asynchronous brood = 36%; n = 97). Thus, the mother is better off raising a synchronous batch of brood while the father is better off with an asynchronous batch of brood.

The most likely reasons for these male–female differences are the following. The authors of the same study have data suggesting that male blue tits, while participating in parental care, are apparently not as conscientious as the females. They take care of the larger and stronger chicks, and when such chicks are successfully fledged, they stop working and pay more attention to territorial defence and moulting and enhance their future survival probabilities. The burden of difficult and prolonged care of small and weak chicks falls on the mother. When the chicks are all of more or less the same age, the mother thus has more help from the father, who in turn has to work harder as all the chicks satisfy his criteria of being big and strong. When the brood is asynchronous, however, the male benefits by stopping his work early while the female carries on alone, caring for the smaller and weaker chicks, and in the process, lowers her chances of being alive and fit to breed again the following year.

Now why should males and females be so different in their commitment to parental care? Firstly, female parental care is more fundamental and as soon as there is any opportunity for one of the parents to desert, it is usually the male who is the first one to jump at it. This happens throughout the animal kingdom and may be related to the fact that females invest more in their offspring, starting right from the cost of an egg, while males invest much less, often nothing more than inexpensive sperm[5,6]. Hence, females have much more at stake in the survival of their offspring than males do. Secondly, the small and late-hatching chicks in a nest are more likely, at least in some species, to be sired by neighbouring males in extra-pair copulations[7,8], so that the male has even less interest in the welfare of these particular chicks[1,3,9,10]. Interestingly, however, it is the female that appears to win in this domestic quarrel about whether the brood should hatch synchronously or asynchronously. Only the female incubates and it is thus only she who decides when to start incubating and, therefore, how synchronous the brood should be.

Until not too long ago, unexpected conflicts among animals were buried under the carpet as being pathological. The evolutionary approach to animal behaviour permits us to face such unexpected conflicts head-on and even to predict when conflicts may occur and how they may be resolved. As a bonus, our understanding of animal behaviour grows in richness. But if these revelations of domestic conflict in birds appear to make them unsuitable as role models of good behaviour, we must reflect on the fact that they are still able to maintain an external appearance of faithfully bonded monogamous pairs in spite of such simmering discontent!

1. Burke, T., Davies, N. B., Bruford, M. W. and Hatchwell, B. J., *Nature*, 1989, **338**, 249–251.
2. Westneat, D. F., *Behav. Ecol. Sociobiol.*, 1990, **27**, 67–76.
3. Dixon, A., Ross, D., O'Malley, S. L. C. and Burke, T., *Nature*, 1994, **371**, 698–700.
4. Slagsvold, T., Amundsen, T. and Dale, S., *Nature*, 1994, **370**, 136–138.
5. Trivers, R. L., in *Sexual Selection and the Descent of Man* (ed. Campbell, B.), Aldine, Chicago, 1972, pp. 1871–1971
6. Alexander, R. D. and Borgia, G., in *Sexual Selection and Reproductive Competition in Insects* (eds. Blum, M. S. and Blum, N. A.), Academic Press, New York, 1979.
7. Gottlander, K., *Ornis Scand.*, 1987, **18**, 269–276.
8. Westneat, D. F. and Sherman, P. W., *Behav. Ecol. Sociobiol.*, 1993, **4**, 66–77.
9. Davies, N. B., Hatchwell, B. J., Robson, T. and Burke, T., *Animal Behav.*, 1992, **43**, 729–745.
10. Westneat, D. F., *Am. Nat.*, 1994, **144**, 343–354.

Raghavendra Gadagkar is in the Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012, India and Jawaharlal Nehru Centre for Advanced Scientific Research, Jakkur, Bangalore 560 064, India; and H. S. Arathi is in the Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012, India.

OPINION

University science education: Who funds?

Who should fund university science education? Can the private sector generate enough resources to be able to sustain universities in their intellectual pursuits and not merely merchandise education? The questions have appeared rather suddenly on the horizon. Pt Nehru's vision of modern India, the first Education Policy and the National Policy on Education 1986, carved a direction for science education in the country and led to creation of a strong infrastructure. Yet, the science education system needs reforming to respond to the challenges of national economy and international competitiveness. The current policy of the government of releasing control to the industry and the people and the Punnanya Committee recommendations in cutting down the establishment expenditure call for greater support to universities from the industry, NRI and affluent members of the society. The creation of the infrastructure, the areas of concern, the role played by public and private sector so far and the response actions for attracting multisource funding are discussed in this paper.

