Science, Technology & Society

An International Journal
Devoted to
the Developing World

v°12 n°2
July - December 1997

ISSN: 0971-7218

Science, Technology & Society

An International Journal Devoted to the Developing World

Published biannually in March and September, ***Science, Technology & Society*** is a journal of the Society for the Promotion of S & T Studies.

Subscription: Regular ***institutional*** rate Rs 350 £56 $80. ***Individuals*** may subscribe at a one year rate of Rs 195 £27 $36. Single copy Rs 200 (institutions), Rs 115 (individuals). *Inquiries and subscriptions from the Americas* should be sent to Sage Publications Inc, 2455 Teller Road, Thousand Oaks, California 91320. *From the UK, Europe, the Middle East and Africa* write to Sage Publications Ltd, 6 Bonhill Street, London EC2A 4PU, England. Other orders should be sent to the New Delhi office.

Inquiries/Correspondence: Address all permission requests and related matters to Sage Publications India Pvt Ltd, 32 M-Block Market, Greater Kailash I, New Delhi 110 048, India. Articles submitted for publication should be sent directly to the Editorial office of the journal (see inside back cover for full details).

Advertising: Current rates and specifications may be obtained by writing to the New Delhi office (address above).

Claims: Claims for undelivered copies may be made no later than three months following the month of publication. The publisher will supply missing copies when losses have been sustained in transit and when the reserve stock will permit.

Change of Address: Four weeks' advance notice must be given when notifying change of address. Please send the old address label to ensure proper identification. Please specify the name of the journal.

Sage Publications India Pvt Ltd
32 M-Block Market, Greater Kailash I
New Delhi 110 048

Sage Publications Inc
2455 Teller Road
Thousand Oaks, California 91320

Sage Publications Ltd
6 Bonhill Street
London EC2A 4 PU

Science, Technology & Society

Volume 2 Number 2 July–December 1997
Special Issue: International Mobility of Brains in Science and Technology
Guest Editor: JACQUES GAILLARD

CONTENTS

Science, Technology & Society

This journal is partially supported by ORSTOM, Maison des Sciences de l'Hommes (Paris), CSIR/NISTADS and the Department of Science and Technology (New Delhi).

This journal is abstracted in **Sociological Abstracts**

EDITORIAL

WHEN WE LOOK back at the post-war efforts of the developing countries, the problem of brain drain in science and technology emerges as one of the most crucial issues facing the developing world. The migration of scientific and technical personnel from the developing to the developed countries was not solely due to economic and material reasons. Steven Dedijer, Abdus Salam and M.G.K. Menon, to name some important personalities, recurrently drew our attention to the problem of isolation of scientists and the lack of appropriate social and professional climate for the constitution of scientific communities from the mid-1960s. The case of Latin American countries was compounded by the political situation in those countries. As various contributions to this special issue show, the experience of Latin American countries has been quite different from that of Asian and African countries. Even though the phenomenon of brain drain still remains a major problem in several countries, the developing countries no longer 'sail in the same boat'. The social and economic progress made by countries such as South Korea and the relative growth of scientific communities in countries like India demonstrate varying experiences of brain drain and brain gain. Despite the magnitude of the problem of managing intellectual human resources, the issues of brain drain and brain gain did not attract the attention of scholars and policy makers they deserved over the years with the possible exception of countries like South Korea. This special issue deals with some of these issues and presents country reports from different social science perspectives. Given the limitations of dealing with so vast a subject as the international mobility of brains in a single issue of a journal, we were constrained by time and space to incorporate the perspectives, themes and country experiences in any exhaustive manner. This, indeed, leaves scope for further examination.

We are grateful to our Collaborating Editor, Dr Jacques Gaillard (and Dr Anne Marie Gaillard for the introduction) who was involved in this special issue on the international mobility of brains. We are also grateful to Dr Jean-Baptiste Meyer, Jorge Charum, Jose Granes, Luz Stella Parrado and other friends at the National

University of Colombia and Cuidad Universitaria, Bogotá, Colombia, who were instrumental in the origin of this special issue.

As mentioned in our earlier issues, this journal is striving to become a truly international journal devoted to the exploration and understanding of the interaction between science, technology and society in the developing world. We are conscious of the fact that the book review section needs to be enlarged in its scope and efforts are being made towards this end. The editors will be happy to receive comments and suggestions from the readers of this journal and other scholars.

VVK & RW

ARTICLES

Introduction: The International Mobility of Brains: Exodus or Circulation?

JACQUES GAILLARD and ANNE MARIE GAILLARD

THE MOVEMENT OF scientists and scholars throughout the world is as old as science itself. From the very beginning science has been built up through the circulation of men and ideas. In the late 1960s and the early 1970s, however, this mobility applied increasingly and more massively to the developing countries. Embedded in an ideology of Third Worldism that gave it the aura of a problem, it soon became the subject of many impassioned discussions, and it was addressed in numerous studies.[1] Thus, *brain drain* as a term came to be used regularly to condemn the flight of good minds from the developing countries to the rich countries, and as a one-way phenomenon, because it often hastily combined and confused the notion of loss conveyed in the term *drain* with the migration of educated and professional people. In this context, the United Nations defined the term *brain drain* as a one-way movement, or an exodus, that only covered migratory flows from the South to the North, from the developing to the developed countries, and only benefited the industrialised countries.[2]

Jacques Gaillard is a senior scientist at the Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM), LSSD, 32 avenue Henri Varagnat, 93143 Bondy Cedex, France.
Anne Marie Gaillard is a social anthropologist specialist in international migration studies, 17 allée des Coteaux Briards, 91800 BRUNOY, France.

Science, Technology & Society 2 : 2 (1997)
SAGE PUBLICATIONS NEW DELHI/THOUSAND OAKS/LONDON

During the late 1970s and the early 1980s, although *brain drain* continued to affect a large number of developing countries (for India see Krishna and Khadria in this issue), the theme stimulated relatively less political and academic interest. The various attempts by international circles to formulate policies to stem the brain drain from the South or to devise compensation mechanisms failed and faded into a sort of lassitude. Since the late 1980s and the early 1990s, however, the subject is emerging again because of changes in international scientific migrations, marked by a *brain return* to an increasing number of Asian and Latin American countries (cf. Song; Barreiro and Velho; Kreimer in this issue). Along with this phenomenon, there have been new flows of well educated scientific and technical minds as a result of the recent upheavals in the scientific and technical systems in the erstwhile USSR and the countries of Eastern Europe (cf. Kitova and Kouznetsova in this issue). This is also taking place in a context of increasing globalisation of scientific activity, changing trends in scientific and technological policies,[3] and development of new information and communications systems. As a result, renewed or new modes of scientific collaboration are developing which do not necessarily require the translocation of people. As far as international scientific migration is concerned, in the late 1980s and the early 1990s this led to the quasi-simultaneous development in a number of countries of networking organisations aimed at the remote mobilisation of the country's expatriate scientists and technologists and their reconnection with the national scientific community at home (cf. Meyer et al.; Kaplan in this issue).

The term *brain drain* has dominated the discussion on international scientific migration for several decades. This is partly because the term is a catchy allusion to the phenomenon it sought to illustrate. It also gained recognition in the context of what was perceived as a 'politically correct' battle based on solidarity, with a train of values it would not be proper to oppose. This explains why *brain drain* is, and always was, a concept often used in the newspapers and in articles for the lay reader. Yet, it has been contested by a number of scientists for being a concept that encourages a wrong way of thinking or even a concept that has been totally spent.[4] But many of these critics implicitly consider *brain drain* in accordance with the restrictive definition once given by the United Nations.

The difficulty is that brain drain can hardly be restricted to a univocal concept. It seeks to encompass a multifaceted phenomenon. It is actually a loaded term that conveys a large number of explicit and implicit connotations. Consequently, its definition cannot be hard and fast. It is all too often used to describe or analyse migratory phenomena that are dissimilar. A retrospective examination of the successive uses of a variety of expressions such as *brain drain, brain gain,*[5] *brain overflow,*[6] *reverse transfer of technology,*[7] *brain waste,*[8] *transit brain drain or delayed return*[9] *brain return, skilled/professional transients,*[10] *brain mobility,*[11] *back and forth or pendulum migration*[12]—only to mention a few of the expressions in the halo of the archetypal *brain drain*—is indicative of the diversity of the phenomena and the emergence of new orientations.

Using the word *brain* as a generic term, moreover, is offensively simplistic. The term refers to different phenomena, depending on whether the mind is being trained[13] or has already been trained, on the nature and type of such training, and on the location and profession involved. The term is becoming so versatile that less and less *brainpower* is involved (in the sense understood in intellectual and scientific professions). The word 'brain' may refer to any professional person whose qualifications are in short supply in his home country. In studies and documents the term may mean a medley of craftsmen, skilled labourers or other qualified staff.[14] Finally, the term *brain drain* is used just as well to describe the migration of students, intellectuals, scientists and technologists from a home country to a foreign country (external *brain drain*) and to describe the migration of scientific and technical personnel into non-scientific sectors within the home country (internal *brain drain*).[15]

In the 1960s and 1970s *brain drain* was considered as the worst of all evils;[16] and this perception has changed since then. Substitute words such as 'mobility', 'exchange' and 'circulation' are readily used. The 'mobility of brains' is also increasingly understood as 'belonging to an international scientific community' in a context in which world science and the global economy are continuously shaping our societies.[17] Yet, a number of countries are typical cases with recurring *brain drain* problems and the term *brain drain* continues to be widely used today. It is used in many of the titles of

the papers appearing in this issue and the very idea of 'turning the *brain drain* into *brain gain*' or 'reversing the *brain drain into brain gain*' points to the reality of its permanence.

The papers in this issue are central to this ongoing debate. They partly cover the situation in countries on four continents, namely, Latin America, Asia, Africa and Europe, and one paper focuses on the situation in Russia, a country in transition. The geographic distribution of the studies presented here reflects the relative intensity with which scholarly work on scientific mobility is carried out in the world today, with a slight bias in favour of Latin America.[18] For Asia, there are two papers on India and South Korea, where, over the recent past, the issue of mobility of brains has evolved differently by adopting new forms and new directions. Other important countries are missing from this selection. The People's Republic of China (PRC), a country about which, over the last few years,[19] a lot has been written on subjects that are at the heart of this special issue is one of them. What is going to happen to the tens of thousands of Chinese students and scientists (located all over the world but mainly in the United States) who have been in a situation of *delayed return* since the Tiananmen Square event (Pedersen 1993)? Should they be classified under 'exodus' or under 'circulation'? Countries of Africa, except for South Africa, are especially noteworthy because of their absence! Although greatly affected by brain drain,[20] during the last forty years, this is the continent where the least academic work has been carried out on the subject.[21]

Before locating the position of each of the following articles in the problem-oriented approach proposed here and in the context of new, emerging prospects, we would like to take a step back in time to look at the reality and the permanency of the phenomenon and how it developed through the ages. We also want to consider the semantic evolution of the term *brain drain* and the controversial viewpoints surrounding it.

The Historical 'Itinerance' of Science

The circulation and mobility of scientists and scholars throughout the ages has been so permanent that it may be viewed as a socio-anthropological, even a universal phenomenon. Of the sixty most

eminent scholars of Ancient Greece, forty-five left their native land for the road to wisdom, learning and research (Granberg 1967, 1969). Some returned, while others continued their travels or established schools far from their homeland, like Pythagoras (c. 570 BC) who ended his travels around the Mediterranean and Asia Minor when he established a philosophical school in Italy.

Various models based on the 'circulation' of scholars and scientists have existed since time immemorial. At the height of its period of glory, the city of Alexandria welcomed hundreds of scientists and scholars from the Hellenistic world (Parsons 1952) who, according to history, were attracted to the immense research opportunities offered by the museum, and also by the gold of the Ptolemaic rulers. Another example of mobility in Antic times: of all the known Lycée directors in Athens between the fourth century BC and the beginning of the third century AD, one was born in Athens (Dedijer 1968). The Arab science that flourished between the eighth and the tenth century in Baghdad was also the fruit of intellectual migrations, thanks to the Nestorian scholars who came and transmitted the Hellenic culture. When Emperor Justinian compelled these scholars of the Academy of Athens to leave, they regrouped east of Persia, at the invitation of the king of Jundishapur, and laid the basis for what was to become Arab science (Benoit and Micheau 1989).

Medieval universities were also instances of geographic mobility, because in the beginning many of them were itinerant. Furthermore, the teachers and the students, who originally came from many different regions and countries of Europe, settled in a city for a few years and then moved elsewhere. In Bologna in 1265, for instance, students from the Italian provinces, were joined by students from fourteen other 'nations'; there were the French from Ile de France, Spaniards, English, Picards, Burgundians, Norman-French, Catalonians, Hungarians, Poles, Germans and people from Gascony, Provence, Poitou, and Touraine (Kibre 1948).

What happened to these 'migrating' students and scholars? Most likely many of them returned home upon completion of their studies and shared their knowledge with other people around them (if one can ever be a 'prophet' among peers), thereby elevating the level and the living conditions of their people. In this case, there was no *brain drain*, and the period of migration was undoubtedly seen as a 'gain' since it provided access to some of the benefits of

science. This was the justification (and still is) for the large-scale migration of students from the Third World to universities of the North, as long as these students returned to their home country after completing their studies.

These migrants also include a good number of scholars who spend their life travelling or who settle in academic centres far from their birthplace. When this happens, they sometimes use their skills for work and occupations that do not require their total scientific knowledge, their capacity which is so urgently needed in their home countries. Does not this qualify as an example of *brain drain*? But who could predict their non-return?

Among these migrants, there were also scholars whose formidable potential for teaching and caring for people in their immediate environment would have been lost if they had not been able to enter the sanctuaries of science and knowledge. It was thanks to their itinerant existence that their wisdom could serve all of humankind. Consider Avicenna, whose medical and pharmaceutical work was utilised in Europe until the seventeenth century, and compare the benefit that it would have brought to his immediate surroundings with the benefit it brought to all of humanity. In this case, the term *brain drain* is inappropriate because his migration meant a far-reaching, global gain for humanity.

Mobility was thus a precondition to scientific creation and to the dissemination of knowledge. It was at the convergence point of the wisdom lover's need for movement in search for knowledge and the external call from enlightened patrons who provided appointments and real arenas for science. For the noble quest of the itinerant scholars were not without personal interest, making prestige, social mobility, comfort and money the frequent corollary of their migration. The understanding of this polarised migratory dynamic—individual need on the one hand and external enticement on the other—made up the real foundation of scientific policies formulated by the authorities who, early in history, used science to enhance their power and prestige.

There is no doubt that scientific migration in historical times was a combination of the individual's determination to seek greater wisdom, and determined scientific policies. As Dedijer (1968: 28) wrote: 'primarily those people in power who had a high degree of appreciation of the social value of science of their time had such policies'. Further, had the scholars not had the urge to travel and

had people in power not been determined to attract them,[22] scientific mobility would not have been as widespread as it always was, 'because intellectual movement, directly or indirectly, depends on the "favour of the prince". Science is never gratuitous. Without financial backing, there can be no new library or hospital, no translations, no observation programmes' (Benoit and Micheau 1989: 157–58).

The historical migration of the early scholars sowed the seeds of the animated discussions on *brain drain* that began in the 1960s and contributed to its semantic development.

The Semantic Slippage of 'Brain Drain'[23]

International scientific mobility, as a phenomenon, grew following the rise of Nazism, and even more so immediately after the Second World War, when a considerable number of intellectuals and scientists left Europe which lay in ruins to try their luck in North America, mainly in the United States.[24] In 1963, a document of the Royal Society used the term 'brain drain' in this context to describe the migration of British intellectuals and scientists to the United States.[25] According to Johnson (1965), the purpose was to highlight the loss of trained personnel (especially scientists and doctors) who left the United Kingdom to take up attractive positions in research in the United States. The notion of 'brain drain', at that time, meant loss of trained minds to the pull of a foreign market. Furthermore, because of similarity in training, language and experience, the British 'brain' was almost immediately operational in the American scientific world, which was becoming increasingly powerful partly due to skills 'flowing in' from Britain (Hoch and Platt 1992). In that particular case the image of immediate drainage and the use of brains that have migrated from one environment to another is relevant.

The same expression was used to describe the case of 'brains' who migrated from the developing countries to the developed ones, but the situation was somewhat different as most of these 'brains' left home to study, and therefore were not yet trained in research at the time of their departure (Gaillard 1991). The loss of a qualified person is due to the non-return of the student, who after completing his studies, becomes a scientist, and decides to

remain abroad, usually in the country where he studied. Even if most of them had the intention of returning home,[26] few of them did.[27] Estimates indicate that close to a million students and scientists during the last forty years stayed in—or emigrated to—the United States or Europe after completing their studies (Kallen 1994).

