2.8 The International Flow of Scientific Manpower

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The problem of the 'brain drain' and its effect on economic development in the Third World are well known; planners can plan but they cannot implement without adequate skilled manpower. The aim of this paper is to point out that a potentially massive shortfall of scientists, technicians and engineers in the USA, caused in part by the 'swing from science', could greatly increase both the magnitude of the 'brain drain' from the Third World and the pressures on their governments to find appropriate solutions.

The 'Brain Drain' and the Shortage of Skills in the Third World

In the 1960s two events served to heighten interest in the 'brain drain'. First, the coining of the phrase 'brain drain', originally used in a 1962 Royal Society report to describe the migration of British scientists and engineers to the USA, helped to focus attention to the problem; it was later applied to the migration of skilled manpower in general and from developing countries in particular. Secondly, significant changes occurred in the immigration policies of the major receiving countries (USA, Canada, Australia), eliminating ethnic discrimination and giving priority to highly skilled workers; this triggered a serious loss of skilled scientists, engineers and medics from most Third World countries, which has continued ever since.

The phrase 'brain overflow' was subsequently introduced to emphasise that at least part of the problem was due to a surplus of trained manpower over available jobs in the giving country and the phrase 'reverse technology transfer' to emphasise the serious economic consequences due to loss, both of the resources invested in education and training, and of the potential contribution of trained manpower to the national economy. UNCTAD has found (1) that some developing countries were losing 20-70% of their annual output of doctors and has calculated (2) that in 1970 the value of the incoming scientists, engineers and doctors to the USA was equal to $3.7 billion compared to outgoing development assistance of $3.1 billion, while India's Centre for Research, Planning and Action calculated (3) that the capital value of the transfer of highly qualified people from India during the period 1970-85 was ca $51 billion to the USA, $13 billion to Canada and $2.8 billion to the UK. On the other hand, remittances can be substantial (equal to 15% of India's total exports in 1977 (4)) and expatriates can provide the manpower with the further experience needed (as in Taiwan) when economic development reaches a certain stage. The brain drain can be used to reproach either the developed countries for taking away with one hand what they give with the other or the developing countries for paying insufficient attention to the problems of population growth, job creation and human rights.

Much was written and debated about the brain drain in the 1960s and early 1970s, but relatively little in the 1980s. The recently published conference proceedings entitled 'The Impact of International Migration on Developing Countries' (5) includes several good surveys of the brain drain. Its causes ('push' from developing and 'pull' from developed countries, moderated by passport requirements and immigration laws respectively) and different aspects (economic, ideological, human rights) have been analysed and solutions proposed; the issues are complex. A Sri Lankan cabinet committee investigating the causes of its country's brain drain has listed the main **push** factors as high rate of unemployment, lack of opportunity, low salary, lack of recognition, lack of technical support and equipment, low status and limited participation in decision-making and the main **pull** factors as opportunities for intellectual contact, shortages of manpower and higher standards of living (6). Solutions could include both reform of the education system (to provide skills more relevant to the needs of the country, perhaps also less marketable in developed countries) and better working conditions (salaries, incentives, promotion; facilities, equipment, contact with colleagues; closer involvement in national decision-making) (4,7), but little effective action appears to have been taken. Suggestions for some form of financial compensation of giving countries by receiving countries have frequently been discussed, but never agreed (8). 'The great challenge is to find appropriate solutions for mitigating the negative effects of the brain drain for developing countries, which takes into account the interests of all parties as well as the basic right of human beings to move freely' [8].