Areas of concern

With the increasing cost of research, lack of suitably trained manpower and the shrinking budget, enormous pressure is being put on university education. The current situation is seen as reflecting the existence of a mismatch between the generation of S & T manpower, production of technology know-how and the availability of financial resources.

Generation of S & T manpower and comparisons

Data on enrolments of students in higher education can be taken as one of the parameters to assess the growth of S & T manpower in the country (Figure 1). What are the demand profiles and where does this S & T manpower get absorbed? The total stock of S & T manpower, which was approximately 1 million as per 1981 census survey, has grown to 4 million by the end of the seventh plan. Out of this only 0.3 million were employed in the R & D establishments, including the industrial sector in 1990. The R & D stastistics of the Department of Science & Technology also points out that in the same year 0.6 million S & T graduates were registered at the employment exchange, though all may not have been unemployed at that time. It is obvious that employment opportunities and the demand for indigenous know-how for technology development fall short of the quantum of S & T manpower generated in the country.

In the global context, data on the percentage of population with university degree for India are shown in Figure 2 in comparison to the US, Japan, Germany and others. A comparison of the ratio of S & T enrolments to the total graduate enrolments, for a few Asian countries, is shown in Figure 3. This indicates a low percentage of the total numbers entering the university and opting for science and engineering education, in India.

Besides the above differences, compared to India, in the advanced countries, flexible systems operate with stress on job-oriented education and greater emphasis on scientific literacy. The major structural differences occur in

- the ratios between enrolments at higher secondary level and at university level,
- the ratios of students opting for general education and for vocational/technical education,
- the enrolments for full-time and part-time courses,
- the degree of flexibility and variability of emphasis on pre-vocational education.

Production of know-how

Not only in India but also globally, a key problem is the integration of science education with economic reforms dictated by market compulsions. Science education must relate to the existing real world. Views are being expressed on what shape science education would assume in the 21st century. The issues of costs and value of the returns are also being reexamined in this context. It is being realized that the demand for future is going to be for technological skills in hi-tech areas. Not just new product technologies but more importantly new process technologies will be required to meet the demands of international standards such as ISO and those of environmentally cleaner production systems. And science education is an essential ingredient in these hi-tech processing technologies. The countries with the best-educated scientific manpower are expected to gain in the long run. Countries like Japan and Singapore are attentive to this situation and are taking steps to ensure that they continue to lead in producing skilled manpower. Companies are being persuaded to set up training institutions and heavy emphasis is laid on re-training of the workers.

With the increasing importance of emerging technologies in the fields of composite materials, microelectronics, informatics, data communications, construction, environment and biotechnologies of importance to India, it is evident that a large number of engineers with an advanced degree in these high-technology areas would be needed. The R & D focus of academic institutions needs to be directed towards solving the immediate and distant problems in the areas of current thrusts and missions mode projects in potential growth areas, with industry as a partner. In the Department