Within the framework of economic analyses ensconced in the ideology of Third Worldism, the concept takes a different turn, but nonetheless retains the notion of 'economic drainage', which is attached to the concept of pillage of the South (Amuzegar 1968). The word 'drain' has retained its economic connotation, but the word 'brain' has become multifarious. The word 'brain' refers increasingly to a 'brain to be trained' rather than to a 'trained brain'. At the same time, it is less 'brainy', so to speak, since it no longer only refers to the intellectual and scientific profession, and the emphasis is shifted to the 'drain' part of the 'brain drain'. Hence the term no longer defines a specific migration, that is, the movement of scientific or intellectual minds, but rather a phenomenon that occurs through immigration, and connotes a country's real or potential loss of professional skills at all levels. Despite the shift in meaning, the question of scientific migration (of both trained and trainable minds) remains central to the debate.

The recent wave of scientists and engineers migrating from the erstwhile Soviet Union and the countries of Central and Eastern Europe to the Western countries,[28] is a phenomenon somewhat comparable to what occurred when European, especially British, scientists went to the United States. These scientists are well experienced when they leave their home countries, unlike many of the scientists from the developing countries. As was (still is) the case among scientists from Western Europe, they often migrated because their home research system was unable to fully support their research activities. We are back to the initial definition of the term *brain drain* meaning exodus of trained *brains*. The question of whether the latter migration is an exodus without return remains to be answered and will be discussed later.

The Ideological Controversy: Countervailing Economic Postulates

Is international migration of minds synonymous to 'exodus', in other words, a country's loss due to migration? Or, does it contribute to the international circulation of knowledge, which should benefit all? This question has stoked many animated discussions. Some analysts refuse to analyse the migration of the professional elite using the paradigm inspired by the neocolonial approach. Their position is that these migrations will continue to benefit their home country because money is 'sent home', because migrants influence the policies of their country of residence, that is, make them more favourable to their country of origin,[29] and because high level expatriates contribute to the development of their home country through technology transfers (even when they themselves do not return home) (Grubel 1966; Grubel and Scott 1966; Johnson 1967, 1968). This is the beginning of what has been called the 'brain drain controversy' (Das 1971) where the internationalist and nationalist streams of thought, each with its own economic perspective, clash (Adams 1968; Kindleberger 1977). According to the former, the migration of brainpower to the countries of the North is a normal phenomenon in a global market, because that is where wages and productivity are optimal. Furthermore, according to this approach, migration is of equal benefit to the South and the North.[30] The 'nationalists' buttress their thesis on two postulates: (*a*) in an international economy, expertise is not evenly distributed—the North benefits from what is cruelly wanting in the South, and (*b*) these migratory movements are artificial because they constitute a response to a selective migratory policy of the 'importing' country whose immediate goal is profit (Amuzegar 1968).

The 'nationalist' thesis was adopted as the basis for international policies, in particular within the United Nations. Governments and international organisations were urged to compile information on the scope of the problem in order to prepare their position (Grubel 1976). In 1974, this gave rise to the UNCTAD term, 'reverse transfer of technology' (UNCTAD 1974) which clearly locates the problem within international cooperation policies. According to this analytical model, derived from the 'nationalist' theories on brain drain, the migration of the elite from the countries of the South, 'reinjects' in the industrialised countries the benefits

of aid that they originally granted to the South. This laid the basis of the ambiguous concept of 'reverse transfer of technology'. The goal then becomes to calculate the 'loss' and to find some way of preventing or offsetting it.

The Impossible Quest for Compensation

The first so-called preventive measures were designed to stimulate the 'exporting' countries to create a political, economic, scientific and social environment that could stem the flight of good minds (Baldwin 1970; Zahlan 1977). Restrictive measures were also introduced. Some countries of the South introduced emigration regulations, and at the same time, the intake countries of the North adopted immigration regulations that abolished the earlier incentives offered to the elite of the South (Böhning 1977). The other proposals which called for measures of restitution were also recommended. They entailed the return of trained professionals (the country of training was to encourage the temporary—not definite—emigration of these intellectuals), and a compensation system designed to replace any emigrating specialist from the South through technical assistance from the North to the South. The most well-known measure was taxation (Bhagwati 1976; Bhagwati and Dellalfar 1973), which advocated for a levy of tax on the income of professional immigrants from the less developed countries (LDCs) into the DCs. The funds raised were supposed to be 'routed to the United Nations for disbursement in LDCs for their development programmes' (Bhagwati 1976: 3).

These measures were doomed to fail from the very beginning because the underlying theoretical approach was biased. They erroneously assumed that, on the one hand, all intellectual migrants left home for economical reasons which was not the case (Böhning 1982; Glaser and Habers 1978; Johnson 1965, 1968) and, on the other, that there was a 'correspondence between the migratory movement and the movement of capital, products, salaries, and prices' (Salomon 1973). Another bias was the difficulty in measuring the migration of the elite (unclear definition of the concept, no mechanism for observing their movement, unreliable and non-standardised available statistics). Departures were recorded to some extent, but the returns were not. Thus, the consequences of brain drain were grossly overestimated (Johnson 1965).

As a result, these measures did not produce the desired effects and, more often than not, were not applicable. The preventive measures were evolved on the most radical principles because their aim was to keep the elite in the home country by offering them attractive salaries and a stimulating professional environment. It was difficult to see them as transitional measures, since they stood out clearly as the principal goal. The prerequisite to implementing policies such as these was a level of economic, scientific and cultural development that ensured the *de facto* existence of conditions propitious to solving the problem of the high level brain drain (Keely 1985).

The restrictive measures were no more successful and were almost inapplicable. To ensure the success of these measures, the countries of origin would have had to seriously tighten their emigration rules. This would have meant establishing a police and control system that most of the states could not (nor wanted to[31]) impose. This would also have obliged the countries of destination to change their immigration policies, a prerogative of the states alone that depends on geopolitical, economic and social choices. Considering the present state of international relations, no country in the world would agree to alter its policy on incoming foreigners in response to an injunction or advice from international organisations. Measures of restitution were not effective either. Since they ultimately depended on individual migrations, every time a specialist from the South moved to the North, he would have been subjected to pressure to return home, or failing this, a specialist from the North would have had to fill the intellectual gap the migrant left in his country of origin. It is not difficult to understand that North-to-South cooperation policies are not built on this type of an issue; other geopolitical parameters are far more important. In short, these measures were a fiasco. Compensation measures (mainly taxation) were to be organised via a new international fund to help develop the countries of origin. The idea was to reimburse the training cost of each non-returning trained emigrant and the potential skill loss that occurred in such situations. These measures proved practically impossible to apply because of problems with the statistical design and the collection systems (Mundende 1989). The 'tax' option and the concept of 'reverse transfer of technology' died a natural death (UNCTAD 1987), following endless discussions and numerous studies between 1973, when the idea was proposed, and 1987, when it was dropped.

The Sociological 'Career' of Brain Drain Studies

As the debate on solutions to the brain drain phenomenon (based exclusively on a macro-economic approach) was progressing, another agency of the UN organisation, UNITAR (the United Nations Institute for Training and Research) began to look at the problem from a sociological angle. (The first publication of the UNITAR brain drain project appeared in 1970). This approach was fundamentally different from the economic approach, which kindled the controversy, and from the attempted remedies, but was not an altogether new way of analysing migration as a phenomenon.[32] Literature is abound with studies that use sociological approaches to the *brain drain* problem, albeit often to a lesser extent.

When Glaser and Habers (1978) published the results of a uniquely broad study (6,500 students investigated in eleven countries), some unexpected aspects of the brain drain phenomenon came to the fore. They became landmark references for years to come, for they showed, contrary to popular belief, that (*a*) students who stayed in their country of study upon completion of their courses nonetheless intended to return to their home country, (*b*) most of the students who had returned to their home country intended to stay there, and (*c*) it was not necessarily the brightest students who stayed back in the country of study. In other words, student migration, which had been one of the main issues under discussion, was not necessarily a real 'drain', because, if the hypothesis on the students' eventual return to the home country proved true (something that was not, however, established),[33] there would be no brain drain, just temporary migration. Furthermore, by using the sociological approach, UNITAR brought out the tremendous complexity of the migratory process and dynamics, and the infinite number of reasons for individuals and groups to emigrate, stay abroad and/or return home.[34]

This partly called into question the very notion of brain drain as postulated in economic analyses. Furthermore, through the study's geographic coverage, the authors showed that brain drain was not, and could not be, uniform since it resulted from a social reality that by definition was polymorphic because of its connections with the country's political, social, economic and cultural conditions.

The logical conclusion was that the way brain drain, as a phenomenon, was expressed, depended on the country and on the migration characteristics (nature, direction, number of people leaving). Going a step further, it seemed ill-found to advocate that global solutions, like earlier proposals based on a macro-economic approach, be applied to brain drain.

As mentioned earlier, the work done by the UNITAR team made it possible to understand the complexity of migration. In so doing, however, it did not challenge the basic idea of loss of expertise and talent for the country of origin, but gave it relative value. Actually, for students and professionals who intended to return home but did not, the loss became more than obvious. Thus, the converse was that returning home was the best remedy against brain drain. Gradually, the global economic measures that had been advocated to fight brain drain were replaced by national approaches that devised ad hoc solutions, for instance, return incentive policies (see Song, Barreiro and Velho in this issue). This led to a perception of elite migration (students and professionals) that rested on the earliest ideas on these migrations, that is, that they would favour the development of the South.

The shift away from strictly economic research did not mark the end of an economic approach to brain drain. But, this type of approach no longer enjoys the same resonance it formerly had in international organisations and fora. Moreover, brain drain, defined as a phenomenon that led to loss of human resources to the country of origin, moved away from the economic approach of the 1970s and 1980s, to embark on a new career in the 1990s, based on its original definition that viewed the migration of high level, trained scientists, researchers and technicians to foreign lands mainly as a response to a scientifico-politico-economic reality (cf. UNESCO/ROSTE 1994; Kitova and Kouznetsova in this issue).

International Mobility of Brains: Recent Trends and New Prospects

As mentioned earlier, the end of the Cold War and the opening of the borders of the former USSR released new waves of well-educated scientists and technicians. The numbers and consequences are difficult to assess. Several other 'waves', that have different

forms, directions and magnitudes, are appearing and moving on the horizon. The end of apartheid in South Africa may not only attract African scientists from the neighbouring countries, but also from Nigeria, Kenya, and French-speaking West Africa. The case of the People's Republic of China (PRC), which did not perceive the importance of brain drain until the uprising at Tiananmen Square, is very different. As of the mid-1980s, migratory flows have been limited essentially to students (Orleans 1988) who decided to stay in the country of study, generally the United States, after graduating (Zweig and Chen 1995).

Russia and the PRC[35] have been used as examples to answer the question raised at the beginning of this paper, that is, is this 'exodus' or 'circulation'. Using other case studies presented here, we will address the reality of the returns, the conditions in which they occur, and their potential impact on the structure and strength of the national scientific communities. Finally, we will discuss the extent to which expatriated scientists can be reconnected to their national scientific communities, and scientific activities in the home country can be strengthened by the establishment of S&T diaspora which participate in the international circulation of people and ideas.

One Way Migratory Movement or Circulation?

The paper by Kitova and Kouznetsova shows that Russian scientists abandoned their field of excellence and, in many cases, joined other sectors of the Russian economy mainly because of the cut-back in research facilities and funds, the deterioration of scientific equipment and working conditions, and the cut in wages. Between 1990 and 1995, for instance, the size of the Russian S&T staff decreased from about one million to 500,000. Besides the enormous slash in the research budget, further aggravated by the fact that the Russian government did not fulfil its financial commitments, and that professional working conditions deteriorated, there is another reason why the national research system collapsed, namely, inadequate demand for Russian scien Before 1990, the state was the main client and (often artificially) created demand. Demand from industry and from public institutions declined substantially because of the overall 'climate', which was not very favourable for research investments. Both the international experts and the Russian

government recognise the need to reduce the previously oversized national scientific/technical system and the need to reorient and restructure major parts of research, in particular those parts that are under the military-industrial complex of the former USSR.

Kitova and Kouznetsova also demonstrated that the recent mobility of Russian researchers was a polymorphic phenomenon that often eludes analysis. The exodus to foreign lands, seen as a phenomenon, is difficult to assess because it generally entails a mixture of real, permanent emigration, short periods of time abroad, and potential departures. Many exaggerated evaluations have been made not only by Russia (probably in an effort to sway the Western donor countries favourably), but also by Europe and the United States as a reaction of alarm at the thought of having to take in tens of thousands of Russian scientists and techologists, together with a wave of nuclear specialists who might otherwise defect to sensitive countries like Iran or Iraq.

Many recent surveys and studies indicate that a large number of Russian students and scientists, especially in the basic and applied sciences, intend to emigrate, but the actual number of departures varies considerably from one assessment to the next. According to Kitova and Kouznetsova, these (direct and contractual) departures only account for 3.5 per cent to 4.5 per cent of the total number of people leaving the Russian national research system. This shows that the internal exodus (which usually means that the scientist leaves his professional field) constitutes the largest part of this migratory movement. The question of whether the external exodus is a 'one way brain drain', as Kitova and Kouznetsova suggest, has yet not been settled, even though the Russian scientific community generally thinks so. Nevertheless, leaving Russia today does not have the same significance as it did a few years ago. It is not automatically considered as exile with no hope of return, and 'the right to return changes the very notion of departure' (de Tinguy 1995: 101). On this particular point, the difference of opinion between Russian and other observers is noteworthy. According to Kortunov (1992), out of the 500 high level scientists and academics from the Academy of Sciences who left Russia between 1989 and 1991, only around 100 intended to return at the end of their contract period abroad.[36] Two surveys conducted in France in the autumn of 1992 showed that out of 88 nationals from the former USSR (50 scientists and 38 students) presently in France, only a

minority wanted to stay in France or in another foreign country (de Tinguy 1994). Another survey carried out in 1993 revealed a significant increase in the number of people in this group who wanted to spend several years in France (de Tinguy 1995). Most of them expressed their desire to return to their country, but wanted to come and work in the West at regular intervals; this pattern fits into the model of pendular migration. Many people in the West (Morokvasic 1996b) believe that for Russia, the opening of borders and emigration of the country's scientists is both a risk and an opportunity; there is a risk of losing highly qualified scientists who will be beneficial to the West, and, conversely, there is an opportunity for these scientists to help their country reconnect with mainstream science and catch up in fields where it is lagging behind. Although the exodus is not generally perceived as a permanent loss, there are so far very few reports that clearly reveal the reality of circulation.[37]

As for the PRC, it is estimated that between 1978 and 1994, 230,000 Chinese students and scientists left the country to study abroad.[38] 1978 was the year of the policy for reform and greater openness, which considered studies abroad as a decisive factor in modernising the Chinese society. In the beginning, these flows largely comprised qualified scientists and academics (visiting scholars) from various leading research institutes whose aim was to keep abreast of the latest scientific developments in their specialised fields. Since the mid-1980s, however, when foreign countries and international organisations offered more aid programmes, and the Chinese emigration policy became liberal enough to allow students to go abroad if they could self-finance their studies, the composition of this migratory flow changed to include essentially students, regardless of level (Orleans 1988). In 1984, the United States, the main intake country, began to grant visas to the students' spouses. As a consequence, the number of departures rose very substantially.

These changes in student flows (ages and academic levels) also triggered off a change in attitudes toward returning home. The first migrants could not even conceive of settling in the country of study; since the mid-1980s, however, things have changed and many expatriate students decided to stay on after completing their studies. Only in 1987 did China truly realise that its students were not returning home. As a result of the 'anti-bourgeois liberalisation' campaign launched by Deng Xiaoping, in response to a student

uprising in 1986, 22 per cent of the students in the United States applied for visa extension. Following the Tiananmen Square episode on 4 June 1989, many students and university teachers applied for visa extensions, and the government decided to grant them resident or refuge status; this further increased the number of 'non-returns'.

From 1987, the Chinese authorities began to view the defection of students and trained professionals as a real or potential loss that had to be stemmed. But the government's restrictive, authoritarian measures, designed to force students to return home, were largely unsuccessful; they were unable to prevent outbound flows and strongly discouraged return flows. The Chinese government continued its efforts to check the number of migrants and, at the same time heeding lessons from past experience, introduced a return encouragement policy that included an invitation to Chinese scientists settled abroad, to come to China for fixed periods of time, and measures that facilitated their reintegration (such as providing housing for those with a doctoral degree and releasing funds for research), but the most important incentive was the government's promise of unrestricted travel for returning scientists.

Although there were far fewer returns than departures,[39] it was interesting to observe the intentions of the expatriates; a relatively large number of expatriates expressed their intention to return home (44 per cent according to a survey by Zweig and Chen Changgui) although this number is lower than that for other countries.[40] This observation confirms the thesis of scientists like Pedersen (1993) who believe that many Chinese outside their country are 'on hold', waiting to return (delayed return). But the longer they stay abroad, the less likely they are to return, as has been confirmed in other studies (Gaillard 1991) and is exemplified by the case of the Russian expatriate scientists.

