaluation are qualities which are at least as important as buildings and equipment. They can be strengthened through proper incentives: Recognition of research quality in connection with promotions, support to individual research projects of high quality, and a general openness about research performance. Evaluations should be performed for all research. Unproductive researchers should not be deserted; new tasks should be defined or guidance provided, so they can become productive. In the coming years, Indonesia will need all quality scientific manpower available.
A 1.5 Support for Applications of University Research: Science Parks.

In many countries, the establishment of science parks has been successful. Although this has primarily taken place in industrialized countries, there are also positive examples from developing countries; one such example the Center for Pure and Applied Chemistry, a Japanese-sponsored science park at the private Atheneo de Manilla University in The Philippines. In science parks, university researchers meet with industry and other users of research methods and results. After initial investments in buildings, laboratories, and equipment, science parks have sometimes become a convenient source of revenues for universities. Another, even more important benefit of science parks, is the transfer of information about industrial needs to the academic environment. There are also benefits for industry; through science parks, small industries may get easy access to the latest research results at an affordable price, and industry in general may learn to appreciate the value of scientific research and researchers without having to invest heavily in facilities and know-how. Similarly, university researchers may find help in their efforts to commercialize their scientific results. In science parks, research projects of relevance for national development may be identified, and used by graduate students in their thesis work. A discussion of the role of science parks in developing countries is given by Parker (1992).

One way in which the Indonesian government might consider supporting university-industry cooperation explicitly, would be by providing attractive physical facilities for science parks at a few selected universities near relevant industries. The costs of operation should be covered by the users, at least after a short, initial period. The Indonesian IUC's are, in many cases, equipped with the facilities needed, and as an experiment, the first, experimental science parks might be established in cooperation with IUC's. Together with an increased course activity for industry, this would help them proceed towards the original (but probably somewhat unrealistic) goal of making the IUCs financially self-supporting.