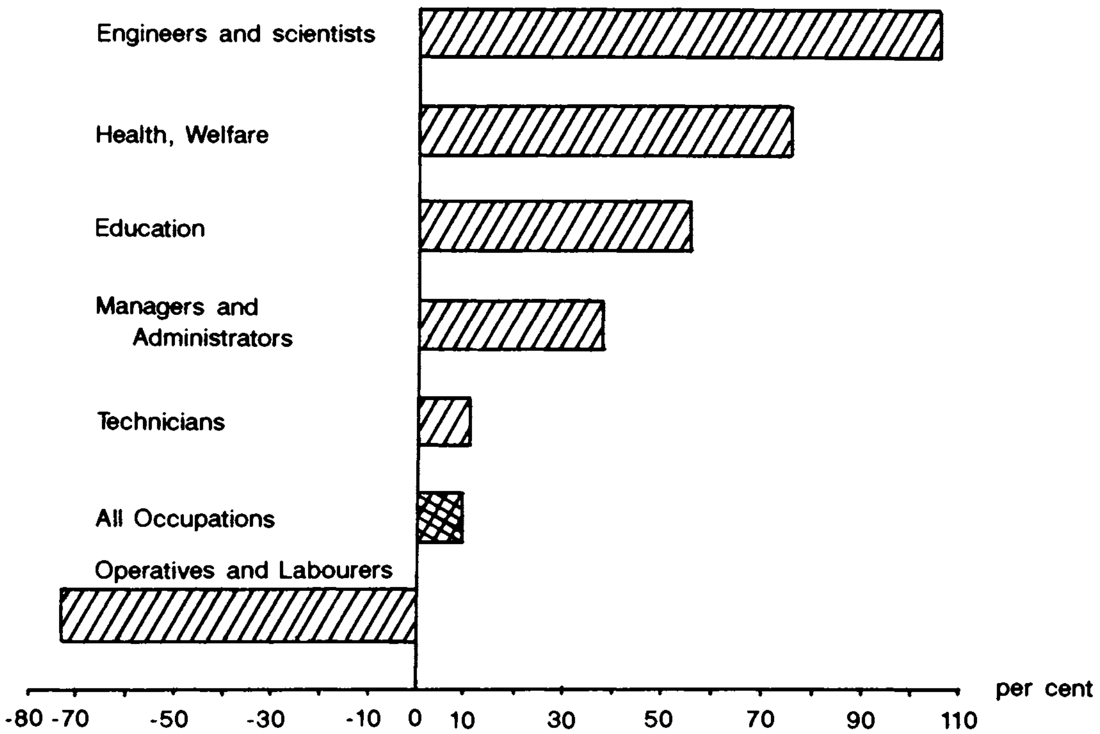
The 'Swing from Science' and the Shortage of Skills in the USA

Both the USA and the UK will see an increasing gap between the demand for, and home production of, STEM (science, technology, engineering, medicine) manpower, all of which depend on school science and mathematics, for three reasons:

1. The **changing skill requirements** of an increasingly affluent and ageing society (see figures 1and 2). Projecting future requirements is fraught with difficulty and the results must be treated with caution. For both countries, however,similar marked increases are predicted for STEM manpower with the interesting difference of an apparently much lower demand for technicians in the UK; this reflects the current under-supply of technicians, acknowledged to be a weakness in the UK economy.

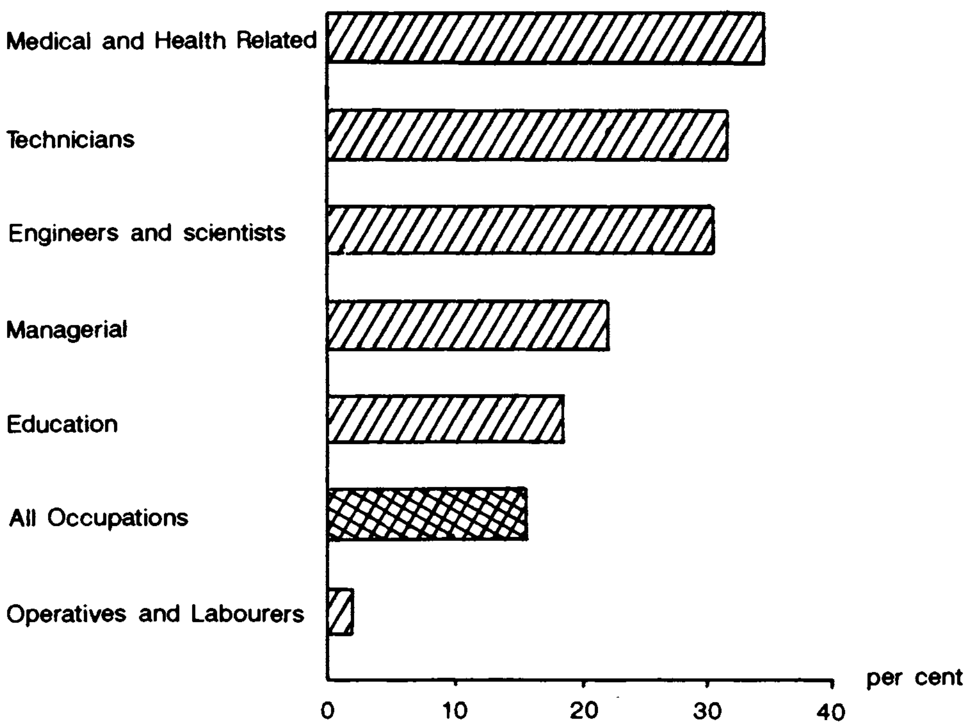
2. **Demographic Trends.** The physical sciences are intrinsically difficult subjects taken by students of high academic ability, as shown by their IQ scores and relative examination performance (9); it is likely that only a small proportion of any population will be able and willing to pursue them to a high level. This means that the supply of physical scientists and, by extension, of engineers is likely to be more closely related to demographic trends than graduates in other fields. Figure 3 shows how changes in the number of schoolchildren taking A-level exams in physics shadows changes in the total population of 18-year olds in the UK; the relatively faster fall in the number of A-level physics entries since 1982 can be ascribed to the swing from science at the school level. Since developed countries tend to have lower birth rates (see Table 1), demographic trends alone will tend to produce relative shortages of STEM manpower in the developed countries and surpluses in the developing countries.