Figures on actual returns, and exchanges with the rest of the world that have been made possible by the presence of Chinese scientists and students abroad, also offer a relative idea of the cost of the exodus (if it can be assessed!) and the associated notion of loss. Studies on the impact of returning scholars (Schnepp 1989) show that Chinese students trained abroad have made major contributions to improving the scientific and academic standards in their country and that they are better prepared than their nationally-trained colleagues to cope with the changes needed to modernise

science and technology in China, because they are more efficient, more self-confident, have a more creative professional approach, better international contacts, greater ease in speaking foreign languages, and also a keen understanding of new technologies and new approaches in research. Many expatriate Chinese stay in contact with their home institutions and other institutions in China. The survey by Zweig and Chen Changgui (1995) indicates that more that 31 per cent have relatively frequent contacts with their institutions in China, and nearly a quarter (24.7 per cent) are in contact with their Chinese colleagues at least three times a year, although they do not intend to return home within the near future. Here, we have a clear-cut benefit directly connected to exchanges between the scientific diaspora (even if it is not formally and systematically organised) and the national scientific community.

Not returning is no longer considered as a breach of obligation, quite the contrary. Many Chinese students think that they can live abroad and still serve their country and be patriotic. They feel that their stay abroad can be justified politically. This recent change enables us to look at the concept of exodus often applied to the migration of Chinese students and scientists with greater relativity. As was the case in Taiwan and Korea (Song in this issue), it probably takes more than an incentive policy to convince scholars to return. More scholars will return only if the Chinese national scientific/technical research system and the economy continue to grow and if the underlying logic is truly one of 'circulation'.

Brain Return: Policy or Development?

From the day they leave, nearly all migrants have the intention to return home (Gaillard et al. 1997). In his paper on the migration of scientists in Argentina, Kreimer cites the well-known statement by Dr Bernardo Houssay that 'science has no country but scientists do'. But, as we have already seen, the intention to return home does not always mean returning home, far from it. As discussed earlier, the awareness of scholars' 'non-return' was a major issue in debates on brain drain in the 1960s and 1970s and led to the introduction of policies that 'favoured' their return. For the last twenty years, two international organisations—IOM (International Organization for Migration) and UNDP, through its TOKTEN programme—have been funding assistance programmes to help

trained migrants return to their home country. The 'little dragons' of Southeast Asia are often presented as the champions of the 'brain return'; incentive return programmes have also been promoted in other countries, notably in Latin America, as illustrated by Barreiro and Velho in their presentation of PEDECIBA, the Uruguayan basic science development programme. Yet, among the developing countries, it is probably South Korea and Taiwan that had the earliest and most determined repatriation policies (Chang 1992; Song in this issue; Yoon 1992). The policies were established in the 1960s and 1970s and are geared towards the systematic reintegration of their nationals trained abroad.

The efficacy of these policies was very limited in the 1960s and 1970s. In the case of South Korea it was not until the 1980s that large numbers of scientists and engineers, who had gone to the United States, decided to return home. The Korean case, like other examples from newly industrialised countries in the region, clearly shows that the return of the scientific and technical elite is strongly connected to the country's economic development (and the development of an effective national research system), and depends largely on the quantity and quality of contacts between the country of origin and the expatriate S&T diaspora. By withdrawing aid to returning scientists and engineers in the early 1990s, South Korea actually recognised that incentive policies no longer played a leading role in the professionals' decision to return. This aid was replaced in 1994, *inter alia*, by a programme called the 'brain pool', which enabled the Korean science and technology institutes to invite Korean scientists and engineers living abroad to return for a certain period of time, usually not more than a year. At the same time as the 'brain pool' was being established, the Korean government increased its support to Korean engineers and scientists' associations abroad, whose carefully created and developed databases served as an interface between the national demand for expertise in science and technology and the Korean scientists abroad. Although not considered in Song's paper, during the last fifteen years, the returning South Korean scientists and engineers have made a decisive contribution to the development of science and technology in their country and to the diversification of international relations with the rest of the world.[41]

Two other case studies included here, on the problem of scientists returning to Argentina (Kreimer) and Uruguay (Barreiro and

Velho), where the historico-political context is different, highlight the importance of the return of even a small number of scientists in developing research training programmes, creating/strengthening laboratories, and helping new disciplines to break ground. The institutionalisation of the PEDECIBA programme in Uruguay has unquestionably provided incentives and played a catalytic role for returning scientists. But going further, these two examples also emphasise the importance of interpersonal relations among the scientists of the diaspora and between them and the local scientists, thereby participating in the circulation of people and ideas:

> . . . (while abroad), fellow countrymen very often gathered together . . . developed and shared the idea that all the research work that was being done abroad could be carried out in Uruguay (Barreiro and Velho).
> . . . the fact that scientists live abroad does not necessarily mean that their ties with the local scientific community have been interrupted or broken . . . on the contrary . . . they contribute to the establishment of a more fluid network of international relations (Kreimer).
> . . . . Although, I stayed in my home country (Uruguay), the continued assistance of my professor who was abroad meant a sustained support for my work here . . . (Barreiro and Velho).

These three case studies (South Korea, Argentina and Uruguay) also confirm the importance of having a dynamic national scientific community active on the national territory to allow the returning scientists to play an effective role (Gaillard, Krishna and Waast 1997). This is also illustrated by Kreimer, one of the incentives for the dozen or so researchers who returned to Argentina at the beginning of the 1980s to help develop modern molecular biology was the presence of a handful of first rate biochemists who had continued to work in Argentina while their younger colleagues went abroad.

S&T Diaspora and National Scientific Communities

National scientific communities must also exist, of course, if national scientists living abroad are to be reconnected to them through a mode of organisation called the S&T diaspora option. The diaspora

option is not a new way of allowing a country to take advantage of the presence of national scientists abroad. Meyer and colleagues rightly acknowledge the existence of earlier forms of the S&T diaspora option, which may have existed during the Meiji era in the 1870s when Japanese students in Europe, were systematically organised to bring home S&T knowledge. Its recent reemergence in a new, extended form is closely linked to developments in information and communications technologies, and to changing trends in S&T policies. Thus, earlier forms of the diaspora option were not as fully developed as the new forms, among which the so-called 'Caldas network', or the Colombian Network of Scientists and Engineers abroad, is probably one of the most highly developed.

What is new, is mainly the systematic interlinkage with the diaspora (that has been made possible through the Internet) and, to a lesser extent, the establishment of a broad-based strategy organised within national planning policies. Thanks to the many and very extensive configurations now available, members of the diaspora can vastly increase their contacts. During the last decade, an increasing number of countries have been taking initiatives to create database, mobilise, organise and reconnect their scientists abroad with the scientific community at home. New projects are also in the pipeline, as is shown in papers such as Kaplan's on organising the large 'intellectual South African diaspora'. Many examples of the S&T diaspora, already organised in one way or another, are given in recently published works (Gaillard and Meyer 1996; Halary 1994; Meyer et al. in this issue; Portnoff 1996).

The originality and most interesting part of the paper by Meyer et al. is the presentation of a case study (the Caldas network), during its development phase, with emphasis on who participates in building up the network and how it can or could contribute to developing science in Colombia. This case study clearly demonstrates that the emergence of the diaspora is intrinsically tied to the existence of Colombian associations or 'nodes' throughout the world, and the internal dynamics of the Colombian scientific community.

The Caldas network is an interesting and promising model for turning the negative effects of emigration into potential benefits for the development of S&T activities in Colombia and for promoting the circulation of Colombian students, scientists and technologists between Colombia and the rest of the world. Interestingly,

but not surprisingly, it not only strengthens contacts and collaboration between Colombians abroad and at home, but also stands out as a strategy that complements the 'repatriation' programme of Colciencias and contributes to the return of a number of expatriated Colombian scientists.

The idea may seem simple and enticing, but it may not be easy to implement. One of the first problems is identifying and locating this mobile, volatile expatriate population.[42] In the Caldas case, the work was facilitated by the existence of groups and associations abroad. In the case of South Africa, an initial attempt to assess the different dimensions and characteristics of the intellectual diaspora was made easier by the existence of alumni associations which maintained contact with graduates, wherever they resided. Another problem is the organisation of the identified individuals amongst themselves and with the home country. Outside the home country this requires dynamic local associations and co-ordinators who are willing to invest a lot of time in it. For the home country, this entails more than a political commitment; it also requires the development of administrative and technical capacities to manage the diaspora and ensure its sustainability, which may be beyond the reach of a number of developing countries.[43] When launching joint projects, possibilities for productive interface will be all the more if the diaspora and the national scientists have symmetrical expert capacities, but for this to happen, the national scientific community must be sufficiently networked and developed. This may be the case in South Africa and in Colombia, but many other developing countries, particularly in Africa, are not as highly developed.

Other limits to the model may stem from the fact that it is based on a double postulate with an internal contradiction: the universality of science versus the expatriate scientist's feeling of national allegiance. Observations show that the more researchers see themselves as true scientists the more they tend to want to use the diaspora network as an international scientific network. They tend to prefer contacts with their professional peers, rather than with colleagues from different disciplines, even if they are fellow citizens, because science knows no borders. From an opposite viewpoint, the more 'national' they feel, the more they give into the temptation to convert the diaspora network into a network for national

exchange and mutual assistance, thereby weakening its strictly S&T potential (Schlemmer et al. 1996).

Furthermore, both the North and the South have to cope with the trend toward globalisation and privatisation of scientific and technological development and organisation. The resulting changes in professional values and models, notably with regard to collaboration and exchange of information, will be radical. For Colombian research scientists in various public research institutes in different countries to build up a project together may be difficult, as shown by Meyer et al.; we can imagine what it may be like in the case of privatised or private institutions. To begin with, the basis for cooperative activities is hardly likely to be single national origin. It is not surprising that very few members of the Caldas network belong to private research organisations abroad.

Yet, despite these limitations, the 'diaspora option' like the 'return option' is, for the time being, one of the most promising approaches to the brain drain problem, which earlier policies were unable to check. Retrospectively, it is interesting to note that this approach reverts to a recurrent theme of the past, namely, developing the country of origin via the expatriate elite. This was the main principle of the 'technology transfer' concept applied to foreign study and was one of the preferred themes of the 'internationalists' in the 1970s. The idea is spreading rapidly and almost seems to reach a consensus. It is significant that people who long rode the nationalistic wave now recognise the advantages, for the home country, that can be derived from the external migration of the elite. Bhagwati, the specialist and supporter of tax and compensation systems in the mid-1970s, wrote in 1994:

> These (developing) countries have changed their opinion . . . . They increasingly view the emigration of their most talented nationals as an opportunity for them (the nationals) to gain distinction and contribute to the glory of their home country . . . . These countries hope to profit from the talents of their overseas nationals. In short, what appeared as a brain drain is now seen as the diaspora (Bhagwati and Rao 1994).

Can it be concluded that *brain drain* is not a handicap for the countries confronted with it? Assuming that scientists in the diaspora

will henceforth be fashioning the future (Portnoff 1996), to what extent and under what conditions can they contribute to strengthening the scientific/technical capacities of their home countries? Since globalisation facilitates and justifies the international circulation of ideas, projects and people, how can we differentiate between emigration (that is, potential exodus) and normal circulation within a single, but worldwide space?

Conclusion

Examples and case studies presented here illustrate the permanency and recurrence of international migration of students, intellectuals, scholars and scientists through the ages. The short historical review stresses the importance of itinerance as a learning process leading to scientific creation and the dissemination of knowledge. It also shows that the generosity of the patrons, the need to escape persecution, and changes in world poles of science and knowledge have always played a decisive role in attracting or pushing away scholars and scientists, and that migrations were also, and already back in time, the result of determined scientific policies.

With scientific and technical activities playing an increasingly greater role in the affairs of the world, the scope of this phenomenon grew in the 1960s and 1970s since large numbers of the cohorts of students from developing countries who went abroad for studies did not return home after graduation. The *brain drain* phenomenon became part of the 'centre–periphery' debate and was heard in international circles and organisations. Referring to the original term, defined in the early 1960s to describe the migration of British scientists to the United States, it was stigmatised as an evil to be fought at all cost. Following the failure of various attempts to stem *brain drain* from the South or to devise compensatory mechanisms the debate in international circles fell flat. Since the late 1980s and the early 1990s, the *brain drain* issue has been re-emerging in a changing context marked by a brain return to a number of countries, new flows of well educated scientific and technical minds, and renewed or new modes of scientific collaboration which do not necessarily require translocation. The emergence of this new context is mainly due to increasing globalisation of scientific activities, changing trends in scientific and technological

policies, and the development of new information and communication systems.

The term *brain drain* is still widely used, although, as argued here, the term is too 'catchy' and loaded. However unsatisfactory the term, the phenomenon it sought and seeks to describe still exists, and the recurrent use of the term is indicative of its persistence. Clearly, *brain drain* defined as a loss (or exodus) of scientists and technologists is affecting and will continue to affect a large number of countries for many years to come, even if the perception of what it is has changed and, even if, it may eventually contribute to the internationalisation and thereby to the strengthening of scientific and technological activities of the countries of origin. The case of India presented by Krishna and Khadria is a typical example of a country with an unending *brain drain* problem. The rates of return migration (or circulation) for the well-known Indian Institutes of Technology (IITs) are very low; 30 per cent of the graduates 'join' the *brain drain*, of which, in engineering, only 6.7 per cent of undergraduates and 3.5 per cent of postgraduates return. Yet, the return of some first rate Indian biologists, mainly from the United States led to the establishment of advanced research units in molecular biology (Krishna 1996), just to mention one specific area of advanced research. But, according to Krishna and Khadria, 'the gain supposed to be accrued through globalisation or other institutional mechanisms and policies is likely to be neutralized by the gravity of the *brain drain* problem'. *Brain drain* also continues to constitute a problem of disturbing dimensions and consequences in many African countries, even if new possible directions and policies to counteract the negative consequences of this emigration are being considered.

Two important options have been extensively discussed in this paper: the return and the diaspora options. The example of South Korea shows that, although incentive return policies were being implemented in the early 1960s, foreign educated Korean scientists and engineers only began to return to Korea in large numbers in the 1980s, when the Korean economy and the national research system had reached a certain size. The example of the Caldas network shows that the diaspora option, while reconnecting national scientists living abroad with their national scientific community, is a promising model for turning the negative effects of emigration into potential benefits for the development of S&T activities in

Colombia. But since the Caldas experience was observed in its development phase, follow-up studies would be needed to assess its sustainable contribution to the internationalisation, structuring and strengthening of the Colombian scientific community. The diaspora option also comprises a number of limitations and obstacles as discussed here. One of the most important may be related to the increasing denationalisation (Crawford, Shinn and Sörlin 1993) and privatisation of scientific and technological activities which mean that radical changes in professional values and models, notably with regard to collaboration and exchange of information are to be expected.

These two options—return and diaspora—are interdependent. On the one hand, the diaspora is vital to the success of the 'return' strategies, on the other hand, to revitalise and redynamise its links with the national scientific community, a certain number of its members must return home. Scientists and other professionals, who belong to active diaspora networks and participate in associations that facilitate their new and continued connections with the professional community in their country of origin find it easier to take the decision to return to their home country when the opportunity arises. Furthermore, the interface between the national scientific community and the diaspora expands as the number of returning scientists increases. In the long term, if more and more professionals return to their home country, the gap between the scientific/technical activities at the national level and the level at which the expatriate scientists operate will shrink. Thus by returning home, the professionals will not only help strengthen and diversify the national scientific communities, but will also provide an indispensable base for maintaining and developing the diaspora option itself.

While brain drain is far from over, the profile of the exodus has changed; it is no longer systematically perceived as a permanent loss or a breach of obligation. Most of the papers in this issue treat international scientific migration as part of circulation policies and models (including the return policies and the diaspora models) based on a changing line of logic. From this vantage point, scientists who migrate contribute to the internationalisation of S&T activities in their home country, to the development of new disciplines and high-tech industries, to strengthening research and higher education, to boosting mainstream science outputs, notably in the Asian

NICs, and more generally to a greater circulation of scientists and S&T knowledge. A genuine 'logic of circulation' will only be possible if the countries of origin offer conditions which make the return option attractive. These conditions have not changed much since Glaser and Habers (1978) summed them up nearly twenty years ago: political stability, a minimum of economic development, and a scientific policy that favours the exercise of scientific and technical professions.

NOTES

1. Using a broad variety of documentary sources, we constructed a 1,816 entry database of bibliographic references, written between 1954 and 1995, on international migrations of highly qualified professionals (Gaillard and Gaillard 1996).
2. This definition of brain drain applies to much of the work done in the 1960s and 1970s, for example, Abdollahi (1979), Fyodorova (1981), Godfrey (1970), Mahajan and Sudarshan (1985), Truscott (1971), Washington (1980), Watanabe (1969), Yesufu (1966).
3. On this question of changing trends in science policy, see the special issue of *Science, Technology & Society*, 1(2) (July–December 1996).
4. One of the earliest discussions on the semantics of the term can be found in Johnson (1965); see also Baldwin (1970) and Salomon (1973); for the latest contributions criticising the concept see Meyer and Charum (1994), Pedersen and Ko Shan Lee (1996).
5. The term *brain gain* appeared towards the end of the 1960s in Swedish and American publications to show that *brain drain* mainly benefited the developed countries (Dedijer and Svennigson 1967; Friborg et al. 1972). It 'disappeared' and then reappeared towards the end of the 1980s and the early 1990s mainly in relation to *brain return* to the home country.
6. Baldwin proposed the term *brain overflow* instead of *brain drain* because: 'the less developed countries (LDCs) are not being stripped of manpower they badly need; more often than not they are being relieved of manpower they cannot use' (Baldwin 1970: 359).
7. This terminology was proposed in 1972 at the Third Session of the UN Conference on Trade and Development. Some authors considered this change in terminology extremely important. They felt that it reflected political recognition and meant that the international scientific community considered the phenomenon to be justified (Ardittis 1985).
8. The term *brain waste* has only very recently made its way into literature. See, in particular Avvedudo (1993); Fassman et al. (1993).
9. See, for example, Pedersen (1993).
10. The term *skilled transient* appeared towards the end of the 1980s. See, in particular Findlay (1988); Appleyard (1989).