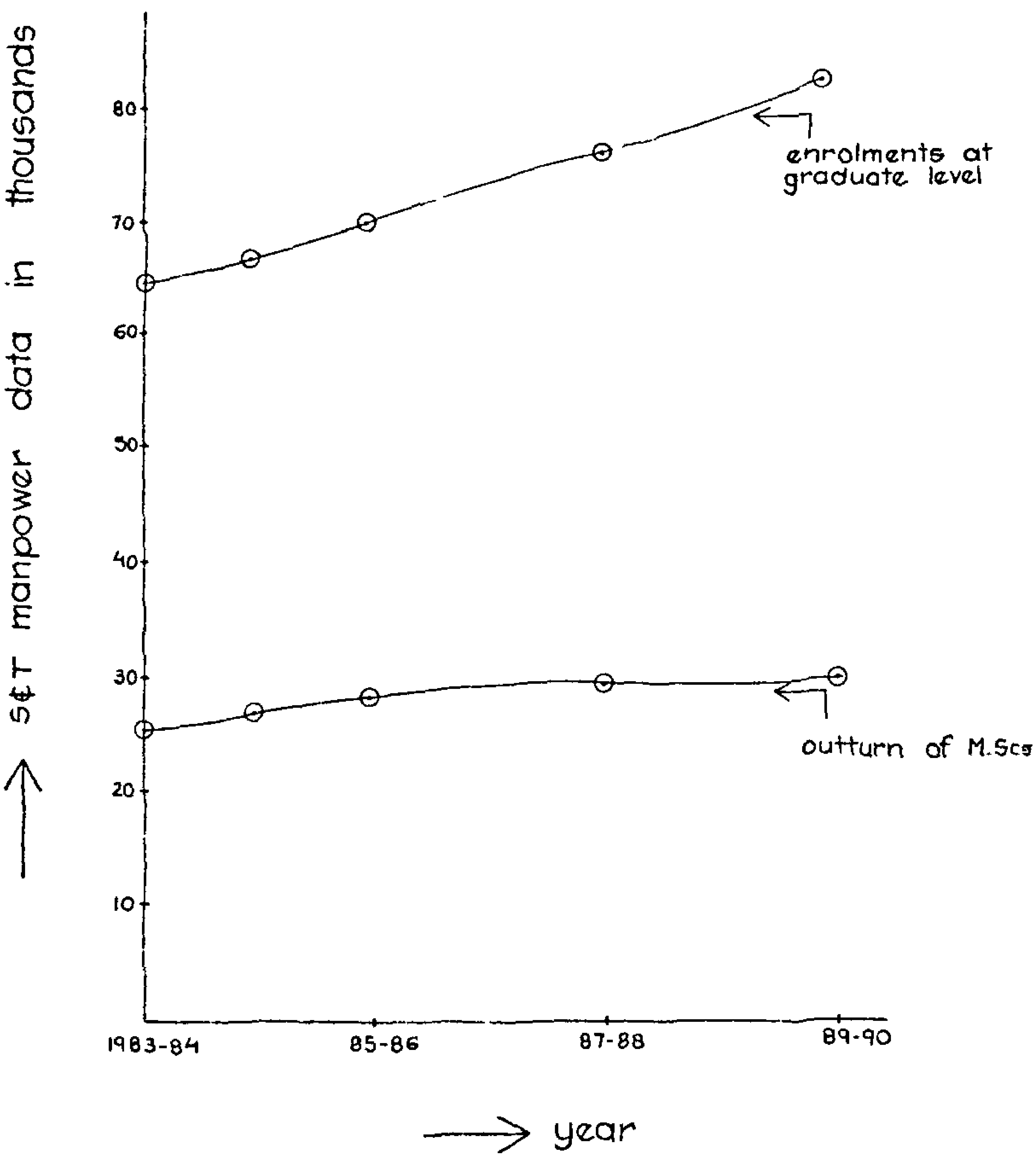

Figure 1. Growth of enrolments in basic sciences and turnout of M Sc degree holders. (Source: R & D Statistics of DST and HRD Group Report of CSIR, 1993).

