SCIENCE & TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT: QUALITY OF RESEARCH IN R&D INSTITUTIONS

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ABSTRACT

Science and Technology in a country is an essential requirement for a strong economy and security needs of any country. The countries having strong and meritable S&T institutions are indeed the “Advanced Countries” in the world and their people enjoy a high standard of living. Further it is also very important that to continue such an advancement the sustainability of the S&T institutions is insured by effective planning by the governments in power.

The important parameters required such as regular availability of a well-planned meritable human resource, the application of the research quality parameters for S&T, human resources and the institutions are discussed with respect to the available examples of advanced countries. Emphasis has been laid on developing strong research and development culture and the methods of ensuring quality of research are discussed. Extensive literature is referred to for further reading on this important subject for the interested readers. Examples of progressive and advanced countries of Europe, USA and Japan are discussed, describing the mechanism by which the quality research and development for their S&T institutions has been emphasised to ensure their sustainability as well as effective utilisation of quality R&D for Industrial products to help the economy effectively.

It has been proposed that for the sustainability of S&T institutions, a visionary planning is important to prepare qualified and competent manpower to regularly replace the retiring manpower. Extensions beyond retiring age are in injustice to good successors and are damaging to the sustainability of S&T institutions. Examples of Sustainable institutions in Pakistan and abroad have been mentioned.

Scheme for ensuring better utilization of basic research to improve Industrial products have been proposed which could help the economy of a country. Examples of such recent schemes benefiting the economy of the advanced countries such as Germany and Japan are given.

INTRODUCTION

Sustainable development for any country is most desirable for any country for its progressive existence and a decent life for its people. There are a number of essential parameters which play an important role for such a sustainability of a country. Apart from good governance and social excellence, the scholars and men of science and technology in a society play a pivotal role. I shall here restrict my discussion to the role played by science and technology in this venture and then in particular the culture of research and development with a measure of “Merit” and **“**High Quality**”**. The countries where science and technology have been well cared for consistently over a period of time, are the most powerful and economically well-advanced. Their subjects are living a very comfortable life with high standards of living and better quality of life. Those countries where S&T are lagging behind have not been developed, are indeed living a poor life and are regarded as the “Under- Developed” countries. Those where efforts are in progress to pay attention to strengthening the science and technology are termed the “Developing Countries”.

Although the nations such as oil-producing countries where natural resources are abundant, the people have higher standard of living but they are heavily dependent on the import of consumer goods and high technology utilities from the technically advanced countries. Their raw materials and natural resources are exported without value-addition and thus the imported high-technology items consume their natural resources with a lot of exploitation.

Apart from natural resources of a country, the most important resource is “human resource”. Even if the natural resources are scarce but the human resources are well- developed in the field of science and technology, the countries are well advanced and their people enjoy a high standard of living. The obvious

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examples in South Asia are Japan, Singapore, Korea, Malaysia, Taiwan and Thailand.

TWO MODELS OF SUSTAINABLE DEVELOPMENT

We can consider two main models for a sustainable development, in both of these however, science and technology play the controlling role.

In Model-I the stress is laid to improve the economic conditions in the country through the mass production of low-technology consumer goods, thus gradually improving job opportunities and earning power, thus raising the standard of living of the common man. In Model-II the emphasis is on higher education and development of higher science and technology and its use as a vehicle of high value addition to local products as is done in USA, Japan and in most West European countries. The Model-I is the case of newly emerging progressive nations like Malaysia, Thailand, Korea, etc. However at some stage the effluence of higher education and higher science and technology in accordance with Model-II is essential if the country has to "sustain" its progressive existence. With reference to education, it is important to note that exclusive stress on mass literacy of lower education is not optimally useful, but it is the necessary level of higher education supported by a strong culture of quality research and development which is essential for proper high-tech developments. This means that the education with the proliferation of the primary education only does not make a country developed. For instance, in Sri Lanka there is a very high percentage of lower education (about 86%) but the country is not developed in the sense that similar smaller countries (having dominant higher education) like Switzerland in Europe have much higher standard of living than Sri Lanka. The obvious reason is the domination of higher education backed by a strong research and development of high technology which adds to better economic development of Switzerland.

In my opinion the Model - I has a shaky sustainability for economic stability as well as progressive strength of a country. The Model - II backed by high quality scientific research and development has a long term progressive stability as has been established in the history of advanced countries like USA, UK, Europe, Japan, China, etc. A better approach of course, is the well planned overlap of the two models, keeping in view the economy of the country.

At the same time there is obvious evidence that an advanced country faces severe decline if it neglects higher education and science and technology. A very recent example of this decline is the case of the USSR. When, in earlier times, scientific research was well-supported by the government during the tenure of Stalin and Khrushchev, USSR developed into a powerful country. Due to initiation by Khrushchev, within 10 years a Science City, *Akademgorodok* about 30 km from the city of Novosibrisk, flourished with science eminence in research at the international level and even US thought of the fact at the time that the USSR got a lead in space science when Sputnik was launched into space in 1957. Thus the USSR made rapid strides to be a strong country of world influence. The development of science of the 60's thus led to the Nobel Prize winning work in the field of semiconductors and opto-electronics (Prof. Zhores Alferov was awarded the Noble Prize in Physics in year 2000 for this work of the 60's.). But with the fall of Khrushchev, the support to science and technology waned and the fall of Russian science and technology started and as soon as in the recent years (after the dismemberment of the Soviet Union) this support was further neglected, the country plunged into economic problems and went into oblivion of the world notice[1]. Since 1991 government funding of scientific research shrunk six-fold in Russia and as a result, Russia fell by 1999 from its lofty pedestal as a cold-war superpower to the bottom rung of the states with least scientific potential. The Science City of Akademgorodok presents pathetic situation of science funding. The salaries of Russian scientists have been reduced (a promising computer scientist earning 90 dollars a month, drastically lower than in advanced countries) and they are in a very frustrated situation. The research quality and quantity have both gone down in the past 10 years. Such is the importance of the support of "political will" and the funding of science if the countries have to have sustainability of development. This recent example of dependence of sustainability of a country on the Research and Development in science and engineering is an eye-opener for the developing countries as well as for the developed countries. Aware of this fact the advanced countries however continue keeping priority of higher education and science and technology in their annual budgets and they remain in the fore-front of the scientific research and the consequent economic development[2]. It is interesting to quote a paragraph from the recent biennial report of the National Science Board, USA for the year 2000 submitted to the US President where it is stated; that *the research and development in the United States is on the rise and is providing a boon to the economy. The two-volume edition of Science and Engineering Indicators 2000 documents that the U.S. economy approached the end of the 20th century with "unprecedented real growth, miniscule inflation, low unemployment and strong consumer and investor confidence." An indicator of that confidence was seen in the continued rising investments in research and development, which in 1998, grew by 6.5 percent, adjusting for inflation. Meanwhile, the U.S. Gross Domestic Product grew by almost four percent per year for the two-year period 1997-98, bettering historical averages. Federal support for research and development rose by 2.1 percent inflation-adjusted, in 1998. The much larger percentage increase in industrial research and development, however, helped to lower the federal share of the national total to below 30 percent for the first time since 1953, when the National Science Foundation started monitoring these trends.* The Chairman of this board further states “that the over all economic impact of a “stimulated” research and development climate has been positive. There has continued to be a consistent balance between investments in fundamental and applied research and development within the US and steady increases in these investments since 1980 that have contributed to a strong research system and a vital economy.”