11. See the recent issue of the quarterly journal of the International Association of Universities (IAU) *Higher Education Policy*, 7(4) (December 1994). See also de Tinguy (1994).
12. See, for example, Morokvasic (1996a); Pedersen and Ko Shan Lee (1996).
13. Volumes have been written on the question of studying abroad and the non-return of students after completing their studies, Borgogno and Vollenweider-Andersen (1995); Hekmati (1972); Hossain (1984).
14. See, for instance, Di Benedetto (1991); Gould (1990).
15. The concept of internal brain drain has just been revived by Russian sociologists: 'the most educated and creative part of the population is leaving science and technology to work in business management and administration' (Kortunov 1992).
16. See, in particular, references in note 2.
17. See, for instance, Yap Mui Teng (1994). A similar type of subject is being reflected in cooperation policies (cf. Dewitte 1995).
18. The bias towards Latin America arises from the fact that some of the papers included here were first presented in a different form at the Symposium on 'International Scientific Migration Today' held in Bogota in June 1996 where a large number of papers on that continent were presented. The proceedings of this symposium have been submitted for publication to ORSTOM.
19. Out of the Asian countries of origin, more has been published on scientific migrations from the People's Republic of China than on any other country: of the 366 indexed references for Asia, 92 are for the PRC; 72 for India; 22 for the Philippines; 21 for Hong Kong; 15 for South Korea; and 15 for Taiwan (Gaillard and Gaillard 1996).
20. For African scientists and politicians who recently met in Abidjan brain drain clearly constitutes a problem of disturbing dimensions and consequences even if new possible directions and policies are acknowledged. See special issue of *Afrique Education*, March 1997 devoted to the seminar on the returning African cadres and graduates (*Retour en Afrique des cadres et diplômés africains*), held in Abidjan, 5–7 February 1997.
21. Out of the 1,816 bibliographic references indexed in our database during the last forty years, 861, that is, just less than half, deal with the problem of scientific migration from the vantage point of the country of origin. The breakdown per continent is as follows: Africa 103, the Americas 140, Europe 259, and Asia 366. Furthermore, nearly half the references concerning Africa are general reviews of the continent as a whole. Country case studies are more scarce: Nigeria (15), Egypt (9), Sudan (6) (Gaillard and Gaillard 1996).
22. One should not, however, forget here that the exodus of intellectuals could also be the result of tyrannical policies that threatened the intellectuals and created a certain obscurantism that was not conducive to the development of science.
23. This paragraph draws on Gaillard and Gaillard (1996); Gaillard and Meyer (1996).
24. The number was estimated at somewhere between 200,000 and 300,000 (see Kallen 1994).
25. The term 'brain drain' was in fact coined before the 1960s by Ayn Rand, in her novel *Atlas Shrugged* (Rand 1957) to mean the departure of innovators and

entrepreneurs from fields of research and production in general for a variety of social, economic and political reasons.

26. According to Glaser and Habers (1978: 14), 'not only do most students expect to return home—75 per cent said they definitely or probably would return—but 51 per cent said their plans were definite'.
27. In the United States, an estimated 60 per cent of the non-American students who obtained a doctoral degree stay in the United States after completing their studies (Stewart 1993).
28. Brain drain from these countries to the Western countries did not begin in 1989. After the Second World War, and more so when the communists came to power, millions of people fled to the West. Qualified professionals accounted for an exceptionally large proportion of the people taking flight (Kallen 1994).
29. Thereby preceding the increasingly widespread idea on the political role of the diaspora in the country of destination (Bhagwati and Rao 1994).
30. In this context M.S. Das (1971) talked about replacing the term *brain drain* by *brain gain* or *brain exchange*.
31. Countries which made the political choice to impose drastic emigration regulations on their elite (countries in the East, for instance) were not models of democracy and did not wait for recommendations from international experts to implement these measures.
32. Sociologists from the Department of Urban Ecology at the Chicago School had extensively tested the sociological methods (among others) to analyse migration patterns since the beginning of the century (1914–30).
33. Other subsequent studies proved that many in fact did not return, cf. note 28.
34. The studies by UNITAR inspired a lot of work on both exodus and return during the following decades.
35. Since no paper on the People's Republic of China is included in this issue, it was felt that the introduction should include a short summary of the main traits and features of the Chinese brain drain. Most of the information is based on a survey carried out in 1993 in the United States by David Zweig and Chen Changgui (1995) who interviewed 273 students, scholars and other former residents of the PRC who were residing in the United States. Data and opinions not referenced in the introduction come from David Zweig and Chen Changgui.
36. The fields most severely affected are theoretical, solid states, nuclear physics, computer sciences, mathematics, biotechnology, organic chemistry and molecular biology (Kortunov 1992).
37. Yet, the presence of Russian scientists abroad has certainly contributed to boosting the number of transnational publications (that is, papers co-authored by two or more countries) in recent years. Thus, the proportion of transnational publications between the Commonwealth of Independent States and the rest of the world versus the total of co-publications has increased from 11.7 per cent in 1990 to 35.1 per cent in 1995 (OST/ISI).
38. Official figures published by the China National Institute for Educational Research (CIER), Beijing.
39. According to official figures (see note 38), for 230,000 departures between 1978 and 1994, 70,000 returned.

40. Cf. in particular, the writings of Glaser and Habers (1978), and Meyer et al. in this issue show that 75 per cent of the expatriate Colombian students and scientists intended to live and work in their home country.
41. See Swinbanks and Tacey (1996) for Taiwan.
42. The term diaspora is of ancient Greek origin, and etymologically means dispersion.
43. Simpler models could be applied in other 'less developed' countries, for instance, at an institutional level. One possible example is the attempt made by the University of Asmara in Eritrea to organise Eritrean scholars and professionals living abroad so that they could contribute to the advancement of higher education in their home country (Yisak and Ogubazghi 1996).

REFERENCES

ABDOLLAHI, M. (1979), 'Capitalism and Brain Drain: A Dialectical Analysis of the Migration of Highly Qualified Manpower from Less Developed to More Developed Capitalist Countries Iran and the U.S.' PhD thesis, Western Michigan University.

ADAMS, W. (1968), 'The Brain Drain: Fact or Fiction', *Population Bulletin*, 25(3), pp. 57–67.

AMUZEGAR, J. (1968), 'Brain Drain and the Irony of Foreign Aid Policy', *Economia Internazionale*, 21(4), pp. 679–719.

APPLEYARD, R., ed. (1989), *The Impact of International Migration on Developing Countries*. Paris: OECD.

ARDITTIS, S. (1985), 'Pour une régulation concertée des courants de compétences entre pays en développement et pays d'emploi', *Revue Européenne des Migrations Internationales*, 1(1), pp. 103–21.

AVVEDUDO, S. (1993), 'Brain Drain, Brain Gain or Brain Waste? Mobility of Human Resources in European Science and Technology', in S. Biggin and V.A. Kouzminov, eds, *Proceedings of the International Seminar on 'Brain Drain Issues in Europe'*. Technical Report No. 15, Venice: UNESCO-ROSTE (Regional Office for Science and Technology for Europe), pp. 157–79.

BALDWIN, G.B. (1970), 'Brain Drain or Overflow?', *Foreign Affairs*, 48(2), pp. 358–72.

BENOIT, P. and F. MICHEAU (1989), 'L'intermédiaire arabe?', in M. Serres, *Éléments d'histoire des sciences*. Paris: Bordas, pp. 151–75.

BHAGWATI, J. and M. RAO (1994), 'Vive les étudiants étrangers', *Courrier International*, 204 (28 September–5 October).

BHAGWATI, J.N. (1976), *The Brain Drain and Taxation—Theory and Empirical Analysis*. Amsterdam: North-Holland Publishing Co.

BHAGWATI, J.N. and W. DELLALFAR (1973), 'The Brain Drain and Income Taxation', *World Development*, 1, pp. 94–101.

BÖHNING, W.R. (1977), *Compensating Countries of Origin for the Out-Migration of their People*. ILO-WEP 2-26/WP. 18E. Geneva: International Labour Office.

——— (1982), *Towards a System of Recompense for International Labour Migration*. ILO-MIG WP.2. Geneva: International Labour Office.

BORGOGNO, V. and L. VOLLENWEIDER-ANDRESEN (1995), 'Les migrations étudiantes des pays du sud de la Méditerranée vers les universités européennes: premiers aperçus', *Study Emigrazione, Etudes Migrations*, 117, pp. 177–88.

CHANG, S.L. (1992), 'Causes of Brain Drain and Solutions: The Taiwan Experience', *Studies in Comparative International Development*, 27(1), pp. 27–43.

CRAWFORD, E., T. SHINN and S. SÖRLIN, eds (1993), *Denationalizing Science: The Contexts of International Scientific Practice*. Dordrecht: Kluwer Academic Publishers.

DAS, M.S. (1971), 'The "Brain Drain" Controversy in a Comparative Perspective', *International Review of Comparative Sociology*, 1(1), pp. 55–65.

DEDIJER, S. (1968), 'Early Migration', in W. Adams, *The Brain Drain*. New York: MacMillan Co., pp. 9–28.

DEDIJER, S. and S.L. SVENNIGSON (1967), *Brain Drain and Brain Gain*. Research Policy Programme. Lund: University of Lund.

DE TINGUY, A. (1994), 'Le Départ des Cerveaux de la CEI en Occident: Fuite ou Mobilité? Enquêtes en France', *Innovation*, 7(2), 177–87.

——— (1995), 'La mobilité des élites: une chance historique pour la Russie?' *Studi Emigrazione/Etudes Migrations*, XXXII (117), pp. 98–105.

DEWITTE, P. (1995), 'Les Migrants, Coopérants de Demain?' *Projet*, 241, pp. 80–88.

DI BENEDETTO, M. (1991), 'Mobilités et savoirs-faire: les itinéraires et trajectoires d'élites professionnelles du bâtiment'. Thèse de doctorat en Sciences Economiques, Université d'Aix-Marseille 2.

FASSMAN, H., J. KOHLBACHER and U. REEGER (1993), 'Brain Drain and Brain Waste, Skilled Migration to Vienna'. Paper presented at the international Seminar on Skilled and Highly Skilled Migration, Università Pontina, Latina, 28–29 October.

FINDLAY, A. (1988), 'From Settlers to Skilled Transients', *Geoforum*, 19, pp. 401–10.

FRIBORG, G. et al. (1972), *Brain Drain and Brain Gain of Sweden*. Stockholm: Swedish National Science Research Council.

FYODOROVA, A. (1981), 'The "Brain Drain": An Imperialist Policy', *International Affairs* (Moscow), pp. 60–67.

GAILLARD, A.M. (1994), *Migration Return: A Bibliographical Overview*. Staten Island: Center for Migration Studies.

——— (1997), *Exils et Retours, Itinéraires chiliens*. Paris: CIEMI/L'Harmattan.

GAILLARD, A.M. and J. GAILLARD (1996), 'Les migrations internationales de personnes hautement qualifiées: un itinéraire bibliographique et conceptuel'. Paper presented at the Conference on International Migration Today, Bogotá, 24–27 June.

GAILLARD, J. (1991), *Scientists in the Third World*. Lexington: Kentucky University Press.

GAILLARD, J. and J.B. MEYER (1996), 'Le Brain Drain revisité: de l'exode au réseau', in J. Gaillard, ed., *Coopérations Scientifiques Internationales*. Paris: Editions de l'Orstom, pp. 331–47.

GAILLARD, J., V.V. KRISHNA and R. WAAST, eds (1997), *Scientific Communities in the Developing World*. New Delhi: Sage Publications.

GLASER, W.A. and G.C. HABERS (1978), *The Brain Drain: Emigration and Return*. UNITAR Research Report. Oxford: Pergamon Press.

GODFREY, E.M. (1970), 'The Brain Drain from Low-Income-Countries', *Journal of Development Studies*, 6(3), pp. 235–47.

GOULD, W.T.S (1990), 'Occupational Continuity and International Migration of Skilled Workers: The Case of Mersey Port Workers', *International Migration*, 28(1), pp. 3–13.

GRANBERG, A. (1967), *The Migration of Scientists in Antiquity*. Mimeo. University of Lund, Lund.

——— (1969), *Migrationen av vetenskapsmän under hög—och senmeltid—en historisk—sociologisk studie*. Mimeo. University of Lund, Lund.

GRUBEL, H.G. (1966), 'The International Flow of Human Capital. Theoretical Analysis of Issues Surrounding Foreign Students Electing not to Return to Their Native Countries', *The American Economic Review*, 56(2), pp. 268–74.

——— (1976), 'Reflections on the Present State of the Brain Drain and a Suggested Remedy', *Minerva*, 14(2), pp. 209–24.

GRUBEL, H.G. and A.D. SCOTT (1966), 'The Cost of U.S. College Student Exchange Programs', *Journal of Human Resources*, 1, pp. 79–98.

HALARY, C. (1994), *Les exilés du savoir: les migrations scientifiques internationales et leurs mobiles*. Paris: L'Harmattan.

HEKMATI, M. (1972), 'Non-Returning Foreign Students: Why do They not Return Home?', *Die Dritte Welt*, 2(1), pp. 25–43.

Higher Education Policy (1994), 'Theme: The Mobility of Brain', 7(4) (December).

HOCH, P. and J. PLATT (1992), 'Migration and the Denationalization of Science', in E. Crawford, T. Shinn and S. Sörlin, *Denationalizing Science*. London: Kluwer, pp. 133–52.

HOSSAIN, N. (1984), 'Indian Students in U.S. Universities: A Question Revisited', *International Review of Modern Sociology*, 14(1), pp. 55–63.

JACOB, M. and A. ELZINGA, eds (1996), 'Special Issue: Changing Trends in Science Policy', *Science, Technology & Society*, 1(2) (July–December).

JOHNSON, H.G. (1965), 'The Economics of the Brain Drain: The Canadian Case', *Minerva*, 3(3), pp. 299–311.

——— (1967), 'Letter to the Editor on Thomas' the International Circulation of Human Capital', *Minerva*, 6, pp. 105–12.

——— (1968), 'An Internationalist Model', in W. Adam, ed., *Brain Drain*. New York: Macmillan.

KALLEN, D. (1994), 'Brain Drain and Development: Opportunity or Threat?', *Higher Education Policy*, 7(4) (December), pp. 11–15.

KEELY, C.B. (1985), 'Return of Talent Programs: Rationale and Evaluation Criteria for Programs to Ameliorate a Brain Drain', *International Migration*, 26(1), pp. 179–90.

KIBRE, P. (1948), *The Nations in the Medieval Universities*. Cambridge, Mass: Medieval Academy of America.

KINDLEBERGER, C.P. (1977), 'Internationalist and Nationalist Models in the Analysis of Brain Drain: Progress and Unsolved Problems', *Minerva*. 15(3–4), pp. 553–61.

KORTUNOV, A. (1992), 'La fuite des cerveaux: le cas de l'ex-URSS', *Hommes et Migrations*, 1155, pp. 22–25.

KRISHNA, V.V. (1996), 'Brain Drain, Brain Gain and Scientific Communities: Indian Experience in the Field of Biotechnology'. Paper presented at the conference on International Scientific Migrations, Bogotá, Colombia, 23–26 June.

MAHAJAN, S.M. and E.C.G. SUDARSHAN (1985), 'Indian Scientists—The Foreign Trap', *Science Age* (June).

MEYER, J.B. and J. CHARUM (1994), 'Se agoto el brain drain? Paradigma perdido y nuevas perpectivas', *Integracion, Ciencia y Tecnologia*, 1(1), pp. 47–54.

MOROKVASIC, M. (1996a), 'Entre l'Est et l'Ouest, des migrations pendulaires', in M. Morokvasic and H. Rudolph, eds, *Migrants: les nouvelles mobilités en Europe*. Paris: L'Harmattan, pp. 119–58.

——— (1996b), 'La mobilité des élites scientifiques de l'Autre Europe: exode ou circulation?', *Revue d'études comparatives Est-Ouest*, 3, pp. 31–73.

MUNDENDE, D.C. (1989), 'The Brain Drain and Developing Countries', in R. Appleyard, ed., *The Impact of International Migration on Developing Countries*. Paris: OECD, pp. 183–95.