Figure 1. UK Projected Occupational Change 1971-95



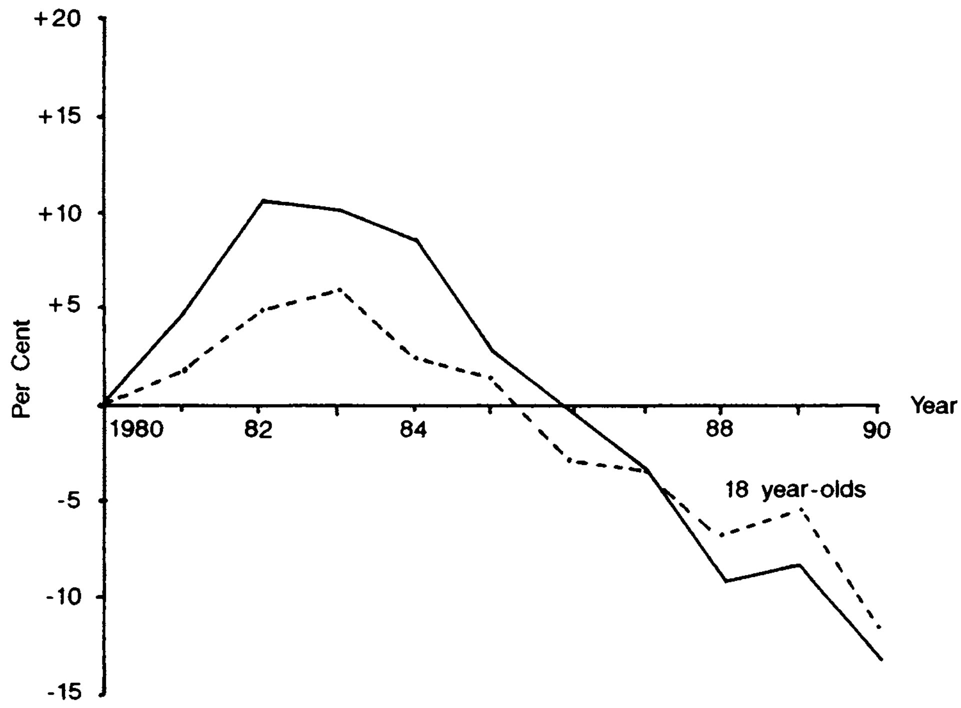
Source: Institute of Employment Research, University of Warwick (1989)

Figure 2. US Projected Occupational Change 1988-2000



Source: US Bureau of Labor (1989)

Figure 3. A-Level Physics Entries in England and Wales in Relation to the 18 Year-Old Population



Source: Smithers (1991) Physics World, 4, *4, 26-31*

Table 1. Population Trends, 1987

Country	Population (millions)	Annual Growth Rate (%)	Median Age in 2000
Nigeria	101.8	3.4	15.5
Malaysia	13.2	2.7	
Bangladesh	103.0	2.4	
India	788.0	2.2	25.4
Australia	16.2	1.3	
Canada	25.9	1.2	
USA	244.1	1.0	30.0
UK	56.7	0.1	34.6

Source: OECD Demographic Yearbook (1989) and Hobbs in 'Exploring the Future: Trends and Discontinuities', Royal Institute of International Affairs, London (1989).

3. The **'Swing from Science'.** Table 2 shows the changes in the preferred university subjects among school-leavers in the UK; many of those who would previously have studied science or engineering now go into business administration or accountancy. Figure 4 shows similar trends for the USA. A recent study at one USA University (Purdue) showed a further serious swing away from science even after enrolment with only 15 of the 97 chemistry freshmen still on the course after 2 years; the major new preference was management sciences but, because those programmes were already full, most enrolled for liberal arts, biology and health sciences (10). It is often assumed that the 'swing from science' is due to association of eg. chemistry with pollution and physics with atomic bombs in the public mind but at least one study (11) has shown that, for the brighter science educated school leavers who might have become science PhDs, factors such as career prospects and the image of the profession are far more important.