SOME MAIN ASPECTS OF SUSTAINABILITY WITH REFERENCE TO S&T

There are a number of aspects for which sustainable development is being discussed today. They both require social as well as technical aspects to deal with. The social aspects to deal with are;

1. Poverty Alleviation
2. Environmental Issues
3. Good Governance and Management of Society
4. System of Government
5. Human Resources
6. Traditional Culture & Religion
7. Social Implications of Technical Advancement
8. Provision of Clean Water, Air and Shelter for the People.

The Technical aspects to deal with are:

1. Political will for Higher Education and Science and Technology
2. Vision for establishing strong and meritable R&D Institutions
3. Emphasis on Quality rather than Quantity in Technological Research and Development Institutions.
4. Continuous Development or Replacement capability for retiring individuals rather than service extensions i.e. a well planned and a viable infrastructure.
5. Continuous Monitoring of Scientific and Technical progress
6. Up-date of Information Technologies and their use for economic development as “technology-support” applications.

Although all of these factors play their respective role in the sustainable development of a country, I shall like to discuss the contributions of the “Quality Research and Development” to this aspect. This is one of the primary factors for the technical part of the sustainable development and has a strong correlation with the economic indicators like GNP as a mark of standard of living.

One of the dominant and most used indicators of quality of research and development is “Citations Per Paper” (c.p.p) for scientific research and the “Applications for Scientific Research”. A recent data (year 1999) of 79 countries shows [Fig.1,2] clearly that both these parameters are large for well developed and rich countries, say in the group of the top 30 nations [mostly consisting of European nations, USA and Japan][3]. The same is the case of the world-ranking of the countries for research quality defined by the “citations per paper”, c.p.p. [Fig.2]

JOURNAL IMPACT FACTOR (JIF) *VERSUS* QUALITY OF RESEARCH

A brief discussion of the Journal Impact Factor as a measure of Quality of Research publications is useful for scientific purpose to clarify certain prevalent misconceptions in its use for assessment of research merit of scientists and scientific Institutions.

The Journal Impact Factor (JIF) was introduced in 1955 by Prof. Eugene Garfield of, USA to assist scientists in the area of Information Science. Since a large number of research journals were published in any one branch of science like Physics, Chemistry, Biology, Agriculture, etc. and the cost of Journals was increasing day by day it was a problem for the research institutions for their libraries to select journals of optimum utility within the allocated budget constraints. Mainly to help in this matter, Prof. Garfield introduced the '*Journal Impact Factor*', as a quantitative measure to assess the comparative utility of the research journals. JIF was measured from the number of '*Citations*' made to the papers by other researchers published in a Journal over a period of 2 years following the publication of the journal[4, 5]

Thus JIF is equal to the number of total citations to papers in the journal, 2 years after its publication *divided by* the number of total papers published in the journal.

$$JIF = \frac{Cy+2}{Ny}$$

Where "y" is the year in which the journal was published and Cy+2 is the sum of citations (of those papers of the journal) in the two years after the publication of the journal. Two years is considered a reasonable time during which the papers published in a journal could come to the notice of other researchers. Although some authors have increased the two-year period based on their later research in this regard.

Although the numerical value of JIF was mainly for a '*possible*' assistance for purchasing the appropriate journals but in early times attempt was made to use this parameter as a measure of higher quality of research of the papers which authors or scientists published in journals of higher JIF[6, 7]. This was immediately negated and severely criticized by a majority of researchers and a large number of detailed research papers were published which proved on statistical analysis that it was incorrect to judge that the quality of a researcher should simply be judged by the Impact Factor of the Journal in which he published the paper[8, 9, 10, 11, 12, 13, 14].

It was, however, clearly established that the quality of research publication be judged by the '*Average Citations to the All Papers*' i.e. citations per paper of the author rather than JIF which represents the average citations to papers of all authors who publish in that journal and assigning this average to one author is not logical. One author must not share the credit of "citations of papers of other authors" who have published in that one journal. Rather any author must get the credit of '*the citations to his own paper alone*', which is given by another parameter independent of JIF and is referred to as "citation Impact" or "citations per paper, c.p.p," and rightly pertains to the quality of papers of that "particular author alone".

Therefore, citations per paper (c.p.p) is now normally used as a measure of research quality for a scientist rather than JIF. For further reading on this topic one could refer to references 15, 16, 17, 18, 19, 20, 21, 22. While c.p.p is a good measure of quality of Research papers, for a detailed assessment of a group of scientists a Peer Review Committee should decide their relative merits where of course quality of research should be a dominant factor among other considerations. Thus for sustainability of science and technology in a country, the assessment methods of quality of research in this area are extremely important. The extensive references given here will be very useful in this regard.

However, it is important to note that the support to the assertion that those nations, who apply the political-will and cater for investment in research and development in S&T, have higher standard of living. This is well illustrated by a recent study on this aspect. [Fig.3 (a) and (b)]

Even in quantitative productions of research, defined by the '*number of papers per person*' as shown by the study of OECD [Fig.1], it is clear that the same group of countries are on top ranks, only their '*ranking*' may be different on the research quality assessment scale of c.p.p [Fig.2].

REFERENCE ON JAPAN

Studies on Japan indicate that Japan has over the years invested relatively more in basic science research than in application of technology. This was based on the realization that strong development in research leads to better innovation for application of science to industry which means both quality and quantity in production. The number of researchers in Japan has increased over the years, both in the universities; research institutes as well as in companies. [Fig.4].

Moreover, the trends in budget for Grants-in-Aid for scientific research have been progressively increasing and it increased by 2.5 times over 10 years, from 45 billion Yen in 1988 to 112.2 billion in 1997 [Fig.5].

Over a period of 20 years from 1975 to 1996 [Fig.4], the researchers in universities increased from 134,458 to 242,262 about 1.6 times while such an increase for companies has been from 146,604 to 384100 about 2.62 times in the same period. This shows a trend of significant increase in the research and development for science and technology.

Also the trends in research funding have gradually increasing percentage amounting to 20% for universities and 65.2% for companies over a period from 1986 to 1995. [Fig.6]. However, the important thing to note is that while the universities are spending relatively more on basic research [about 53% of the allocated budget] the companies spend correspondingly 6.6% on basic research and 71.3% on the development, the requirement of the companies being more on production oriented R&D. These relative expenditures are given in [Fig .7].

The boost to research and development efforts in the country and the support to post-doctoral research were given special attention in a special programme to support about 10,000 post-doctoral fellowships. From 1985 to 1998 this increased from 176 to 5,701, an increase of over 30 times [Fig. 8].

These research supporting measures improved the world ranking of Japan in quality of research as indicated by '*citations of research*' published and placed Japan among the first 5 nations in most of the scientific disciplines and at ranking No.2 in Agricultural and Material Sciences [Fig.9]. This relative shift towards basic sciences will not only further boost the product quality of Japanese goods and thus strengthen the economic sustainability but it will also add to the knowledge-based eminence among the advanced countries of the world. Already the Nobel Prize for chemistry for the year 2000 was shared by a Japanese Chemist, in the area of conducting polymers. Japan is thus poised to be a strong country in the world both economically and research wise.

In attaining this improvement in research development, Japan exercised a systematic approach to the monitoring techniques for efficient production in research. The system of '*self-evaluation*' evolved with specific rules of self monitoring in the universities is being followed in most of the universities (about 70%) [Fig.10] and this self-regulation in science is a matter of great self-discipline.