ORLEANS, L.A. (1988), *Chinese Studies in America: Policies, Issues and Numbers*. Washington D.C.: National Academy Press.

PARSONS, E.A. (1952), *The Alexandrian Library*. Amsterdam: Elsevier.

PEDERSEN, P. (1993), 'The New China Syndrome: Delayed Return as an Alternative to the "Brain Drain"', *International Educator* (Spring), pp. 31–33.

PEDERSEN, P. and KO SHAN LEE (1996), 'Back-and-Forth as a Viable Alternative to the Brain Drain Perspective'. Paper presented at the Symposium on International Scientific Migration Today: New Perspectives, Bogotá, Colombia, 24–26 June.

PORTNOFF, A.Y. (1996), 'Les diasporas scientifiques modèlent l'avenir', *Futuribles*, pp. 57–59.

RAND, A. (1957), *Atlas Shrugged*. New York: Signet.

SALOMON, J.J. (1973), 'L'exode des cerveaux, résultats d'une enquête de l'OCDE', in WHO, *La formation des chercheurs en science médicale*. Report of a panel discussion organised by CIOMS, Geneva, 10–11 September 1970. Geneva: WHO, pp. 105–11.

SCHLEMMER, B., J. GAILLARD, N. NARVAEZ-BERTHELEMOT and D. BERNAL (1996), 'La dialectique du virtuel et du concret dans le cas Caldas'. Paper presented at the conference on International Migration Today, Bogotá, 24–26 June.

SCHNEPP, O. (1989), 'The Impact of Returning Scholars on Chinese Science and Technology', in D.F. Simon and M. Goldman, eds, *Science and Technology in Post-Mao China*. Cambridge: Harvard Contemporary China Series, pp. 175–98.

STEWART, D.W. (1993), *Immigration and Education: The Crisis and the Opportunities*. New York: Lexington Books.

SWINBANKS, D. and E. TACEY (1996), 'Chinese Scientists Drawn Back to Asia', *Nature*, 383(5), (September), pp. 11–13.

The Royal Society (1963), *Emigration of Scientists from the United Kingdom*. Report of a Committee Appointed by the Council of the Royal Society. London: Royal Society.

TRUSCOTT, M.H. (1971), 'The Brain Drain of Scientists, Engineers and Physicians from the Developing Countries of the United States'. PhD thesis, Louisiana State University.

UNCTAD (United Nations Conference on Trade and Development) (1974), *The Reverse Transfer of Technology: Economic Effects of the Trained Personnel from Developing Countries*. UNCTAD Trade and Development Board, GI74-45088, Mimeo.

——— (1987), *Trends and Current Situation in Reverse Transfer of Technology*. Study prepared by the UNCTAD Secretariat, UNCTAD doc. TD/B/AC.35/16, Geneva.

UNESCO-ROSTE (1994), *Brain Drain from Russia and Ways of Regulation*. Moscow: Ministry of Science and Technology, Brain Drain Committee, 10 January.

WASHINGTON, E.A. (1980), *Brain Drain from the Less Developed to the Developed Countries: Policy Implications with Focus on the United States, A Monograph*. Washington: National Institute of Public Management.

WATANABE, S. (1969), 'The Brain Drain from Developing to Developed Countries', *International Labour Review*, 99(4), pp. 401–33.

YAP MUI TENG (1994), 'Brain Drain or Links to the World: Views on Emigrants from Singapore', *Asian and Pacific Migration Journal*, 3(2–3), pp. 411–29.

YESUFU, T.M. (1966), *Loss of Trained Personnel by Migration from Nigeria*. Lagos: University of Lagos.

YISAK, W.A. and G. OGUBAZGHI (1996), 'The Role of Eritrean Scholars and Professionals in the Diaspora', in E. Thulstrup and H.D. Thulstrup, eds, *Research Training for Development*. Proceedings of a Conference on Research Training for Countries with Limited Research Capacity. Frederiksberg: Roskilde University Press, pp. 11–14.

YOON, BANG-SOON L. (1992), 'Reverse Brain Drain in South Korea: State-led Model', *Studies in Comparative International Development*, 27(1), pp. 4–26.

ZAHLAN, A.B. (1977), 'The Brain Drain Controversy', *The Proceedings of the International Population Conference*, pp. 319–27.

ZWEIG, D. and CHEN CHANGGUI (1995), *China's Brain Drain to the United States: Views of Overseas Chinese Students and Scholars in the 1990s*. Berkeley: University of California, Institute of East Asian Studies.

*Migration of Scientists and the Building of a Laboratory in Argentina**

PABLO KREIMER

The objective was to demonstrate how, as witnessed in the particular case of one molecular biology laboratory in Buenos Aires, different types of scientific migration emerged, such that they were responsible for the very constitution of this laboratory. To this end, a brief description of the historical background of the scientific community in Argentina, its political-institutional context, and the successive migrational periods which have been produced in the country will be presented. Before discussing this particular case, three 'ideal types' which may be useful in understanding the different types of migration embarked upon by scientists will be described.

Introduction

THE INTERNATIONAL MOBILITY of scientists has been an enduring practice for many decades, it is virtually an additional element in the constitution of the identity of scientific activity itself. Therefore, the study of migration is an inevitable subject for the comprehension of the structures and dynamics of local scientific communities, including the consideration of that which lies beyond the national reality. Quantitative studies (carried out on different aggregate levels), which have highlighted the movement of migrational flows through history, have been established as highly useful indicators. Due to the descriptive strength of this data, it is possible to draw inferences about the conditions under which scientific practice takes place, or the perceptions that the actors form of these conditions.

* I am grateful to Leonardo Vaccarezza and to an anonymous reviewer for their helpful comments. My friend Peter Kahn translated and reviewed the English text.

Pablo Kreimer is Associate Research Professor, Instituto de Estudios Sociales de la Ciencia y la Tecnologia, National University of Quilmes, Av. Rivadavia 2358 (1034), Buenos Aires, Argentina.

Science, Technology & Society 2 : 2 (1997)
SAGE PUBLICATIONS NEW DELHI/THOUSAND OAKS/LONDON

If the above is true for all countries—especially during a period when communication has made the process of scientific internationalisation even more evident—it is all the more true in the case of less developed countries, inasmuch as they have been, in general, areas of 'expulsion' rather than 'reception' of scientists as well as of intellectuals and professionals. It is the particular case of Latin America, where in recent decades it can be observed that a steady current of researchers has been drawn, for varying periods of time (including permanent relocation), in general, to North America and Western Europe.[1]

The reflections that guide this study have emerged as a consequence of a micro level investigation by Kreimer in various laboratories. The study, illustrating the Argentinian case, was carried out in a molecular biology laboratory in Buenos Aires and, simultaneously, a similar study was carried out in London and Paris, which served as a model for the analytical framework. In the comparative view, a dimension concerning the *peripheral condition* (present in Argentinian laboratories *vis-à-vis* the European labs) was immediately evident.[2]

Second, to distinguish between the different *origins* of scientific migration, the notion of *strategy* is useful (regarding the actors involved). This concept permits a clear-cut differentiation of deliberate decisions from those decisions which are imposed upon the actors, or necessitate a choice between different alternatives. On the basis of a study of a particular case, the most significant variables will be brought together to explain the problem of migration from a qualitative perspective which will necessarily be complementary to the analysis of the great migratory flows, and which will incorporate the elements that emerge from the political and institutional macro determinations.

Historical Background

In the following the most significant components of the scientific tradition in Argentina, the dynamics of the relatively 'new' scientific community and the features of the political–institutional context in which migrational movements have taken place will be discussed. This brief *parcours* is essential to understanding and historically orienting the elements present in the laboratory under study.[3]

Since its emergence as a nation, Argentina has been formed by diverse waves of immigrants, particularly of European origin. Thus, it is natural that since the early[4] establishment of its scientific community, towards the end of the last century, many of its active scientists were from various European countries and that the evolution of many scientific disciplines in Argentina has been linked to the leadership of one or another of these researchers who came from Europe.

The practice of contracting and drawing professors to the country *from the exterior* formed part of an explicit political policy beginning in the 1870s and continuing through subsequent periods. The most significant architects of this policy were the then President, Domingo Sarmiento, and Juan María Gutiérrez, who was the rector of the University of Buenos Aires. This policy was along the same lines as the general policy pursued during the period, broadly based on the promotion of European immigration as a means of 'populating' the country.[5]

During the first decades of this century, there already existed a group of researchers with a tradition in certain disciplines, particularly in what has been called the *biomedical complex*, led by Dr Bernardo Houssay, who was awarded the Nobel Prize in 1949. Certainly, scientific research was far from being a mass phenomenon; the active scientists were, in majority, members of families involved in the very productive exploitation of agro-exportation.

It was during this period that a transition in the institutionalisation of academic science practices occurred: from an orientation centred on aspects of teaching, it would pass, emblematically, with the election of Houssay as the titular head of physiology (at the University of Buenos Aires), to an orientation centred on research or, still further, the *practice* of research.[6]

Thus, a few active groups were formed which were working closely with the international scientific community, earning recognition not only for the topics they addressed but also for the quality of their work. This is characteristic of various Latin American countries and some authors have called it 'the scientific excellence in the periphery'.[7] This concept has been proposed, specifically, for understanding the emergence, in the context of peripheral countries, of groups whose development appeared, *a priori*, similar to that of their counterparts in 'central' countries.

Until the 1950s, the scientific community in Argentina had been experiencing a period of expansion, in large measure due to the slow but increasing access to the University of the middle classes beginning in the 1930s. These members of society who were largely second generation immigrants had arrived in Argentina at the beginning of the century, and comprised Italians, Spanish and Central Europeans. This reflects, to some degree, the political rise of these social sectors, which had begun to emerge during the presidency of Hipólito Yrigoyen at the beginning of the 1920s.[8]

This process was abruptly interrupted in the mid-1940s with the ascension to power of Peronism.[9] In this context, the University massively opposed the Peronist regime, which was perceived as its enemy: for the first time in Argentinian history, science was perceived by the government as a refuge for elitists who were 'disinterested in the *avatars* of the people'. As a consequence, a large percentage of researchers were dismissed or were compelled to resign from their University posts, and *not a few scientists either chose or were forced into exile* during this period. Houssay, for example, founded the Institute of Experimental Biology and Medicine (IBIME) during this period, independent of the University, and Leloir (one of his disciples) founded the Campomar Foundation for Biochemical Research, both of which were soon recognised as centres of academic excellence.

In fact, it was during the 1945–55 period that the first massive exodus of scientists and professionals to the exterior occurred. In a speech delivered some years later, Houssay noted the importance of the 'problem' of massive emigration and indicated that, between 1950 and 1956, almost 1,700 scientists and professionals had left the country, with the numbers steadily increasing every year from the end of the 1940s.[10]

The period following the fall of Perón heralded what has come to be known as the 'golden decade'[11] for science in Argentina: in 1958, the National Council for Scientific and Technological Investigation (CONICET) was established, presided over by Houssay until his death, with Rolando García, then Dean of the *Facultad de Ciencias* of the UBA, as vice-president. The effect on investigative practices was substantial: the CONICET instituted a system of grants for young graduates, it created a degree programme for scientific research, authorised subsidies for research and financed

scientific field trips to the exterior, for grant recipients as well as for investigators. In this sense, migration for short periods of time became a relatively common practice among the most active research groups, directed toward doctoral studies, postdoctoral studies, or 'stages' of shorter duration. The stimulus for this type of travel could be found not only in the existence of institutional mechanisms, but also in the perception, on the part of certain leaders of the scientific community, that scientists need to be exposed to the work of their colleagues abroad, and the need to establish permanent ties of collaboration.[12]

To the creation of CONICET must be added the development of new disciplines (the first professorship in nuclear physics was offered), new degree programmes were added (such as psychology and sociology), and many projects encountered significant new resources available for their development. The previous preeminence of the biomedical complex, although maintaining a part of its influence, also gave way to the development of other disciplines, mostly (but not exclusively) within the *Facultad de Ciencias* of the UBA. To have some idea of the 'explosion' in research, it may be observed that the latter mentioned School increased its population, between 1959 and 1964, by more than 60 per cent, while in social sciences the phenomenon was even greater: in the *Facultad de Filosofía y Letras* (within which programmes of sociology and psychology function), there was 146:6 per cent increase.[13] The university enrolment figures for the entire country increased from 82,500 in 1950, to 180,780 in 1960, and further to 274,000 in 1970.[14]

This process was, however, interrupted, and more profoundly in 1966, with the assumption of power of the military regime, which in the same year generated the violent episode in the University which has come to be known as the '*noche de los bastones largos*'.[15] Subsequently, a progressive exodus of scientists and professionals began, who were either directly dismissed from the University, or were persecuted by political authority. The statistics are revealing: in the University of Buenos Aires alone 8,600 professors resigned voluntarily; and in some cases such as in the School of Exact Sciences 77 per cent of the faculty resigned.[16] Of these scholars, only a few were able to enter into private institutes (Campomar, the Bariloche Foundation); this figure was higher in the case of

the social sciences, as certain institutions that were created during those years sheltered numerous researchers (the Institute Di Tella, IDES, CLACSO, among others).

Notwithstanding, in 1966 the process which had begun a decade earlier took a dramatic turn following forced emigration of scientists and professionals, many of whom sought permanent residence abroad. With the exception of a few groups that travelled together,[17] the emigration of Argentinian scientists assumed the form of a stampede, with each one fending for himself as quickly and effectively as possible, utilising whatever personal and professional contacts one could in order to gain shelter in centres and institutions abroad.

After the brief democratic period in 1973, the military coup of 1976 worsened the environment of scientists and intellectuals that had begun a decade earlier. This time the persecution, assassinations and torture were on a grand scale, and there were no opportunities for researchers who were uncompromised with respect to the military regime to continue working in the country. Thus, some scientists who had managed to retain their posts in 1966, taking refuge in the internal contradictions created by the military itself, no longer had any recourse or option in 1976: exile appeared to be the only feasible solution, in many cases not just to save scientific practice, but also life itself.[18]

The period of restoration of democracy began towards the end of 1983. Many researchers returned to the country immediately and reinserted themselves principally in the universities and some institutes of the CONICET; in fact, practically all the organisation's institutional positions were filled by scientists returning from the exterior, as well as the majority of professorships offered by the public University between 1983 and 1985. The greater part of the institutions 'normalised' their operations and the environment, in general, was similar to that in the 1960s. However, conditions had been modified substantially, and, in spite of the relative importance the government attached to scientific investigation, the resources were perceived as increasingly insufficient in the context of the economy of the country—in the midst of a debt crisis—which made it increasingly difficult to operate.

No doubt, it was not simply a problem of resources; in addition, the return of large numbers of scientists from the exterior generated internal conflicts within the scientific community. On the one hand, those scientists who had remained in the country looked

with distrust upon those who were returning, as they perceived them to be a threat to the positions they had occupied during the period of the military regime. In fact, the majority of those who had governed the CONICET during those years were removed from their posts, which led to resentment and charges of 'ideological discrimination'. On the other hand, the scientists who returned tended to perceive the majority of those who had stayed as accomplices to the regime who did not merit research positions. Where this conflict had the greatest impact was in the relative breach of the *traditions* which had been forged during the previous decades and which had crystallised, to a degree, in the model of the 1960s. Thus, inasmuch as entire groups had been disassembled, intergenerational relations, in order to be reconstituted, required that a new generation of researchers should emerge under the direction of a group of researchers who, themselves, were trying to reconstitute their own laboratories.

Already, a significant proportion of scientists had sought permanent residence abroad, and for various reasons had decided definitively not to return to the country.[19] To this it must be added that, over the last 30 years, many disciplines have been substantially transformed, with respect to concepts, the theoretical challenges facing them, the scale upon which research has developed, and the emergence of new problems; all of which have notably limited the possibilities of development in accordance with 'excellence in the periphery', as mentioned earlier. Rather, it is possible to imagine two possibilities within the framework of the local communities: an 'integrated peripheral' practice, in the context of international science, *versus* an attitude of 'relative isolation', as the predominant forms of carrying out science in less developed countries.

In conclusion, it may be pointed out that, over the last 25 years (until 1987), the exodus of *highly qualified personnel* from Argentina to the United States and Canada numbered more than 170,000.[20] The Secretary of Science and Technology of Argentina estimated, based on data obtained from the consulates, that more than 1,700 *scientific researchers* were residents abroad. The figure assumes significance if one considers that this number is only slightly less than the *total* number of career researchers in the CONICET, that is, around 2,000.[21] In recent years diverse mechanisms for stimulating the *repatriation* of scientists have been proposed; nonetheless, the total number of Latin American researchers living abroad has not significantly diminished. In the case of Argentina, only 15 per

cent of researchers living abroad have registered for the programme of repatriation, and of these, only a fraction have returned.

This study will focus specifically on a group of investigators who, for various reasons, returned to the country, and will analyse the circumstances under which this return took place, and the consequences that have resulted in the disciplines involved and in the scientific community in general.