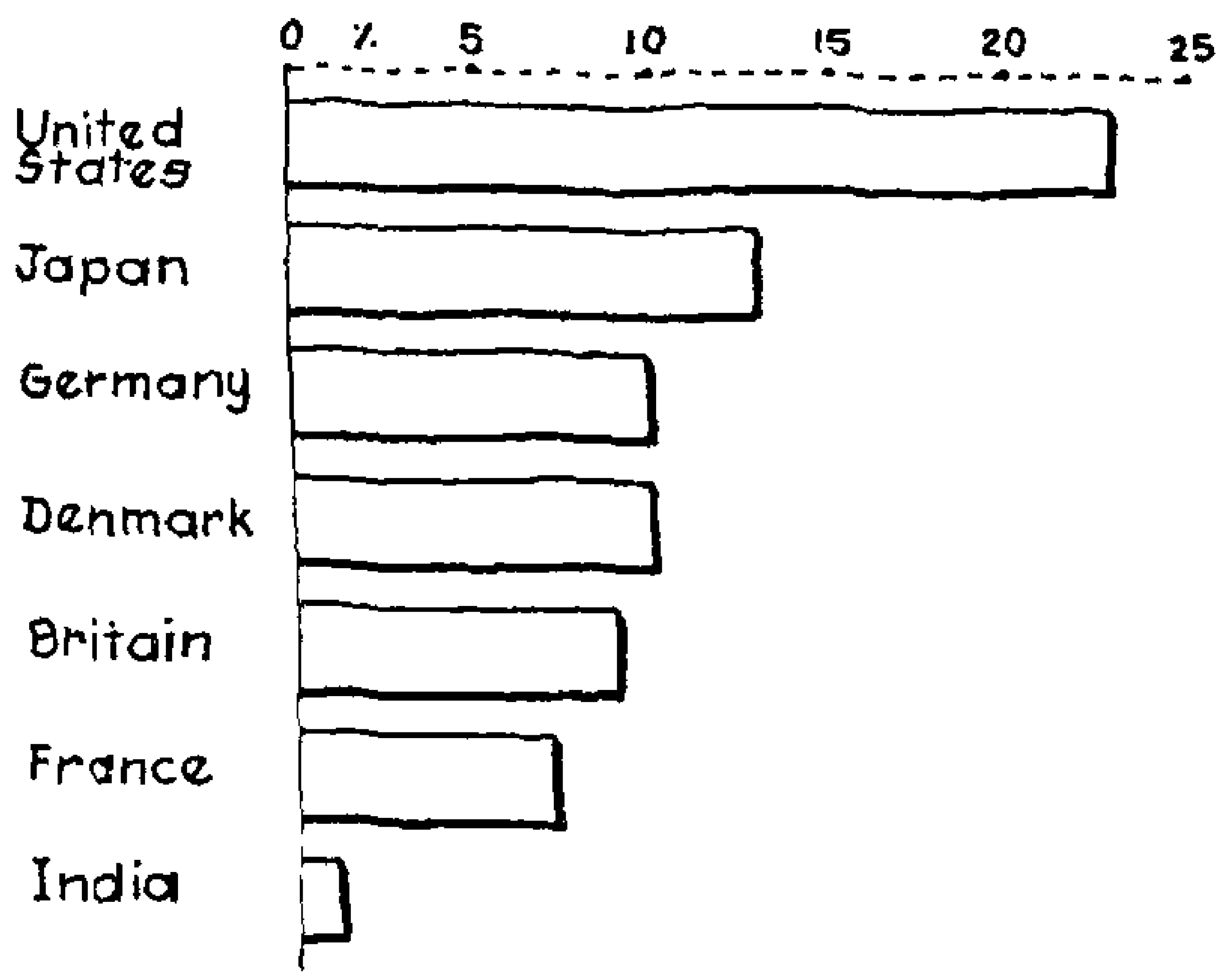

Figure 2. Percentage of population with university degree, few select countries: 1989 (*Source: OECD*).