U.S FUNDING FOR RESEARCH

In the U.S, although a leading country in science and technology, the funding for research and development has changed its pattern. The federal share for R&D has been decreasing over the period of last 10 years. However, while the federal share for R&D has decreased, this has been compensated by the corresponding increase in the '*Industry Share*' in the R&D at the National level, sustaining "the country's research on the world scene as a leading country in the world. This mutual adjustment of funding on R&D between Federal budget support and the Industry contribution is well represented in [Fig.11]. Thus the country's economic development is sustained over longer periods although economic regression does take place because of the management policies and the unforeseen happenings like the terrorists attack on WTC in New York and on Pentagon in Washington on 11th September, 2001. However the stronger science and technology infrastructure of the United State lends a strong support for recovery of the economy in shorter periods of time. Therefore, a strong S&T base is again a great help to US in periods of economic difficulties to sustain country's eminence. Strong R&D base in science and technology quickens the economic recovery when management measures are improved to meet the requirements of new steps for economic recovery. If, on the other hand, a setback occurs in the economy of countries with a weak base of R&D in high science and technology, such as for poor countries, the economic recovery becomes an unachievable target and things may go from bad to worse.

In the recent good days of US economy, the investments in research grew in 1998 by 6.5 percent. And in the two years period of 1997-98, the US GDP grew by almost 4 percent, bettering the historical averages. Federal support for R&D rose by 2.1 percent, inflations adjusted[2].

Further, much larger percentage increase in industrial research and development as referred to earlier, however, helped to lower the federal share of national total to below 30% lowest since a period of nearly 50 years.

Another advantage for strengthening the sustainability of R&D in science, the US adopted the strategy of making use of global science and the US companies entered countries to the tune of about 5100 over a period of about 10 years after 1990. The US companies invested about three times more in foreign cooperative research and development than the domestic similar expenditure. This resulted in an increase of 20% in co-authored research publications with foreign collaborators than compared to just 12% a decade earlier[2].

Another useful trend for the sustainability of US R&D institutions was the change in approach of the universities to concentrate more on patenting their research. The patents increased from about 250 per year in 1970 to about 3100 in the year 1998.

While this shift in approach of the universities towards patented R&D is noticeable today there is also a desire of US to lead the world in scientific research of large size or mega science research projects (MSRP). Eight such mega projects such as observation network for crustal movement in China, or H.7 – 7U super-conducting Tokamak Fusion experimental equipment or 3rd generation synchronous radiation light source etc. Such projects need large scale investment and contribute to the strength of not only large basic research but also helps the evolution of applied research. But more than that, these projects will prove for the US a source of great national strength in science and technology.

Salient Points

Maintaining U.S. excellence in science is not an impossible dream. Like getting rid of crime or narcotics, it does not require building some vast new infrastructure; most of what we have is fine. The gap between excellence and mediocrity is measured in the low billions of dollars per year. Clearly, continued excellence in science is well within the nation’s reach. Living within tighter budgets will mean following these guidelines[23]:

- *Target federal funds more effectively:* Cutting the least productive federal programs is an obvious way to live within tighter budgets, but the existing decentralized process of science budgeting is ill suited to doing that.
- *Nurture—but do not directly subsidize – industrial R&D:* Industrial R&D needs the fundamental science produced by universities, but companies are clearly quite able to fund the “appropriable” applied research specific to their individual requirements. Let’s not waste federal money on research projects that industry would fund anyway.
- *Rationalize the role of the federal laboratories:* The federal laboratories are valuable national resources that need a clear mission to achieve their potential.
- *Recognize the growth of science worldwide and develop policies to take advantage of it:* This involves issues of international cooperation in research, international movement of scientists, and picking up on scientific advances, wherever they occur worldwide.
- *Protect the federal support for academic research:* Academic research, heavily dependent on federal support, contributes crucially to the overall advance of science and is unlikely to be replaced by private initiatives if federal support is withdrawn.

OTHER USEFUL PARAMETERS FOR SUSTAINABILITY OF S&T FOR ECONOMIC DEVELOPMENT

It has been already discussed that a strong R&D in science and technology is the core parameter for sustainable development of a country. However, some of the other factors are listed below:

1. Role of merit, scientific ethics and self regulation in research institutions are important aspects to practice if these institutions are to be established for long term sustainability.

2. The scientific merit needs to be strictly practised in promotions and for appreciation of meritable scientists. Personal preferences of non-professional nature need to be consciously put aside to keep the national and organisational interest supreme with regard to professional ethics. The exploitation of official position should not be made by taking credit of research work in which one has not contributed any justifiable work. This is particularly so if co-authorship is involved in a research publication. The work done by others should not be shared as a co-author simply because a person may be the Director or the Head of an organisation. In several countries, the regulations are framed under what conditions one could be a co-author[24]. The rules are defined.

3. The ethics of professionalism on international norms do not allow the co-authorship simply because if one is a director or head of the organisation, manages to provide facilities for research of his younger scientists. There are commissions, which act as courts for scientific justice to the violations of scientific ethics pointed out by any affected scientist who can approach such a commission. For example, any younger author, who may feel that his Director or the Group Leader has included his name without contributing properly to the research paper published, can put up his case to such courts to get justice. Such commissions are *Government Sponsored* in Germany and Denmark and therefore the misconduct in science is well looked after[24, 25].

SUSTAINABILITY AND NEED OF CONTINUITY OF MANPOWER PROVISION

The sustainability of R&D institutions greatly depends on the continuous supply of well trained and well qualified scientists at well thought timings to replace the scientists reaching the retirement age. This requires a good vision to see in future the needs of manpower requirements of the organisation, and manage the matters in such a manner that competent and well qualified persons are already available to replace the retiring persons. The extension in services of those who have reached the retiring age is not a proper solution of sustainability of the R&D institutions. In the first instance, it is a human injustice if the retiring person arranges extension in his service, and secondly, it is a weakness of his management of the past years not to train and induct persons to replace the retiring person, particularly when competent persons are available for replacement.

Therefore, the planned and well prepared availability of human resource to replace the retiring persons is an important aspect of sustainability of R&D institutions and is in supreme national interest. A good example of this aspect in advanced countries like U.K and Germany is that all persons retire at the specified retiring age and no extensions in service are given by the government even if the Scientist is a Noble Laureate. However, utilization of expertise of retiring persons is made effectively for national benefits in a variety of other useful schemes made available. Therefore, the Institutions like Oxford and Cambridge universities in U.K or Max Planck Institutes in Germany sustain their meritable existence over hundreds of years. In USA, although there is no specific age of retirement of scientists, but younger competent people dominate the progressive scientific organisations and universities necessary for their sustainability.

In Pakistan, we have well known research Institutions of merit like for example PINSTECH (The premier R&D institute of Pakistan Atomic Energy Commission, in the area of Nuclear and Physical Sciences), KRL (in Uranium enrichment and metallurgical sciences), and HEJ (for chemical sciences). Since these centres of excellence are new in age, their sustainability for future, keeping the level of eminence they have attained, will depend on the availability and consequent replacement of retiring persons by competent people in the years to come. A careful attention of the Government is required to this aspect to ensure the needs of sustainability of these Institutions.