The Conditions of Scientific Migration

This section presents a discussion of the most significant elements for understanding the migration processes of scientists, based on the construction of certain 'ideal types', as a component in the development of their scientific careers, as well as their interactions with particular political and institutional contexts. This is followed by an analysis of the conditions which produce (or, may produce) the return to the country of origin. These elements will provide the basis of the analysis of our empirical study in the final section.

As our perspective focuses on the *actors* of scientific migration—that is, the scientists themselves—the first element we will consider is whether the decision to migrate is determined by strategies regarding the development of personal careers, or whether it is the consequence of impositions upon the actors in a specific context. On the other hand, the analysis reveals that scientific migration necessarily gives rise to, in all cases, various consequences within the local scientific community.

On the basis of this differentiation, the first *ideal type* of scientist migration is due to extra-scientific motives, particularly as a consequence of political, religious or ethnic conflicts: this type ('type I') of migration *does not involve a deliberate strategy* on the part of the researchers involved, but rather they are forced to abandon the country in which they have been working, for reasons which, in many cases, pose a threat to their lives. In the extreme case of forced exile, it becomes difficult to evaluate the type of decision made in this context as, in the majority of the cases, the selection of a destination for emigration is dependent on the evaluation of a set of circumstances among which the specific scientific strategies may be difficult to isolate.

This kind of migration tends to be for an *extended duration*, inasmuch as authoritarian regimes are rarely established for short periods of time. As a consequence, a high percentage of the scientists who have emigrated find themselves tempted by the *host* centres to stay for longer periods of time.[22] Once the authoritarian regime has been replaced by a democratic one, the decision to return is taken, and the resolution of this question is dependent upon a different set of variables, which will be analysed later.

One of the consequences of forced migration due to authoritarian-type regimes is the tendency to produce a profound breaking up of the so-called local *scientific community*. As indicated earlier, scientists who have emigrated tend to view with resentment those who have remained in the country and return, and even perceive those who stayed as *accomplices* of the authoritarian regime. For their part, scientists who remained in the country during the authoritarian regime soon realised their positions being threatened, positions which were acquired during the intervening years, especially if significant numbers of scientists return. Thus, the *morphology* of social relations which could have prevailed for a determined length of time is suddenly altered, generating segmentations and short-circuits of communication within the local scientific community.[23]

To the former may be added that the massive emigration of researchers in a specific field of investigation leads to a breaking up which has been labelled as (Kreimer 1996) *filial relationships* (as a component of the 'traditions') in scientific investigation. In the absence of a significant number of scientists in a specific field, or the dismantlement of an entire group of investigators, the subsequent generations lose the opportunity to train with the *masters*, and to internalise, develop, or confront established traditions. At the same time, the scientists who return, independent of the symbolic capital or the credit/credibility they possess,[24] must make large investments in the constitution of new work teams, as well as the installation of adequate equipment; in short, recreating conditions they judge to be most appropriate for their reintegration into the medium from which they had been driven out.

The second 'ideal type' refers to the case in which the decision to emigrate is not the result of a (direct) imposition, but rather in response to a personal decision made by the scientist. Naturally,

the motivations for making such a decision are multiple as well as complex, although, in general, two principal causes can be identified: on the one hand, dissatisfaction with working conditions in the origin country, or, rather, the ideal representation (perception) of better conditions to be encountered in the *host* country. On the other hand, there is a perceived necessity to be exposed to working in a prestigious foreign centre as part of a strategy for improving symbolic capital in preparation for the return to the country of origin.

The first motivational type (which is referred to as 'type II A') leads to long time or permanent migration, when the conditions for inclusion in the host country are favourable. During a certain period, especially during the 1960s, the analysis of this type of migration, whose effects were known as a form of *brain drain*, focused on the determinant causes in the country of *expulsion*.[25] Without denying the conditions prevalent in the country of expulsion, during the following years the problem was considered from a more global perspective. This implied, for studies carried out toward the end of the 1960s and the beginning of the 1970s, that not only should the expulsion from the country of origin be taken into account, but also the factors of attraction to the *receptor or host* country.[26] In this sense, for example, the decision to attract scientists (or other highly qualified personnel) has been part of the explicit strategy of the mechanisms for policy planning of some countries.

As an important part of the strategies that scientists may use, we should note the perception that the investigator (the potential migrant) has of the prestige of the centre in which he wishes to continue working. In relation to this aspect, the 'research topic' the researcher wants to study and the importance or the degree of priority attached to this topic (by the 'international community') play an important role during the period in which the decision to emigrate is made.

With respect to conditions of the local context, the importance of economic factors in scientists' decisions cannot be overlooked. Nonetheless, in the decision to prolong (even indefinitely) his stay abroad, a different class of factors usually plays a part: in general, these are the conditions that a scientist would encounter in case he should decide to return to the country of origin. Thus, the nature of the connections that have been maintained with the initial work

group should be considered, as well as the prestige that this group enjoys, the institutional structure of the country of origin,[27] and the possibility (or impossibility) of continuing and developing work along the same lines as those worked on abroad, etc.[28]

A second type of motivation ('type II B')[29] corresponds to migration for a specified period of time (in general, short to medium term) and for a specific purpose, such as doctoral or postdoctoral work or, more generally, for gaining some experience working in a laboratory situated at the 'centre' of 'international science'.

Regarding this kind of migration, the value attached to the laboratory in which the scientist will work abroad, as well as the fact that this work experience increases the degree of credit/credibility of the scientist at the time of deciding to return to his origin country, is of fundamental importance. In this respect, two types of previous conditions must be examined: on the one hand, there is the force of the cultural matrix and the structure of relations corresponding to each scientist in the context of his country of origin; on the other hand, consideration must be given to the institutional work conditions to be encountered by the scientist in his own country.[30]

Concerning the first set of questions, one may consider: first, analysis of the institutional affiliation *prior* to departure to the exterior, the type of institution the scientist was working in, the research topics he was investigating, and the institutional *position* the scientist held during that period. Second, it is necessary to consider whether, during the period of time spent working in the laboratory abroad, regular contact was maintained with the group of origin. In this sense, in addition to the relations and interests of the individual investigator, it is fundamental to take into account whether the work or studies carried out abroad are in accordance with only to the strategies of the investigator or to the group of origin as well. The possibility that the return should effectively occur within the period of time previously determined increases greatly to the extent to which both strategies coincide as part of a common interest. Naturally, the possibility that these two types of strategies should operate together (migrant investigation–reference group) depends in large measure on the degree of consolidation and institutionalisation of the group, such as the credit/credibility possessed by the head of the local group. In this last sense, it is fundamental to analyse the degree of *internalisation* of the local

group: if the relations with international groups that are working on related topics are developed, it is likely that the investigators of a developing country will opt to do work abroad (in more developed countries), for a specified period of time, after which the return to the institution of origin is the probable outcome.[31]

With respect to the type of institutional questions that influence the return of scientists to their country of origin, it is necessary to take into account several factors: First, the financing of work abroad. It has been observed that the proportion of scientists who return to their country is notably greater in cases where funding is obtained through scholarships or special subsidies granted by an organisation of the researcher or the student's own country rather than through self-financing or through the resources of the *host* country.[32] To this it should be added that the majority of such funds are granted under conditions of a signed agreement on the part of the migrant that he will return to his country within a specified period of time. On the other hand, the existence of institutional mechanisms in the country of origin addressing repatriation can also play an important role in the decision-making process, such as those that have been implemented in numerous countries in recent decades, in addition to diverse international organisations which have formulated and introduced aid programmes for the return of scientists to their country of origin.[33]

As a general rule, in all three 'ideal types' the decision concerning the return depends on the evaluation made by scientists of the conditions of the institutional context in their country of origin (including the funding they might obtain if they decide to return and the possibility of securing a permanent and adequate position), the sense of belonging to and identifying with a group and with a particular research tradition, the possibility (or impossibility) of furthering research on topics related to those focused on during the period of study abroad, as well as maintaining connections with colleagues in the international community and the possibility (or impossibility) of effectively utilising, in the country of origin, the symbolic capital acquired abroad. In addition to this, is the complex set of cultural (extra-scientific) identifications and values which imply a greater or lesser attachment of commitment to the country of origin. In the following these problems will be illustrated on the basis of an analysis of a specific case.

Strategies and the Reintegration of Scientists' Reflections Based on a Case Study

The study which will serve to illustrate some of the problems alluded to above was carried out in the laboratory of an institute of molecular biology in Buenos Aires and was part of a larger research project that included the study of laboratories in France and England.[34] It will be demonstrated how the variety of scientific migrations encountered in this laboratory is a central element not only for its initial formation, but also as a crucial determinant of its current configuration.

The institute under investigation was established as a spin-off from one of the most prestigious institutions in Argentina, dedicated to biochemical research and founded by a Nobel Prize winner. The founder and present director of the institute was one of the privileged disciples of this researcher and will hereafter be referred to as L.

The first remarkable fact is that L, who is considered to be a prestigious investigator in the local community, only spent a very short period of time (less than a year) working abroad. He received most of his training in the country, largely under the guidance of the previously mentioned Nobel Prize winner. The reason for this may be found in two types of causes: on the one hand, in the personal scientific history of L, what may be considered a disciplinary leap from his initial training as a medical doctor (during a period in which very few physicians had a doctorate), to obtaining a doctorate in biology, to working in biochemical research, and then, in a new direction, molecular biology. These thematic and disciplinary passages, as part of a strategy, imply, on the part of the researcher, a special effort to adopt to and follow new directions, especially when they appear at the same time as a strategy that strives to be innovative in the local context. In this case, the researcher has considerable commitment to the development of each of these proposed lines of investigation, inasmuch as they appear, on the local scene, as moments of rupture from other more established lines of work.

During the course of these foundational periods, departure for a foreign destination may imply, from the perspective of the actors, a possibility of losing a foothold in the local context, particularly as the opening of new lines of research which strive to be innovative

necessarily encounter spaces of conflict with more traditional sectors. This appears to have been the case with molecular biology, even more evident by virtue of the fact that it involved a relatively new discipline on the international scene.[35]

The other set of causes can be traced back to the context of science in Argentina three decades ago. The biomedical research tradition in Argentina dates back to the early decades of the twentieth century and is one of the areas of greatest visibility in Latin America.[36] During those years, a major part of the training of researchers took place within the country as very few scientists emigrated abroad for short periods of time for either study or research. It should be noted that the institutional mechanisms for financing research only began to be formalised in Argentina during the 1960s when the CONICET, under the presidency of Houssay, offered the first grant opportunities for researchers. In other words, the process of formalisation of scientific research within an institutional framework similar to that of more advanced countries was just being consolidated, and practices such as going abroad for training period were beginning to be implemented in a more diffused manner.[37] Considering both sets of causes, and the fact that L was not a victim of the attacks of the 'night of the long sticks', which marked the exodus of many scientists in 1966, it can be understood that his strategy of development would not have included spending a specified period of time in a laboratory abroad.

The institute under study is divided into nine laboratories, one of which is under the direct supervision of L and the most prestigious researcher (who will be referred to as M) in whom L has the utmost confidence and who occasionally directs the laboratory (L had, when the research was carried out, an important post in an organisation for the promotion of science which took up a significant part of his time). Of the other eight laboratories, seven are under the supervision of researchers belonging to at least one generation subsequent to L's generation: *all* had obtained their doctorate degrees in the country, and *all* had at least a postdoctorate degree abroad. The heads of each laboratory are also known as the '*post-docs*' of the institute.

Of the seven post-docs, two had obtained their degrees in England, four in the United States and one in Germany. Also, two had worked for more than 3 years in France, two were in Switzerland, and two in Spain. The majority of the postdoctorate work

was done nearly 10 years ago. As may be predicted, in the area of molecular biology, the preferred destinations for study were certain countries of Europe (England, France, Germany) and the United States. Of the seven, two had to emigrate for political reasons ('type I') given that, at the end of the 1970s (the military regime came to power in 1976) they were already working as researchers or as postgraduate students and they had at least some degree of political commitment. The other five decided to pursue their post-doctorate studies abroad as part of a strategic type of decision ('type II B'). We will now examine the careers of three of these researchers. For convenience, they will be referred to as A, B, and C.

The first researcher, A, was working as a research assistant at the end of the 1970s under the guidance of a former professor of his on a project in the area of biochemistry. Following the military coup of 1976, due to his political militancy, he was persecuted and forced into exile. At that time, L, who was an eminent professor in the university and an investigator at the institute which he later left, offered A the opportunity of establishing himself in a laboratory in New York. Given the pressing conditions, the arrangements had to be made hastily and, thus, the laboratory in New York was selected because an old friend of L's, an Argentinian researcher, had already been working there for some time. It is necessary to emphasise, in the light of the importance of this aspect of scientific life in Argentina, the fact that L felt compelled to specify the distance between himself (and his closest associate M) and the other researchers of the institute, in terms of political commitment. In his own words,

> . . . here they are all leftist militants. That has been the tradition in Argentina since the 1960's. Everyone, except M and myself; we are rather *right wing*. Still, people are here to carry out research, and so long as they are good researchers, I don't care what they think in political terms. We are very tolerant.

With the assumption of power by the democratic government, scientific institutions were 'normalised',[38] L had already parted ways with his previous institute and had founded the new institute, dedicated specifically to investigation in various branches of molecular biology, generally in relation to the mechanisms for the

detection of *trypanosoma cruzi* (of special significance in Argentina because it is the cause of the Chagas disease[39]). L appointed younger but experienced scientists in his newly established institute (which was, strictly speaking, still a laboratory). A returned to the country following the change of government, motivated fundamentally by affective and family ties and without any type of institutional support. L heard that A had returned to the country and that he had not yet found a job. Although A's experience in the New York laboratory had been in the cultivation of certain cells that bore no relation to the research being carried out at that time in L's laboratory, L proposed that A join the laboratory under the condition that he would develop a new line of research related to the applied biotechnological manipulation of certain plants. There were two (implicit) reasons for this offer: on the one hand, although the research topics previously developed by A were substantially different from the current interests of the laboratory, the application of the techniques that A had learned in the American laboratory could provide a comparative advantage relative to other researchers. And, on the other hand, research in that area was highly promising in terms of the interests of certain companies in financing the aforementioned projects. From A's perspective, the offer provided both advantages and disadvantages: on the one hand, it meant an opportunity to work with one of the groups with the greatest possibilities for growth during that period, with the added symbolic prestige of carrying on the tradition to which L claimed to be heir. But, on the other hand, it required a significant risk, inasmuch as he would have to experience a *rite of passage* toward a topic of which he knew nothing. However, if he was successful, he would be one of the few to develop work in this field, with all the privileges which such a situation entailed. The evaluation of the risks, together with the overriding need for employment, led to the foregone conclusion and A joined the institute where he formed his own research group.

In the case of B, the situation was very different; he was one of L's disciples. At the beginning of the 1980s, he was working on his doctoral thesis under the guidance of L, and once he had completed his thesis, while L was still working as a researcher in his previous institute, they reached an agreement and B left for a university in New York to work on his postdoctoral degree. They had worked out the strategy together and without pressure; they selected a

university where certain lines of research were being pursued that would be of future interest to the research team, they determined a specific duration of time, and it was evident that, upon his return, B would form part of L's team. The funds for the trip were also 'formalised': a scholarship was requested and secured from the CONICET.[40] When B returned, a fundamental change had occurred: L was no longer head of a group within the institute, but was the director of a new institute. B could have directed one of the subgroups of the institute, but, in order to complete his training in the detection of the particular type of virus, he decided to work for a short time in a laboratory in France, again with a scholarship for study abroad granted by the CONICET. At the end of this training, B established his own laboratory in the institute headed by L.

Another researcher of the institute (and also a disciple of L) C, graduated very young and immediately began working in an organic chemistry laboratory specialising in enzymology at the university. He was offered a postgraduate scholarship in the institute of biochemistry directed by the Nobel Prize winner, specifically, in the laboratory of L. As he was still working on his thesis on enzymology, he began to secretly attend the laboratory of L, taking advantage of his vacations to carry out a series of experiments that he himself had planned. It was at that time that the military coup of 1976 took place and the situation in the university was very difficult for anyone, like C, who had a history of political militancy dating back to secondary school. For him, and for the majority of the *post-docs* at the time, the laboratory of L, which depended upon a private foundation, and which revealed L's demonstrated political tolerance, appeared to be a kind of paradise. C consulted the directors of his own laboratory, and they recommended that he move to L's laboratory if he had the opportunity.

Here was an important point of encounter between L and all the young researchers mentioned thus far: *the conviction that one could, and one should, perform science in Argentina*. This conviction bridged the political, as well as the generational barriers that separated these investigators. The origins of these beliefs were varied: for L, it was the result of his adhering to the tradition of the *heavy-weights* of science in Argentina, with whom he had worked and trained. It was not in vain that Houssay himself had said, 'science has no country, but scientists do'.[41] On the part of the

younger generation, this belief was generated by debates that had been taking place in the country since the 1960s focusing on the *commitment* of the scientist to his national reality. This idea of *commitment* was in opposition to that of the *scientism* of those scientists who were only concerned with the development of their own research topics, in tune with the directives of the 'international scientific community'.[42] In the case of a young researcher during the 1970s, this conviction unfolded within the context of an active political militancy in favour of the development of local capabilities (autonomy) in the fields of scientific and technological knowledge, requisite for breaking with the models of *dependence* characterising these models.