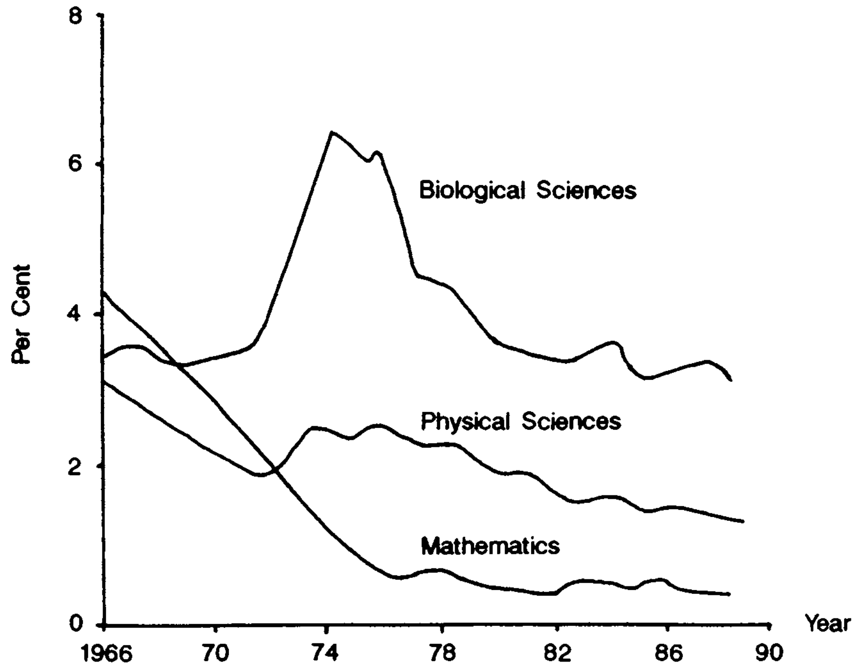
Table 2. University Admissions in UK, 1988

Subject	Applications	Acceptances	Ratio of applications to acceptances	Change in applications 1985-88 (Per Cent)
Biological Sciences	9727	5877	1.7	0.3
Physical Sciences	9118	7153	1.3	- 7.8
Mathematical Sciences	8218	5694	1.4	- 2.6
Engineering and Technology	14274	9466	1.5	- 18.5
Business and Administration	13741	3922	3.5	18.1
Social Sciences	27952	11705	2.4	11.9
All subjects	156981	80496	2.0	- 0.1

N.B. Home students only

Source: Universities Central Council on Admissions

Figure 4. First Year Higher Education Students in the US



Source: Wingspread, 10, *4*, *1*

The production of PhDs in natural sciences and engineering (NSE) has long lead-times and shows a pronounced funnelling effect; see the USA data in Table 3. This is only part of the story because foreign students form an increasingly large proportion of the total PhDs awarded in the USA, accounting for ca 25% of the combined NSE output. In his Presidential Address to the American Association for the Advancement of Science in 1990, Atkinson compared the likely supply and demand for NSE PhDs in the US in the year 2010 (12). He assumed an ouput of 11,250 PhDs (which included 50% of the foreign-born PhDs) available for the home market and compared this with four increasing estimates of demand, starting with the 1988 level of demand (leading to a shortfall of 960), then successively adding in the effects of earlier retirements, expansion in higher education (hence increased demand for staff with PhDs) and increased levels of R and D activity (shortfall of 9600) ie. the shortfall in NSE PhDs in the USA could be anything between 1000 and 10,000 per year.

Table 3. US National Sciences and Engineering Pipeline

Year	Stage	Number	%
1977	High School Sophomores	4,000,000	100.0
1977	High School Sophomores Interested in NSE	730,000	18.3
1979	High School Seniors Interested in NSE	590,000	14.8
1980	College Freshman Planning NSE Degrees	340,000	8.5
1984	BS Degrees	206,000	5.2
1984	Graduate Students, NSE	61,000	1.5
1984	MS Degrees	46,000	1.2
1992	PhDs, NSE	9,700	0.2

Source: National Science Foundation

In considering how this gap might be bridged, the USA has looked towards those groups currently under-represented among PhD recipients (women, blacks, hispanics) but is increasingly coming to view the foreign entrant as the only realistic solution. The extent of immigration into any country is controlled by its immigration laws and these tend to be adjusted in relation to policy and economic need. The idea of a 'green card (ie. permit for permanent residence) on graduation' has been put forward in the USA and similar suggestions made in Canada. Third World countries (and others!) should keep an eye open for changes in the USA immigration laws.

Summary

Developing countries and donor agencies cannot expect a proper return from investments in science and technology, or even from aid in general, until the problem of the brain drain is reduced. The impending shortfall in STEM manpower in North America will (unless filled from, say, Eastern Europe) greatly increase the problem and the need to find solutions. In most countries there is probably scope for re-examining both the production (ie. the education system) and the use (ie. working conditions) of this skilled manpower. The recent changes in attitude of the donor agencies, giving priority to science and technology and placing more emphasis on institution-building, could help to bring scientists and others more into the decision-making process, thereby gaining both their advice and their commitment; the absence of such mechanisms appears to be a common weakness of the present situation.

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