The vision of Dr. Usmani and Prof. Salam gave good sustainability to the working of Pakistan Atomic Energy Commission for about 40 years which has played a leading role in the nuclear capability of Pakistan. Future continuity of its meritable sustainability will depend on, in what manner the aspects discussed above have been taken care of.

The vision of the establishments of KRL by Dr. A.Q. Khan led the country to the development of the Uranium enrichment Laboratories which made very vital contributions in the provision of enriched Uranium to the Nuclear weapon Project of Pakistan, completed under the auspices of the Pakistan Atomic Energy Commission. In addition, KRL has established metallurgical and space technology Laboratories of great importance in the area of high technology.

Similarly HEJ, the Hussain Ebrahim Jamal Institute in Chemistry established at Karachi University with the vision of famous chemist Prof. Salimuzzaman Siddiqui and led successfully with further expansion by Prof. Dr. Atta-ur-Rahman, an eminent chemist, has produced a large number of Ph.D. scientists and this is a good vision for sustainability of the HEJ Institute as a centre of excellence in Chemistry for years to come.

The recent establishment of National Engineering and Science Commission (NESCOM), by the government of Pakistan, under the chairmanship of the eminent Nuclear Scientist, Dr. Samar Mubarakmand (who led the team which successfully exploded the Pakistan's atomic bombs in May 1998) is a promising step for the development of essential scientific and engineering strategic needs of Pakistan. The able and progressive guidance of Dr. Samar Mubarakmand will give a viable strength to our country.

In the field of country's defense, the Institution of Pakistan Army has been sustainable by a praiseworthy vision by the establishment of the Kakul Academy, where regular production of meritable trained young persons are source of continuing strength to our Defense needs in the form of a *Sound Army*. When the experienced generals reach the age of retirement, the competent younger successors are available to replace them. Pakistan Army is thus a successful example of a sustainable Institution in Defense of Pakistan.

Such sort of system may be good to establish for having sustainable Educational and Science and Technology institutions in Pakistan. The Model of Pakistan Army is a good example for this purpose.

NEW MECHANISM OF APPLICATION OF RESEARCH TO INDUSTRY

(Example: Steinbeis Foundation, Germany)

There has always been an urge of applying the outcome of scientific research for improving products of Industry. Several systems have been followed to coordinate the research output (which is mainly done at the universities and research Institutes) to the Industry requirements. Universities, particularly in recent years, have specific liaison officers who interact with industries, and professors at the universities themselves have also direct contacts with Industries to find their problems and solve them through research. On the other hand industry has specific research departments to interact with Professors at the universities. In this way considerable research has been sponsored by the Industries and in return these Industries have derived benefits for their products utilizing the research done at the universities.

Recently certain government helped foundations or commissions have worked purely as technical knowledge-based organisations which have played the coordinating role as '*bridges*' between research institutes and the industries. Such foundations have very competent research based scientists and engineers, usually, who themselves in the past have been research scientists or research engineers. The foundation identifies the problems of Industry and hands it over to the university or to the Institute where in their judgement the problem could be solved. Such schemes in recent years have proved very useful, particularly in Germany and Japan.

In Germany the Steinbeis Foundation, Stuttgart, established about 10 years ago, has proved very successful as a bridge between industry and research Institutes. Its efforts have reduced the gap between the research outcome and its application. The foundation picks up simple problems from Industry, say if *the chimney installed at the top of a house by a certain company does not work so efficiently*. The foundation takes such a project to the relevant research institute which solves this problem and produces a chimney of a better and desired efficiency. There are host of such small or large projects which the foundation handles.

The Steinbies Foundation has branches throughout Germany and even in foreign countries and has proved very effective in providing means of efficient application of research to a better Industrial production[26].

A brief description of this foundation is given below. It is very much hoped that such a scheme if introduced in Pakistan will indeed be very useful for deriving economic benefits of basic research.

STEINBEIS FOUNDATION (GERMANY)

For 25 years the '*Steinbeis Foundation for Economic Promotion*', established in 1971, has provided a bridge between academia, research bodies, politics and industrial companies with great success.

Autonomous, flexible, decentralized, customer-oriented; these are the guiding principles upon which the work of a network of more than 370 Steinbeis transfer centres is founded, most of them based at or near institutions of higher education. These Transfer Centres have immediate access to a pool of more than 3400 professors, engineers, natural scientists, experts on industrial management and designers, covering an enormous range of specializations. Thus the foundation can engage the right specialists to work on each project, meaning that they can concentrate on the particular needs on the spot - no matter how specific.

Research and Development:

Germany is in the fortunate position of having an excellent research and development infrastructure. The Steinbeis Foundation acts as an interface between academic researchers and businesses. With more than 3,400 specialists in all key technologies, it can offer the first-hand access to direct, up-to-date technology transfer that can strengthen the market position and give a lead over other competitors.

International Technology Transfer:

For many years, multinational companies have been pushing ahead with the process of globalisation, and smaller companies now face the task of catching up with them. The most important roles of the foundation being the provision of assistance to small and medium-sized enterprises to enable them, too, to successfully penetrate the growth markets of the future, for example in Asia or the USA. The Foundation maintains an international network of links both with financially secure partners for joint business ventures and projects and with leading research and business institutions. The Foundation can thus extent the benefits to its clients from this "borderless transfer".

Business Promotion:

The federal state of Baden-Württemberg provides funding for new and established businesses in the form of specifically targeted financial aid programs. The Steinbeis Foundation advises during the application stage, and assists and supports during implementation of the project. The task of evaluating and advising projects deemed suitable for funding is in the hands of the Government Commissioner for technology transfer, Professor Löhn, who assesses companies on the basis of their innovative, market and competitive potential.

During 2,000 the Steinbeis network completed more than 19,000 (nineteen thousand) projects with a turnover of more than EUR 80 millions. The Chairman of the Board of the Steinbeis Foundation is Prof. Dr. Johann Loehn Baden-Wuerttemberg, Government Commissioner for Technology Transfer.

CONCLUSION

The sustainable development of a country, and this includes the member states of COMSATS, greatly depends on the sustainability of the high merit R&D institutions which can provide strength to economic needs of the country. The important factors for the sustainability of R&D can thus be listed, among others mentioned earlier:

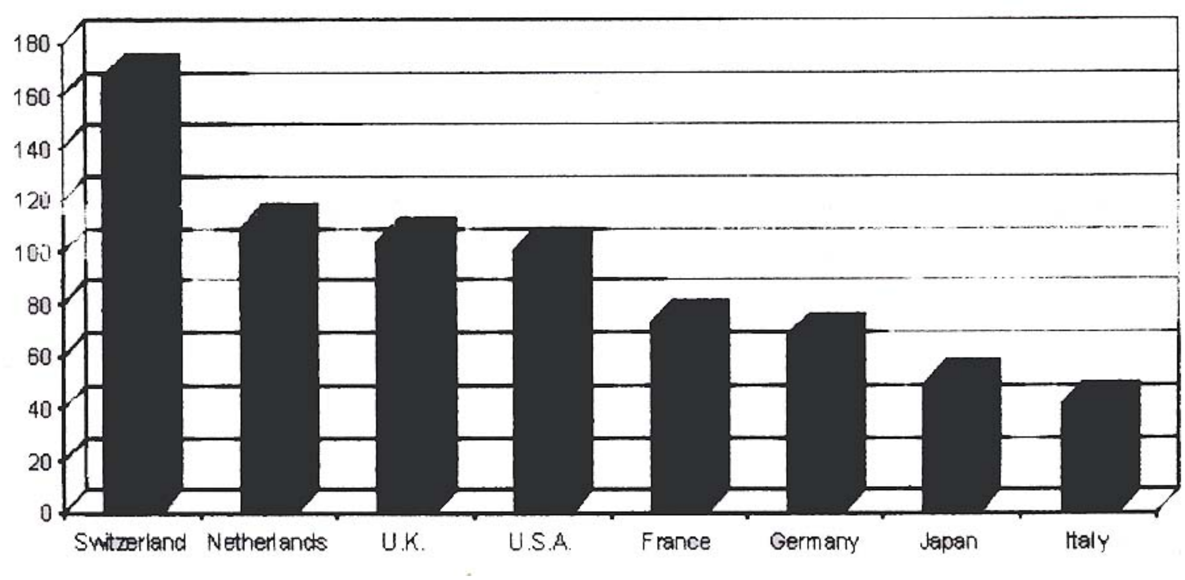
- Establishment of Research Quality of R&D institutions capable of giving strength to economy of the country. Thus quality more than quantity has to be stressed in such institutions.