In C's experience (representative of a generational movement within a group of researchers of the local scientific community) we see how, already during his formative period, there existed a tendency to *establish oneself in the country* to pursue scientific activity. It is for this reason that C made a great effort to gain entrance, shortly after graduation, to one of the most prestigious institutions of the country. The possibility of emigrating was not, however, closed, but rather implied objectives of mutual consent between the young researcher and his teachers and included, by definition, his return to the same laboratory. Consequently, after having begun work in L's laboratory, when the opportunity to emigrate presented itself, C took advantage of the opportunity, but with the time period well determined in advance. During a course organised in Buenos Aires, C had the opportunity of meeting another of L's old friends who was in charge of a laboratory in Cambridge, England, and he decided to go to Cambridge to pursue his postdoctoral studies; a strategy planned out with L, as C had become one of his closest disciples. Upon his return, L had already established his own institute and C was immediately inducted into this institution, directing his own research group in close collaboration with both L and M. Nevertheless, C had to continue work on the topic that he had been working on in the British laboratory.

In general, the other cases of group leaders have characteristics that combine elements of the three experiences presented thus far. Thus, for example, D was the son of a scientist whom L knew very well, and upon his return from Germany, which was due to circumstances very similar to those of A, D established his own line of research. As a general norm, with the exception of A, all the

present *post-docs* have continued to work along the same lines as dictated by their postdoctoral work. This partly explains the fact that the institute, as a whole, maintains close ties of communication and collaboration with a group of research centres in Europe and the United States, each one of which is highly prestigious on the international scene (such as the centre directed by the Nobel Prize winner, James Watson, the Pasteur Institute, and the MRC of Cambridge).

We will now examine the question pertaining to the conditions present in the constitution of the institute. It is possible to consider that L's strategy of recruitment coincided with the younger scientists' own exhibited strategies, inasmuch as, for a *repatriated* researcher, it is especially interesting to continue work along the same lines of research as had been developed abroad, as for the possibility of accumulating knowledge of a certain topic and as for maintaining active established ties and connections. For L, this strategy permitted him to fulfil two objectives at the same time: on the one hand, to diversify research within the institute in directions considered to be the *hottest* on the international scene, while displaying a set of relations that boosted the institute to the 'level' of the most respected centres in the world. In this sense, it would not appear to be coincidental that the new generation of young scientists has expressed a desire to pursue their postdoctoral studies almost exclusively in the prestigious laboratories of the United States. On the other hand, this strategy was fundamental for attaining greater visibility in the local community, and greater *credibility* which would be converted, through a process of reinvestment, into increased *credit*.[43]

However, the reintegration of emigrant scientists, as a result of L's strategy (that is, to establish his institute by profiting from the return of young 'repatriated' researchers), could not be developed within just any framework. If it was successful, this was due to two additional factors. First, the fact that L's departure from the old institution and the establishment of his own institution had coincided, with just a few months gap, with the restoration of the democratic government which gave a new impetus to research and propitiated the return of a significant number of scientists who had emigrated in accordance with the 'ideal type I'. Thus, for example, during the initial years of operation, L's institute had to cope with a lack of resources for financing, for purchasing equipment, etc. However,

in the following years the institute could count on significant financing for the purchase of equipment and this was one of the most important elements in ensuring the success of the recruitment strategy. It would hardly have been possible for the 'post-docs' to continue work along those same lines of research if they had not been provided some minimum amount of equipment for making it technically feasible.

On the other hand, as a consequence of what was perceived as an agreement or, at least a compromise, between L and the authorities shaping science policy during the military regime (who gave the permission for the creation of the new institute), the fact of having recruited a group of young researchers returning to the country has added significance: this strategy enabled L to be perceived more benevolently by the new democratic government installed in 1983. L's public posture in the local scientific community, and his involvement in negotiations and scientific policy-making in the country, also played a significant role in this strategy. Thus, the present operation of the institute is understood as a 'federation of laboratories', and as a result of an 'implicit contract' between the (conservative) head and the (progressive) post-docs, in order to obtain mutual benefits.

It remains to be explained, with respect to the former *young scientists committed to the national reality*, the way in which they render compatible the growing internationalisation that had oriented their research since their return to the country, that is, the development of lines of research that follow the canons of the industrialised world's centres of excellence, with the declaration, still current, of carrying out science that is committed to local problems. Certainly, this problem is not new for researchers in developing countries, nor will it be easily resolved in the near future: it is in the origin of the problem concerning 'scientific excellence in periphery'. Indeed, most of the young scientists (the 'post-docs') in the institute agreed with anti-scientist principles, especially with respect to taking into consideration the political and social dimensions of research, and the need for carrying out (socially) 'useful' research. But, at the same time, partly as a consequence of the tradition founded by Houssay himself, and partly because of their experience of working in laboratories located in a 'central context', they are compelled to align their research practices to the norms, themes, concepts and methods prevailing in the international scientific community. For

instance, the need for publishing in the most prestigious international journals is a *sine qua non* condition for being integrated into the international community.[44] At the same time, L himself expressed concern about similar types of topics, even if he did not agree to discuss the topic in these terms, as he is a representative of the above-mentioned tradition, and he was also concerned about the 'use' of the 'research results'.[45]

Conclusions

The case presented here is illustrative of some of the effects that scientific migration has had on the local scientific community. In this particular case, it can be observed that the return of a dozen researchers at the beginning of the 1980s played an important role in the origin of the development of 'modern' molecular biology in Argentina. In effect, the director of the institute, in his role as pioneer, was not recognised as a true 'molecular biologist' until the new generation of researchers began to develop new topics, new techniques and to confront new challenges in the field, at a point of rupture with the former model, which was still tied to biochemistry. In this sense, many of the migrations which ended with the return of scientists to the country during the pre-established period ('type II B') had crucial consequences for the development/modernisation of the particular disciplines or areas of research.

Of course, other cases of migration (types I and II A) had consequences for the development of research in the local community. On the one hand, as indicated earlier, some negative aspects can be observed, such as the rupture of intergenerational relations and, at the same time, a breach in the particular *traditions* of the community in question, which was necessarily sustained upon these relations. There is, however, another aspect that needs to be taken into account, and that is the networks which were being established with native scientists working in the research centres of the most advanced countries. In this sense, it is normal that certain ties are maintained, and that researchers receive young scientists in centres in order to carry out their postdoctoral work, or that they act as 'gate-keepers' for scientists residing in their country of origin for the establishment of a more fluid network of international relations. In fact, this empirical study has confirmed

that when a scientist decides to migrate to a foreign country, very often he establishes contact with a compartriot who is working in a similar centre in the USA or Western Europe, or he establishes this contact by visiting the country of a scientist already residing abroad. In summary, the fact that scientists emigrate abroad does not necessarily mean that their ties with the local scientific community have been interrupted or severed.[46]

With respect to the three types of scientific migration identified earlier, it is possible to formulate the hypothesis that a new tendency is emerging in Latin America which reveals the predominance of type III; in other words, the strategies of researchers are tending increasingly towards planning their return to the country of origin over the medium term.[47] Naturally, migrations of longer (or permanent) duration continue to occur in Argentina as in other countries of Latin America. Although it is premature to suppose that this is a consolidated tendency, or to even attempt to explain the phenomenon, it is possible to formulate certain hypotheses. First, some industrialised countries, principal receptors of Latin American scientists, have established limits on the acceptance of foreigners. Second, financing mechanisms put into practice by the countries of origin as well as by international organisations and even receptor countries, have been increasingly granting privilege to stay of fixed duration, in general, in strict relation to the carrying out of a research project within the framework of collaborations or doctoral or postdoctoral studies. In general, these mechanisms establish clauses that require the commitment of returning to the country of origin. Third, the democratic stability that the majority of the countries of the region have been able to maintain in recent years has operated positively with respect to training new generations, not necessarily threatened by political persecution or discrimination, and which have led to the reconstruction, at least in part, of certain research groups which had disintegrated earlier. Certainly, there are marked differences between the countries as well as among the various disciplinary fields.

One last aspect that the study of migrations has the potential of demonstrating with great clarity is the *internationalised* character of scientific practice in contemporary society *versus* the characteristics of the local society, especially when we analyse scientific research in a country which, like Argentina, is far removed from the international centres of greater excellence.

Strictly speaking, the majority of scientists appear to adhere in principle to the *universalist* norm proposed by Merton (1973) some decades ago. Thus, the practice of science as well as its validity appear to be similar, beyond the question of in which country or under which set of national conditions its development takes place. Nonetheless, at least in relation to the developing countries with a certain tradition of scientific research, one can appreciate a significant segmentation between those groups which (for various reasons) are more integrated into the international context, and those that appear to be more isolated in this sense, or more oriented towards the local scientific community. This segmentation is highly correlated to the degree of positive appraisal (prestige, visibility, credit) each group possesses on the local scene. Thus, while one segment of the most *integrated* groups appears to be convinced that they are developing projects similar to those of their peers in *developed* countries, other groups tend to be more aware of their peripheral condition. Differentiated publication in certain journals offers evidence of this type of segmentation.

Although an initial evaluation of the prevailing conditions corresponds to the above perception, an indepth examination of the practices and beliefs reveals that certain nuances are emerging that seriously put in question the type of integration that these groups are effectively achieving in the context of 'international science'. As explained elsewhere (see Kreimer 1997) in a study of a line of research (the study of the human fibronectine gene in collaboration with Cambridge University) of one of the groups that demonstrated *a priori* all the characteristics of the so-called 'international science', that is, excellence and relevance, it became apparent to us that despite appearances, the type of integration this group enjoyed with other centres had objective limitations, as much in the sociopolitical aspects as in the cognitive aspects. In this sense, Gaillard (1991: 137) rightly observed that scientists in developing countries 'find themselves at the heart of a dilemma between their decision to participate in solving local problems and their attraction to models and reference systems more or less imposed by the international scientific community'.[48]

To this it may be added that, in reality, the possibility of attacking and solving *local problems* is not that simple either, inasmuch as financing in the majority of developing countries tends to be guided by the patterns of *quality* in *international science* (and the evaluation of requests is overseen by the most *integrated* groups).

In addition, following the models of greater attraction on the international scene either has limitations (due to multiple restrictions), or the collaborations must be carried out from a subordinated position. Thus, the integration itself into international science acquires, quite often, characteristics that are more imaginary than real.[49] Scientific migrations, in this sense, and the return to the country of origin, have operated to fortify two possible directions for the returning scientist: the first, observed in the empirical study, may be denominated as that of *peripheral international integration*. The second, the scientist's taking advantage of credit and prestige by being associated with a centre of excellence abroad in order to enhance his own decision-making power in the local context, may be denominated as that of *national integration with international isolation*. Both modalities explain, at least in part, the dynamics of science in Argentina in recent decades.

NOTES

1. Already in the 1960s this process was observed in the majority of the countries of the region, and this concern gave rise to studies focusing on *brain drain*. For an analysis of this topic, see Oteiza (1971), as one of the most representative works.
2. This dimension is developed by Kreimer (1997). See also Kreimer (1996).
3. However, readers interested in a deeper analysis may refer to the specialised literature. See, for example, Albornoz (1990), Albornoz et al. (1996), Kreimer (1993), Oteiza (1992).
4. Here, the term 'early' must be understood to convey a double meaning: in relation to other Latin American countries, as well as in relation to the socio-economic modernisation of the country. For an analysis of the relationship between modernisation and scientific development, see Albornoz (1990).
5. This policy had certain disadvantages, but at the same time it signified a crucial influence on the development of certain disciplines, particularly insofar as many foreign scientists resided over long periods of time, or permanently, in the country. In addition, this process figured in the establishment of a 'sociability [intellectual] space', see Myers (1994). Also Babini (1986). Immigration policy may be summarised by the famous phrase of Juan Bautista Alberdi: 'gobernar es poblar' (to govern is to populate). See also Vessuri (1997).
6. Naturally, we can do no more than mention this problem here. For a thorough analysis of the transition, see the excellent article by Buch (1994). For a view of the entire process of institutionalisation, see Vessuri (1997).
7. This characteristic, according to Cueto (1989), is that 'not all the science of the less developed countries is marginal and common knowledge, and that the

scientific work of these countries has its own rules, which must be understood not as symptoms of backwardness or modernity, but rather as part of the culture and its interaction with international science'. See also Cueto (1996); Diaz, Texera and Vessuri (1983).

8. It must be emphasised that scientific activity had, from the very beginning, a constant driving force behind it on the part of the state, as by the end of the nineteenth century the majority of intellectuals and politicians were convinced of the intrinsic value of science as a motor for the welfare of the nation. In other words, science formed part of the discourse and the modernising practices: the epistemological optimism that characterised positivism is a key to understanding the peculiar development of Argentinian science in the nineteenth century, but it also endured into the twentieth century, even up to the present, shaping the institutions and orientations of scientific policy. See Albornoz (1990).
9. In effect, Perón succeeded in turning the majority of the urban middle classes into his natural adversaries during his regime, in part as a consequence of the particular alliance he formed with the worker classes and, in part, because these middle classes professed a particular distrust of everything that they identified as exhibiting *fascist* tendencies.
10. Certainly, this figure declined immediately after the fall of Perón, and rose again in the 1960s. Regarding the effect of the Peronist government on science, Houssay's speech eloquently illustrates this:

> In 1945, the second tyranny discharged or obliged resignations from half of the university scholars, such that the majority of professors were removed from their ambits, the most valuable institutions, established over long years of great effort, disintegrated or languished, the teaching profession was weakened and various generations were poorly educated and without hopes.

See Paladini and Barrios Medina (1990: 401).

11. Vessuri (1995a) has called this period 'the years of developmentalism', which is a general term, that includes not only political meaning (*desarrollismo*), but also ideas on 'economic and social development' raised especially by ECLA (CEPAL).
12. Strictly speaking, before the creation of the CONICET there existed some institutional mechanisms to insure international mobility, particularly in the case of biomedical sciences: fellowships were granted by the *Consejo Deliberante* of Buenos Aires City, the foreign foundations or cooperation agencies, such as the Rockefeller and Guggenheim Foundations.
13. Figures from Sigal (1991).
14. The re-founding, in 1956, of the National Commission for Atomic Energy not only led to the development of important research capabilities in the field, but also the construction of the first nuclear power centres, with significant dependence on locally developed civil technology. To complete the picture, it is noteworthy that, toward the end of the 1950s, two new institutions were created for research, particularly with relation to the productive sector, which

were vital during this period: the National Institute for Industrial Technology (INTI) and the National Institute for Agrarian Technology (INTA).

15. The 'night of the long sticks' (29 July 1966) refers to the violent incursion of the police into the University of Buenos Aires, turning out students and professors from the classrooms, especially in the School of Exact Sciences, where even the Dean was beaten with long sticks by the security forces.
16. Sigal, *op. cit.*
17. For example, the mathematician Manuel Sadosky organised the first computer science group at the University of the Republic of Uruguay once the Calculus Institute of Buenos Aires had been dismantled; see Vessuri (1995a). There are many instances of social science researchers who emigrated to Mexico City and found themselves working together during those years in the Latin American School of Social Sciences (FLACSO), which has one of its branches in that city.
18. According to Cereijido (1990), in 1966, after the coup, a brigadier and an admiral summoned him and ordered him to ignore the expulsion order he had received from the President of the University, as 'the security of Argentina does not depend solely upon whether an invader crosses her borders with a gun in hand, but also upon the independent control of her knowledge, *and that her scientists do not permanently cross her borders toward the exterior*' (1990: 156; italics added).
19. Perhaps the paradigm case is that of the molecular biologist César Milstein, who received the Nobel Prize for his work on monoclonal antibodies at Cambridge University.
20. See UNCTAD (1987). No distinction had been made here between scientific, technical, or professional personnel. Nonetheless, given the magnitude of the figure it is possible to assume that, although only a part of the 'highly qualified personnel' may include researchers, this would still be very significant, inasmuch as emigration to the United States (146,756) and Canada (26,965) has been considered. An even greater number accounts for emigration to Europe.
21. The estimated figure on professionals is derived from SECYT (1994). In this case, it is possible that the figure is an underestimation, given that the information obtained from the consulates takes into account only a part of the total migrations. Corresponding figures on researchers of the CONICET are obtained from CONICET (1989). Oteiza (1996) has given other figures: between 30,000 and 50,000 Argentinian university level scientists and technicians living abroad. Although he does not mention his source, it can be surmised from the differences in magnitude with respect to the SECYT that the base definition he used must be distinct.
22. As indicated by Gaillard (1994), there is a strong correlation between the acceptance of an offer of a permanent position and the number of years spent abroad. See also Halary (1994).
23. See Subodh et al. (1995).
24. It is not possible here to elaborate on the important conceptual differences that these definitions imply. The concept of scientific capital (or symbolic) was developed by Bourdieu (1976); and along similar lines of analogy with a quasi-economic function, Latour and Woolgar (1982) proposed the notion of credit/credibility. Both notions have been criticised by Knorr-Cetina (1981, 1982). For an analysis of these concepts, see Kreimer (1994).