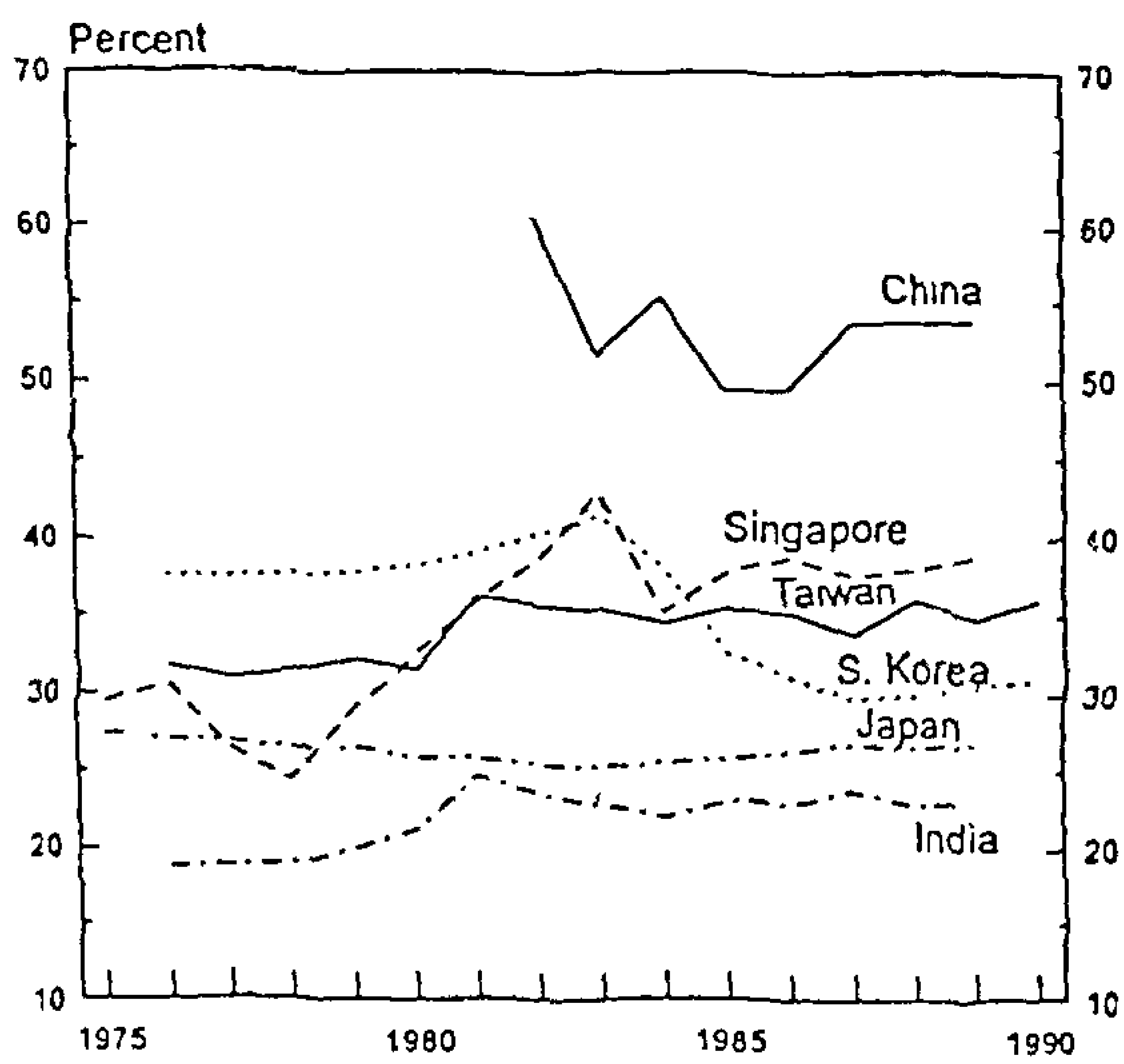

Figure 3. Ratio of natural science and engineering degree holders to total bachelor's degree holders in selected Asian countries, 1975–90 (Source: Prof. E. L. Jossem, paper presented in the International Conference on Physics and Industry: Bridging the Gap, New Delhi, January 1994).

of Science & Technology, Technology Information and Forecasting Assessment Council is carrying out an in-depth study of some of the issues involved and strategies for re-orientation needed in science education at various levels in the context of technology development and global competitions.

Resource crunch

The total educational fund available in any country is considered to be an indicative factor of development. The world average in terms of the ratio of educational fund to gross national fund (GNF) is between 5 and 8%. For India, this ratio is as low as 3%. The amount would be much less if the total funds actually available for education are considered. For example, for India and UK, where this ratio is 3 : 8 and the population ratio is 16 : 1 our country may actually be spending 32 times lower than UK on education. What fraction of it is spent for university science education?

Response actions

All the factors discussed above are highly interactive and a well-matched interplay would be desirable for a dynamic growth. Here we discuss the issue of attracting greater finances for higher education, with response strategies by the universities, industry/private sector and professional bodies. There have been several notable recommendations about the unit cost and the corresponding provision of finances, student fee and scholarships; these aspects are not discussed here.

Role of universities

The government, while laying more emphasis on primary and secondary education support, has announced a policy of attracting investments for higher education from the private sector through income tax exemptions of up to 125% on contributions made to educational and scientific research institutions. The impact of this amendment of tax laws is yet to be felt. Such endowments would not only add to the university resources but can also give more autonomy and accountability to universities. The government policy of releasing control to the industry and the people is a significant step in this direction. The universities can come forward to design programmes to attract multi-source funding and strengthen the linkage with the industry for taking full benefit of the scheme. New models need to be tried for implementing these schemes, or some of the existing models could also be tried.