- Merit, scientific ethics and a correct vision is necessary for continuous supply and availability of well qualified and trained scientists. To ensure sustainability of the institutions rules must be ensured for continuously preparing qualified and competent persons for replacement of the retiring individuals.

- Proper utilization schemes of research for applications for public use to solve the problems for common man. Foundations specialized in the applications of scientific research for industry in the shortest possible duration between the outcome of research and its application. Steinbeis Foundation in Germany is one such example well suited to such needs.

- A proper level of education in the country, the "Central Factor" on which all the above factors depend is education, a balanced combination of low and high education is necessary, not just a mass level lower education. Research based higher education is necessary for the production of eminent leaders and innovators for progress of the country concerned.

REFERRED FIGURES IN THE PAPER



Note: The study was conducted over a 14-year period and covered 79 countries (4000 journals). The Relative Citation Impact (citations divided by publications) gives some measure of the quality of the average paper.

Figure - 1: Research-Papers Per Person of Various Countries

	Nation	Citations Per Paper	Number of Papers	Total Citations
1.	Switzerland	5.66	55,213	312,564
2.	United States	5.03	1,239,188	6,234,187
3.	Netherlands	4.45	80,016	356,025
4.	Sweden	4.38	61,072	267,685
5.	Denmark	4.38	30,719	134,616
6.	United Kingdom	4.19	300,577	1,259,427
7.	Belgium	3.94	38,095	150,206
8.	Finland	3.93	26,998	106,151
9.	Canada	3.83	167,326	641,114
10.	Germany	3.78	258,946	979,823
11.	France	3.66	197,816	723,156
12.	Austria	3.54	24,388	86,275
13.	Israel	3.45	39,977	137,980
14.	Italy	3.42	116,534	398,285
15.	Norway	3.30	19,814	65,305
16.	Australia	3.23	85,215	275,599
17.	Japan	3.18	280,855	892,029
18.	New Zealand	2.94	17,015	50,007
19.	Ireland	2.78	9,233	25,630
20.	Spain	2.72	73,224	199,443
21.	Hungary	2.55	14,768	37,724
22.	Portugal	2.40	7,135	17,097
23.	Chile	2.31	6,666	15,366

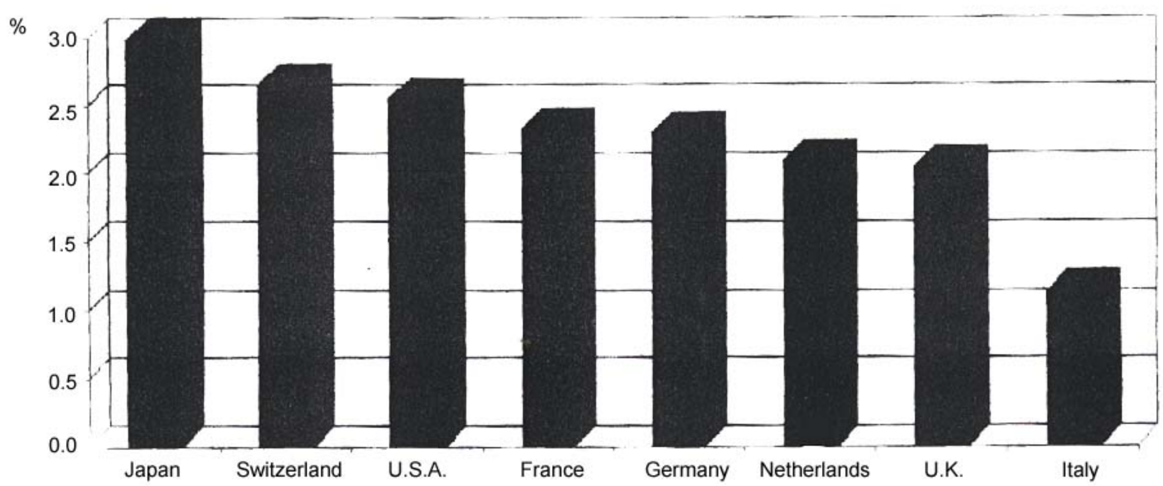
Dated July 7, 1997

Figure - 2: Nations Ranked by “Citations Per Paper (C.P.P)” (1992-96)

Country	R&D investment As % of GDP
Japan	2.98
Switzerland	**2.66** (1)
U.S.A.	2.55
France	2.33
Germany	2.30
Netherlands	2.09
U.K.	2.05
Italy	1.14

Source: *Main Science and Technology Indicators*, OECD, February 1998
Note: (1) Figures are for 1992, and are the most recent available

Figure - 3(a): Investment in Research and Development As a Percentage of GDP



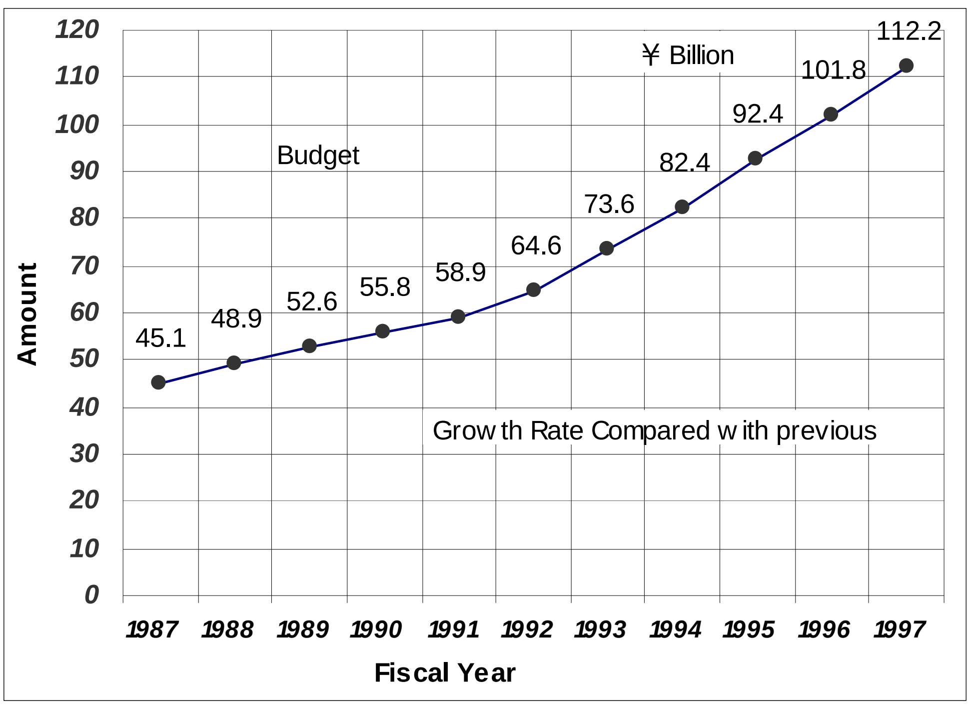
Source: http://www.geneva.ch/research_development.htm (9/17/1999)

Figure – 3(b): Investment in R&D as Percentage of GDP of OECD Countries

YEAR/ ORGANIZATION	TOTAL	UNIVERSITIES	RESEARCH INSTITUTES	COMPANIES
1975	310,111	134,458	29,049	146,604
1985	447,719 [1.44]	180,606 [1.34]	36,016 [1.24]	231,097 [1.58]
1996	673,421 [2.17]	242,862 [1.18]	46,459 [1.60]	384,100 [2.62]

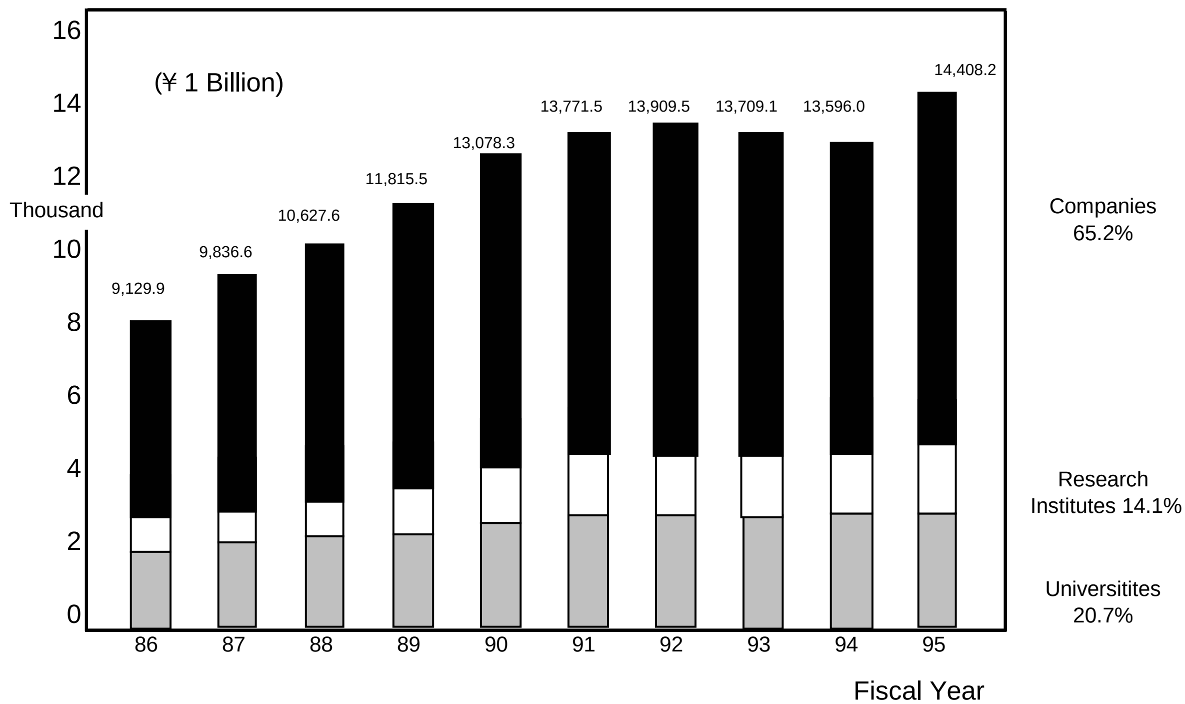
Note: Figures in Parenthesis denotes rates of increase {fiscal 1975=1.00}
Source: Management and Coordination agency , "Survey of Research and Development" (1996)

Figure - 4: Increasing Trends in Number of Researchers in Universities, Research Institutions and in Companies in Japan



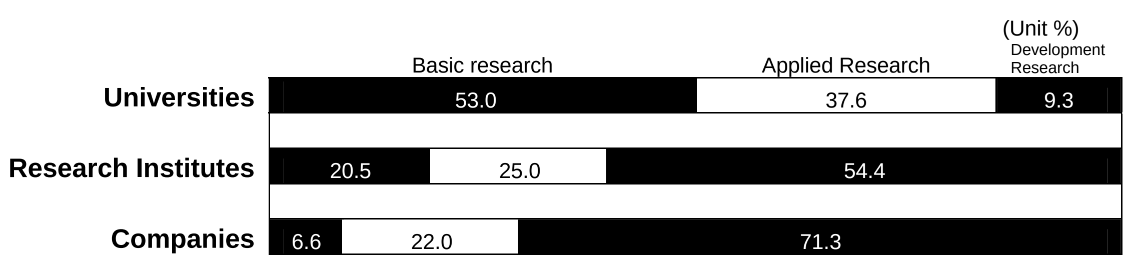
Source: MESSC

Figure - 5: Increasing trends in budgets for Grants-in-Aids for Scientific Research in Japan



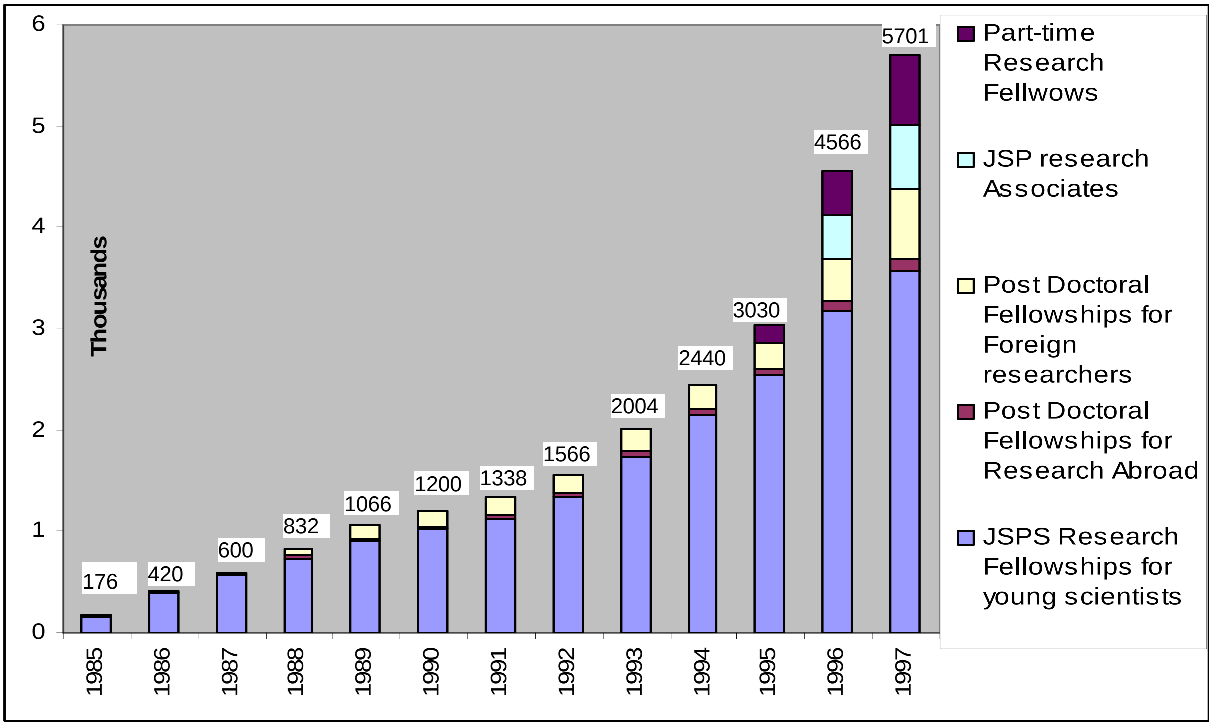
Source: Management and Coordination Agency, "Survey of Research and Development"