In the planning stage of most of the universities, it has been assumed that their creator; be it the government or a missionary body or some other private body; will be responsible for supporting them eternally. It was the vision of few like G. D. Birla who thought about the future sources of funds and the self-sufficiency of the education centres created by him. Along with the creation of the Birla Institute of Technology & Science (BITS) at Pilani in 1964, an endowment fund was created, which has grown today to a level of self-support. The fee has been in consonance with the market forces like price index and inflation. The industry has been involved through the Practice School Programme, as off-campus education programme started in 1973. The programme requires students to undergo the rigour of the professional world in form as well as substance. The cost of education of approximately three hundred students who are in the industry for the Practice School programme for about 7 months is indirectly borne by the industry. By one estimate, less than 10% of BITS graduates have opted to go abroad in the past. There will be more examples of similar innovative pursuits and achievements within the country. Some more analysis may be needed in adopting such models.

To cite a few examples from other countries, Denmark has recently introduced per capita funding in its technical colleges. The American and other governments are thinking in terms of introducing education vouchers. The Canadian universities have offered 'Industrial Research Chairs' so that the industry shares the costs of research professors' salaries, equipment and operating support.

Creation of the Technology & Innovation centre for transfer of technology can also be viewed as a means of indirect resource generation. IIT Delhi, with the start of Foundation for Innovations and Technology Transfer, has set up an interface with the industry. It is suggested that 'Alumni Chair' and 'University Residence Chair' could be created to attract funding from affluent citizens and NRIs.

Role of industry and private sector

In the following paragraphs, some suggestions are made for attracting multi-source funding, which will address the issues of both generation of resources and production of know-how.

(i) Industries need to come forward to offer projects at undergraduate and postgraduate levels. A few additional seats in colleges can be created for industries in the neighbourhood, and the students' programmes can be designed with built-in assessment techniques. Such 'projectized education' will not only sponsor students but also help in problem-solving areas, development of skills, and future employment of students.

(ii) Industries can identify modern laboratory equipment, which matches with the area of their activity, and provide it to the universities or colleges free of cost or at highly subsidized cost and claim tax exemptions. UNESCO has been encouraging such efforts.

(iii) The private sector is contributing not only to formal education but has also been playing a catalytic role through non-formal education at senior secondary level to prepare students for competitive examinations. Similar structured courses may be offered by the private sector at postgraduate level too, for graduates coming out of the universities. One possibility could be that universities have tie-ups with the private industry, which trains the graduate students in the areas of relevance during vacations as well as after graduation. Industries also expose the students to the real problems and also sponsor them.

(iv) In India, several private organizations are running successful computer training programmes in software development. The potential of these organizations can be turned to develop programme texts as a means of informal learning at the universities. They may hire students from the universities for preparation of such a 'course ware' and also link with the industries who offer the facilities for informal learning. Such informal teaching can also become part of the courses offered by the universities/colleges.

Role of professional bodies

The professional bodies could help in organizing seminars and visits to industries for their members. These bodies could also help in widely disseminating the scientific information generated at universities for the benefit of the industry.

Conclusions

In the field of higher education the areas of prime concern are the lack of skilled technical manpower, lack of indigenous know-how, resource crunch and the challenge of globalization of the economy. This write-up addresses the issue of resource crunch. A few models to attract multi-source funding that exist are cited, and existing efforts to bridge the gap between education and industry are enumerated. Suggestions are made to develop other means to attract finances which may also add to the production of suitably trained manpower to fufil the requirements of job markets. Private bodies and professional societies have a greater role to play in this direction.

Malti Goel is in the Department of Science & Technology, Technology Bhawan, New Delhi 110 016, India.

Are patterns a rule in nature?

'Nor is it our business to prescribe, to God how he should run the world. . .'

– *N. Bohr*[1]

Searching for patterns and investigating the basis of their emergence has been probably the major occupation in science. It is because the planets were found to go on circling in a regular pattern that the science of astronomy was born, because the fossils were found changing in a gradual and interpretable manner that the science of evolution started, and chemistry as a science survives because the electrons exhibit a regular pattern of movement around the nucleus; in a crude sense, patterns seem to be the raw material for the build-up of the systematic knowledge that we call science. It is not surprising that science could not have really grown as it has should not patterns exist in nature. In fact, science grows by continuously feeding on the patterns identified in nature.

It is easy to recognize that since patterns are an important raw material for its