Figure - 6: Trends in Research Funding for Universities, Research Institutes and Companies



Source: Management and Coordination Agency, "Survey of Research and Development" (1996)
Note: The Figures may not add upto 100% because of rounding

Figure - 7: Relative Distribution of Research Expenditures for Basic, Applied and Developmental Research for Universities, Research Institutions and Companies in Japan



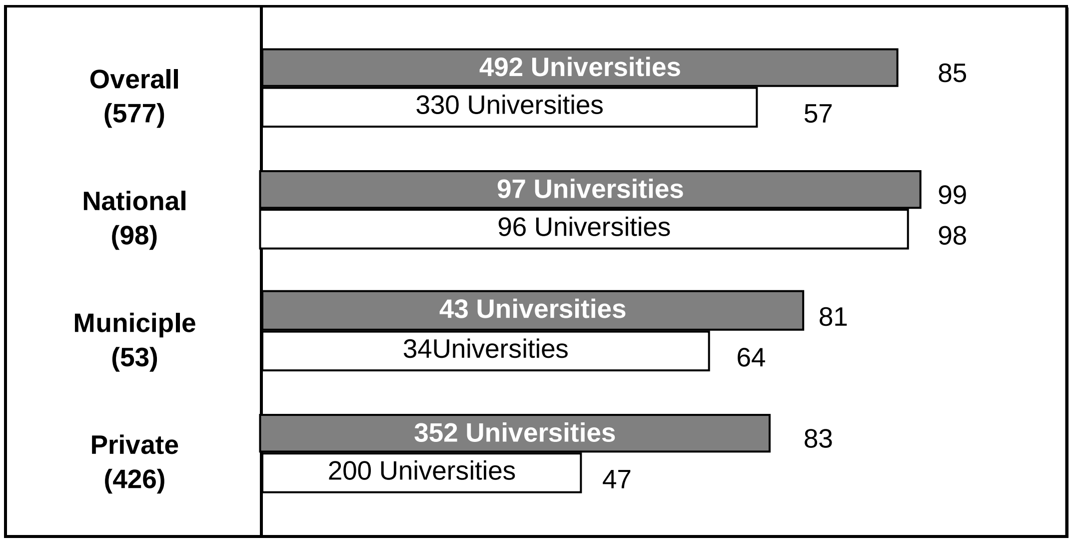
Fiscal Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
JSPS Research Fellowships for Young Scientists	156	400	580	740	916	1020	1128	1336	1744	2150	2540	3170	3570
Postdoctoral Fellowships for Research abroad	20	20	20	20	20	25	35	45	55	65	75	100	125
Postdoctoral Fellowships for Foreign Researchers	0	0	0	72	130	155	175	185	205	225	255	420	680
JSPS Research Associates												440	640
Part-Time Research Fellow											160	426	686

Figure - 8: Increasing Trend in Post-doctoral Research Fellowships from 1985-97 in Japan

	1981-1985		1984-1988		1987-1991		1990-1994	
	Share	**Ranking**	**Share**	**Ranking**	**Share**	**Ranking**	**Share**	**Ranking**
Agricultural Sciences	11.3	2	11.6	2	12	2	11.5	2
Astro Physics	1.7	10	2.8	9	3.4	6	3.2	7
Biology & Biochemistry	6.7	3	7.4	3	7.6	3	7.8	3
Chemistry	10.2	2	10.5	2	10.5	2	10.3	2
Clinical Medicines	2.4	7	3	6	3.7	5	4.4	3
Computer science	3.3	5	3.8	5	3.1	6	3.2	6
Engineering	7.9	3	7.6	3	7.7	3	7.2	4
Ecology & Environment	1.8	8	2.1	8	2.2	8	1.9	9
Geosciences	2	8	2.3	7	2.5	7	2.4	7
Immunology	3.35	6	4	4	3.9	5	4.5	5
Molecular Biology & Genetics	3.9	5	3.5	5	3.9	5	4.2	5
Materials Sciences	9.1	2	11.6	2	12.5	2	12.1	2
Mathematics	3.6	6	3.8	6	3.8	6	3.5	6
Neuro Sciences	3.3	7	3.7	6	4.3	6	5.2	5
Physics	7	4	7.9	3	9.4	2	8.9	3
Plant & Animal Sciences	4.6	5	5	6	5.1	5	5.1	5
Pharmacology	6	4	7.2	4	7.7	3	7.5	3
Micro Biology	5.3	4	5.4	4	5.6	4	6.1	4
Multi Disciplinary Fields	2.3	7	2.7	7	3.4	7	4.3	6
Total	5.3	4	5.7	4	6.1	4	6.3	4

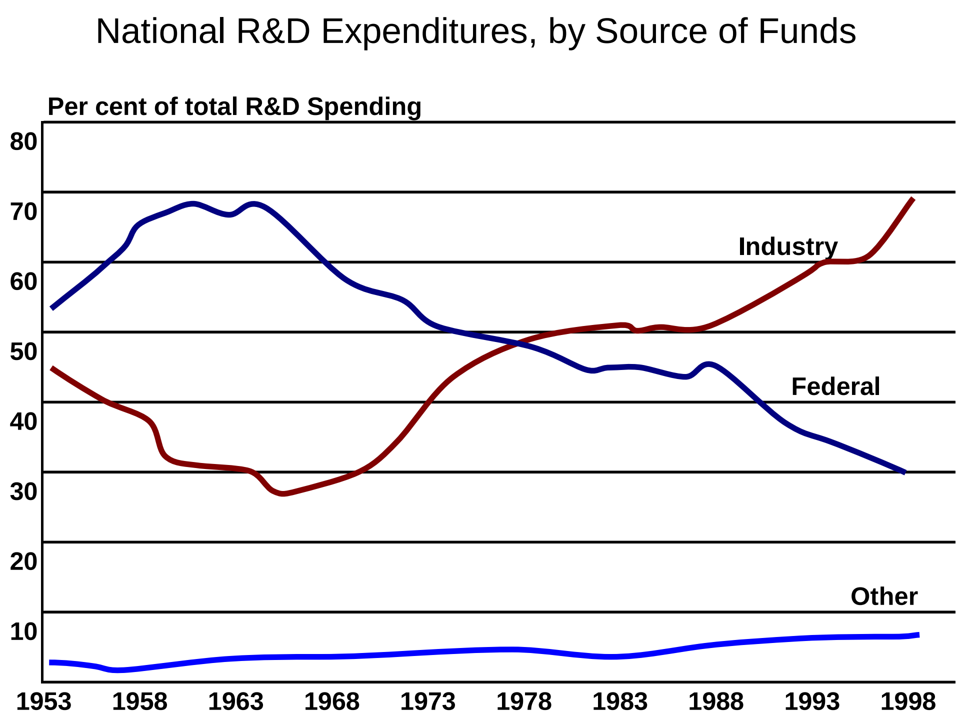
Source: Institute for Scientific Information, “National Science Indicators on Diskette, 1981-1996”

Figure - 9: Japan’s Ranking and Shares of World Totals for Citations from Research Papers in Various Scientific Fields



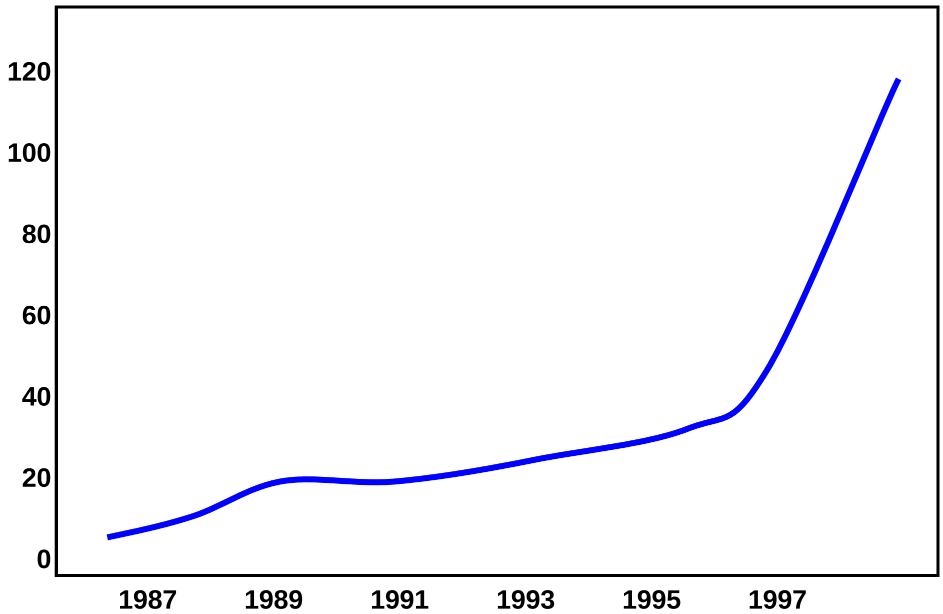
Source: MESSC

Figure - 10: Self-Monitoring and Self-Evaluation in Universities in Japan



Source: National Science Board ,Science Engineering Indicators 2000

Figure - 11: Percentage of R&D Spending by Industry, Federal Govt., and Others in the United States



Source: National Science Board ,Science Engineering Indicators 2000
http://www.nsf.gov/od/1pa/news/press/00/seind_medcharts.htm (10/4/01)

Figure - 12: Increasing Trends in Number of Citations on US Patents to Scientific and Technical Articles During 1987-1998

REFERENCES

1. The daily "The News", Islamabad, Pakistan, 24th February, 2001.
2. Leona C. Bull; Journal of Aerospace and Defense Industry News; August 11, 2000 [http://www.aerotechnews.com/stork/2000/081100/RD_funding.html]
3. http://www.geneva.ch/research_development.htm
4. Garfield E: Journal Impact Factor; a Brief Review; CMAJ, (1999), Vol.161,979-80.
5. Garfield. E: The use of Journal Impact Factors and Citation Analysis for Evaluation of Science; (1998), Inst.of Sci. Information (ISI), 3501 Market st. Philadelphia, PA 19104, USA.
6. Watson D.A: Citation Impact Factors; The Scientist, Vol.12, No.24, Dec.7, 1998.
7. Sen. B.K. and Shailendra K: Evaluation of Recent Scientific Research output by a Bibliometric Method; Scientormetrics (1992) Vol.23, No.1, 31-46.
8. Seglen, P.O: From Bad to Worse; Evaluation by Journal Impact; Trends Bio Chem Sci (1989) Vol. 14, 326-327.
9. Salz-Salinas: Failed Professor; Nature (1990), Vol.381, p.186.
10. Moed, H.F. and Van Leeuwen, Th.N.: Impact Factors can Mislead; Nature (1996), Vol.381, p-186.
11. Opthof, T: Sese and Non-Sense about the Impact Factors; Cardiovasc Res.(1997)Vol.33, pp 1-7. (also: http://www.elsevier.com/hopepage/sab/cardio/jnl/538/menu.htm)
12. Seglen. P.O: Why the Impact Factor of Journals should not be used for Evaluating Research; BMJ (1998), Vol.316,498-502.
13. R. Smith: Un-Scientific Practice flourishes in Science: Impact Factors of Journals should not be used in Research Assessment; BMJ(1998), Vol.316,1036.
14. Hecht.F, Hecht BK, Sanberg AA; The Journal impact Factor: a misnamed, misleading, misused measure: Cancer Genet Cytogenet (1998) Jul.15; Vol.104(2), 77-81.
15. Moed, H.F. et.al., New Bibliometric Tools…. Applications; Scientometrics (1995), Vol.33, No.3, 381-422.

16. Moed, H.F: Bibliometric indicators reflect publications and management strategies; Scientometrics (2000), Vol.47, No.2, 323-346.
17. Joseph K.S, Hoey. J; CMAJ's Impact Factor: room for recalculation, CMAJ(1999), Vol.161, PP 977-8.
18. May. R.M, Science (1997), Vol. 275, 793-796 [also: http://www.sciencemag.org]
19. Butt N.M, Saleem H; Science and Tech. Education for Development in Islamic World; Eds: M.Ergin, M.Doruk, M.R. Al-Zou'bi, Islamic Acad. Sci, Amman, Jordan; 2000. pp 481-495.
20. Seglen P.O, Casual Relationship between Article Citedness and Journal Impact; Journal of the Am. Society for Information Sci. (1994), Vol.45(1), 1-11.
21. Amin M, and Mabe M; Impact Factors: Use and Abuse; Perspectives in Publishing, No.1, Oct. 2000, Elsevier Science, Kidlington, Oxford OX5 1GB, U.K
22. Ingwersen P, Birger L, Ronald R and Jane R; The Publication-citation Matrix and its derived quantities; Royal School of Lib and Inf. Science, Dept of Inf. Studies, Birketinget 6, DK 2300 Copenhagen, Denmark, May 2001.
23. Broin K.M; Downsizing Science: Will the United States Pay Price? Feb., 1998 [http://www.Appl.Sci and funding US.htm]
24. Fruhwald. W etal, Recommendations of the Commission on Professional Self-regulation in Science: Proposals for Safeguarding Good Scientific Practice. Executive Board of the Deutsche Forschungsgemeinschaft, Germnay January 1998. (a 40 page report).
    Ref: http://www.dfg.de/aktuell/download/self_regulation.htm
25. Woodward. J and Goodstein D; Conduct, Misconduct and Structure of Science, American Scientist, (1996 Sept-Oct) Vol.84, 479-490.
26. http://www.steinbeisfoundation.com [M/S Steinbeis Foundation, Willi-Bleicher Str. 19, 70174-Stuttgart, Germany. Postfach 104362, 70038-Stuttgart, Germany. [e-mail: stw@stw.de]