25. As a representative of this focus, see the study undertaken by Charles Kidd from the offices of the OAS. For a discussion of this focus, see Adams (1968); Oteiza (1971). See also Subodh et al. (1995).
26. This topic has been developed by Oszlak and Caputo (1973), Oteiza (1971), among others. For a recent discussion see Jamison (1994), Kreimer (1993), Saldaña (1992), Vessuri (1994).
27. The fact that the institutional hierarchies do not permit an investigator who has carried out part of his work abroad, access to higher posts in research institutes (university or otherwise) relative to those which he had occupied before his departure could have a negative bearing on the analysis of a possible return. In some cases, these structures tend to be quite rigid, and scientists who emigrate face tremendous difficulties in *establishing their own group* upon their return.
28. In the case of countries whose scientists migrate as a mass phenomenon, one study carried out several years ago recommends careful observation of the *training* process of any given country, as well as analysis of whether the number of trained professionals is not *in excess* of the number of alternatives available in the job market. According to this study, this factor is more important than the degree of development of the country, see Glaser (1978). In any case, it is necessary to relativise this proposition, inasmuch as the excess of professionals cannot be considered as an invariant, given that the dynamics of social institutions (public and private) could be driven (as has been verified in various cases) precisely by the abundance of professionals and, thus, undergo development upon this base.
29. Objections may be raised to types 'II A' and 'II B' on the grounds that they can only be distinguished *ex-post*. Our response is that, first, in all cases, given the characteristics of the empirical study, the proposition of the 'ideal types' must necessarily be an *ex-post* relative to the investigation of the laboratory in question, although it must be remembered that these types were constructed basically taking into account the *motivations* dominant in the decision to emigrate. As in all interpretative analyses, the proposal cannot extend beyond its own limitations. And, second, it may be mentioned that, given that these are ideal types, inspired by Weber, they permit transformations and shifts from one to another, just as Weber himself (in *Economy and Society*) permitted; for example, the 'Routinization of Charismatic Domination'.
30. Other possible motives for returning have not been taken into account here, such as the possibility of having met with failure in the host country (including not having secured resources for prolonging stay in the host country), or having had to leave the country for reasons beyond one's control (political or racial).
31. See, for example, the articles included in Crawford, Shinn and Sörlin (1992).
32. Glaser (1978) uses as his base a study carried out by UNITAR on emigration and return to the country of origin.
33. Among the national programmes were the Program of Training, Finishing and Reintegration of Research Personnel of Spain, the PROCITEXT of Argentina, or the PEDECIBA of Uruguay and, with respect to outstanding international organisations, the Program TOKTEN of the United Nations Program for Development (UNDP), the different programmes of the International Office of Migration (OIM), or the Program for the Return of Talent (ROT) of the Inter-Gubernatorial Committee for Migrations (CIM). These programmes offer

different types of aid, ranging from payment for return travel to scholarships for reintegration into the country of origin for a specified period of time.

34. For the general characteristics of this research project, see Kreimer (1997). Detailed information of the institution, such as the names of the investigators, are kept confidential as part of the agreement with the Director of the institute. The Nobel Prize winner referred to here is Dr Luis F. Leloir.
35. Houssay himself encouraged young scientists to emigrate, *but only for short periods of time*. See Paladini and Barrios Medina (1990).
36. In this regard, see Buch (1994); Cueto (1989, 1996); Vessuri (1995a, 1997).
37. However, it is true that there already existed some mechanisms for financing study trips through some institutions in the international sphere, such as the Rockefeller Foundation, in addition to financing offered by the institutions themselves in the receptor countries. For a recent panorama of the research environment during those years, see Cereijido (1990).
38. The functioning of the CONICET, as well as the University, is based on the election of representatives. In the University, the governing body ('Consejo Superior') is composed of professors, students and graduates who elect the rector. In the CONICET, the researchers elect a part of the directorship and also nominate the candidate for president, to be approved by the authorities. These institutions, during the period from 1976 to 1983, were controlled by the political (military) powers.
39. For a parallel analysis of the 'Chagas disease' community in Brazil, see Coutinho (1996).
40. It is important to note that the rules for the granting of scholarships for study abroad by this organisation require not only the commitment to return to the country, but also indication of which institution the solicitant will return to and work for thereafter (for a period of time no shorter than that which the solicitant spent abroad), to be certified by the said institution.
41. See Paladini and Barrios Medina (1990).
42. O. Varsavsky was among those who expressed this opposition more clearly. He considered that a number of scientists were working under the norms and values of the international scientific community, without taking into account the social and political conditions under which the research took place and were disregarding the possible social use of the produced knowledge. This was known as '*cientificismo*', which Varsavsky attacked while proposing a 'committed' science in its stead. See Varsavsky (1969: 14–37).
43. Significantly, during the mid-1980s, L was elected as Deacon of the prestigious School of Exact Sciences of the University of Buenos Aires, the same institution which, two decades earlier, had been a victim of the *night of the long sticks*.
44. For a development of this argument, see Kreimer (1997).
45. In fact, most of the research projects satisfy the dual condition of fulfilling requirements for obtaining a positive evaluation by the research institutions, as well as fulfilling numerous contractual obligations with private companies who wish to obtain the investigative results. For a recent discussion among scientists on this topic, see the *Dossier* in *REDES*, (3), 1995. Vessuri (1995b) has presented several instances of relationships between academic actors and the private sector in Venezuela and Brazil.

46. On the contrary, in many cases scientists living abroad serve as links between their colleagues in the country of origin and institutions of excellence in the more developed countries. Some authors have proposed that this 'Diaspora' model can have important effects. See, for instance, Meyer and Charum (1995) and Gaillard and Meyer (1996).
47. Certainly, type III is not new to the country: during the 1958–66 period, a large number of the most qualified scientists followed this. However, an evaluation of this situation is difficult because of the military coup of 1966, which resulted in the extension of many researchers' stay abroad and, thus, distorted the prevailing tendency.
48. It is necessary to note that, in part due to the heterogeneity, it is difficult to establish general considerations, given that the situations in the countries with the greatest research traditions, principally Brazil and Argentina, followed by Venezuela and Chile, present challenges qualitatively and quantitatively different from those in other countries. See also Salomon et al. (1994).
49. A recent study by an anthropologist shows how one of the most prestigious research groups in Argentina (heirs to the tradition of the Noble Prize winner, Leloir) had to suffer the consequences of what the astonished researchers themselves discovered to be discrimination. In the case studied, the contribution of the local group was ignored and only recently an article was accepted for publication in an international journal when the data were validated by an article written by a group from an American university which had been received later, but published first. For a complete description of this interesting process, see Hernández (1994).

REFERENCES

ADAMS, W. (1968), *The Brain Drain*. New York: Macmillan Company.

ALBORNOZ, M. (1990), 'Consideraciones históricas sobre la política científica en Argentina', in M. Albornoz and P. Kreimer, eds, *Ciencia y Tecnología: Estrategias y políticas de largo plazo*. Buenos Aires: EUDEBA.

ALBORNOZ, M. and P. KREIMER, eds (1990), *Ciencia y Tecnología: Estrategias y políticas de largo plazo*. Buenos Aires: EUDEBA.

ALBORNOZ, M., P. KREIMER and E. GLAVICH (1996), *Ciencia y Sociedad en América Latina*. Buenos Aires: Editorial de la Universidad Nacional de Quilmes.

BABINI, J. (1986), *Historia de la ciencia en la Argentina*. Buenos Aires: Hachette.

BOURDIEU, P. (1976), 'Le champ scientifique', *Actes de la recherche en sciences sociales*, (1–2).

BUCH, A. (1994), 'Institución y ruptura: la elección de Bernardo Houssay como titular de la cátedra de fisiología de la Facultad de Ciencias Médicas de la UBA'. *REDES*, 2(2), pp. 161–80.

CEREIJIDO, M. (1990), *La nuca de Houssay. La ciencia argentina entre Billiken y el exilio*. Buenos Aires: Fondo de Cultura Económica.

CONICET (1989), Aportes para una memoria. Panorama General. Buenos Aires.

CONTRERAS, C. (1993), 'Una estrategia de recuperación de recursos humanos en ciencia y tecnología', in E. Martínez, ed., *Estrategias, planificación y gestión de ciencia y tecnología*. Caracas: ILPES/CEPAL/CYTED/UNESCO/Nueva Sociedad.

COUTINHO, M. (1996), 'Basic Research in Chagas Disease: Laboratory Cultures in Brazil'. Paper presented at ESOCITE 96, Caracas.

CRAWFORD, E., T. SHINN and S. SÖRLIN, eds (1992), *Denationalizing Science. The Contexts of International Scientific Practice*. Sociology of Sciences Yearbook, Volume XVI. Dordrecht/Boston/London, Kluwer, Academic Publishers.

CUETO, M. (1989), *Excelencia cientifica en la periferia. Actividades cientificas e investigacion biomedica en el Peru, 1890–1950*. Lima: GRADE.

——— (1996), 'La excelencia de las ciencias biomédicas del siglo XX', in J.J. Saldaña, coord., *Historia social de las ciencias en América Latina*. México: Grupo Editor Miguel Angel Porrúa.

DÍAZ, E., Y. TEXERA and H. VESSURI (1983), *La ciencia periférica*. Caracas: Monte Avila.

GAILLARD J. (1991), *Scientists in the Third World*. Lexington: The University Press of Kentucky.

——— (1994), 'The Behavior of Scientists and Scientific Communities', in J.J. Salomon, F. Sagasti and C. Sachs-Jeantet, eds, *The Uncertain Quest: Science, Technology, and Development*. Tokyo: The United Nations University Press.

GAILLARD, J. and J.B. MEYER (1996), 'Le *brain drain* revisité: de l'exode au réseau', in J. Gaillard, ed., *Coopérations Scientifiques Internationales*. Paris: ORSTOM Editions.

GLASER, W.A. (1978), *The Brain Drain: Emigration and Return*. Oxford: Pergamon Press.

HALARY, C. (1994), *Les exilés du savoir: les migrations scientifiques internationales et leurs mobiles*. Paris: L'Harmattan.

HERNÁNDEZ, V. (1994), 'Eureka, un *paper*! Producción, propiedad y autoría científica', *REDES*, 1(1), pp. 145–58.

JAMISON, A. (1994), 'Western Science in Perspective and the Search for Alternatives', in J.J. Salomon, F. Sagasti and C. Sachs-Jeantet, eds, *The Uncertain Quest: Science, Technology, and Development*. Tokyo: The United Nations University Press.

KNORR-CETINA, K. (1981), *The Manufacture of Knowledge*. Oxford: Pergamon Press.

——— (1982), 'Scientific Communities or Transepistemic Arenas of Research? A Critique of Quasi-economic Models of Science', *Social Studies of Science*, 12(1), pp. 101–30.

KREIMER, P. (1993), 'Science, politique et information en Argentine: Un billet aller-retour entre Harvard et le Tiers Monde'. *Nouvelles de la Science et des Technologies*, 11(1).

——— (1994), 'Estudios sociales de la ciencia. Algunos aspectos de la constitución de un *campo*', *REDES*, (2).

——— (1996), 'Science and Politics in Latin America: The Old and the New Context', *Science, Technology and Society*, 1(2), pp. 267–89.

——— (1997), 'L'universel et le contexte dans la recherche scientifique. Etudes comparative des laboratoires'. Thèse de doctorat. Paris: CNAM/STS.

LATOUR, B. and S. WOOLGAR (1982), 'The Cycle of Credibility', in Barry Barnes and David Edge, eds, *Science in Context: Readings in the Sociology of Science*. Cambridge: The MIT Press.

MERTON, R. (1973), *The Sociology of Science. Theoretical and Empirical Investigations*. Chicago: The University of Chicago Press.

MEYER, J.B. and J. CHARUM (1995), 'La "fuite des cervaux est-elle epuisée"?', *Cahiers des Sciences Humaines*, 31(4).

MYERS, J. (1994), 'Sísifo en la cuna o Juan María Gutiérrez y la organización de la enseñanza de la ciencia en la Universidad argentina'. *REDES*, 1(1), pp. 113–32.

OSZLAK, O. and D. CAPUTO (1973), *La emigración de personal médico de América Latina a Estados Unidos. Una interpretación alternativa*. Buenos Aires: Organización Mundial de la Salud.

OTEIZA, E. (1971), 'Un replanteo teórico de las migraciones de personal altamente calificado', in *El drenaje de talento*. Buenos Aires: Paidós.

———, ed. (1992), *La politica de investigacion cientifica y tecnologia en Argentina. Historia y perspectivas*. Buenos Aires: Centro Editor de America Latina.

——— (1996), 'Drenaje de cerebros. Marco histórico y conceptual'. *REDES*, 3(7), pp. 101–20.

PALADINI, A. and A. BARRIOS MEDINA (1990), *Escritos y discursos del Dr. Bernardo Houssay*. Buenos Aires: EUDEBA.

SALDAÑA, J.J. (1992), 'Acerca de la ciencia nacional', in J.J. Saldaña, ed., Los orígenes de la ciencia nacional, *Cuadernos de Quipu* (4), UNAM.

SALOMON, J-J, F. SAGASTI and C. SACHS-JEANTET, eds (1994), *The Uncertain Quest: Science, Technology, and Development*. Tokyo: The United Nations University Press.

SECYT (1994), Programa Nacional para la vinculación con científicos y técnicos en el exterior (PROCITEXT). Buenos Aires: Dirección Nacional de Asuntos Internacionales.

SIGAL, S. (1991), *Intelectuales y poder en la década del sesenta*. Buenos Aires: Puntosur.

SUBODH, M., V.V. KRISHNA, E. HARIBABU, V. JAIRATH and A. BASU (1995), *Scientific Communities and Brain Drain. A Sociological Study*. New Delhi: Gyan Publishing House.

UNCTAD (1987), Tendencias y situación actual de la transferencia inversa de tecnología. Geneva: UNCTAD.

VARSAVSKY, O. (1969), *Ciencia, política y cientificismo*. Buenos Aires: CEAL.

VESSURI, H. (1994), 'La cooperación científica internacional, la política y la negociación de la evaluación "experta"', in H. Vessuri, ed., *Ciencia, tecnología y sociedad en América Latina*. Caracas: Nueva Sociedad.

——— (1995a), 'La ciencia académica en América Latina en el siglo XX'. *REDES*, 2(2), pp. 41–76.

———, ed. (1995b), *La academia va al mercado. Relaciones de científicos académicos con clientes externos*. Caracas: Fondo Editorial Fintec.

——— (1997), 'Bitter Harvest: The Growth of a Scientific Community in Argentina', in J. Gaillard, V.V. Krishna and R. Waast, eds, *Scientific Communities in the Developing World*. New Delhi: Sage.

The Uruguayan Basic Scientists' Migrations and Their Academic Articulation around the PEDECIBA[1]

ADRIANA BARREIRO and LÉA VELHO

The so-called 'Programa de Desarrollo de las Ciencias Básicas-PEDECIBA' (Basic Science Development Programme) was launched in Uruguay at the end of the 1980s in order to make possible the rearticulation of the local basic scientists' academic community. The whole system of science and technology was highly affected by thirteen years of military dictatorship. One of the main objectives of the basic science community, during the redemocratisation process, was to create the conditions for the consolidation of a permanent infrastructure for the development of basic sciences, namely, Biology, Chemistry, Information and Computer Science, Mathematics and Physics.

One of the basic conditions in order to attain that goal was the repatriation of a great number of the Uruguayan scientists who had left the country during the 1970s. It is important to point out that Uruguayan scientists who lived abroad had expressed a desire to return to their country, and to collaborate with their peers who had remained in Uruguay to develop a collective and self-managed effort.

In this paper migration waves observed within the Latin American scientific community and those related to the exodus and return of Uruguayan basic scientists are discussed; exploring the reasons, motives and assumptions underlying the return of scientists. Furthermore, some data are presented to help understand PEDECIBA's significance both in terms of the rearticulation of the knowledge generation system and in the reconstruction of the basic sciences' environment.

Adriana Barreiro is Assistant Professor at the Sectorial Commission for Scientific Research (CSIC), University of the Republic, Uruguay; and doctoral student in the PhD Programme on Science and Technology Policy, State University of Campinas/UNICAMP, Caixa Postal 6152, 13083–970, Campinas, SP, Brazil.

Léa Velho is Associate Professor and Director of the Department of Science and Technology Policy, State University of Campinas/UNICAMP, Caixa Postal 6152, 13083–970, Campinas, SP, Brazil.

Science, Technology & Society 2 : 2 (1997)

SAGE PUBLICATIONS NEW DELHI/THOUSAND OAKS/LONDON

Introduction

THE PROBLEM OF migration has been the subject of numerous analyses due to its significant effects on different aspects of social life. In addition to the economic and labour implications of migration movements, their importance as a central element in the internal dynamics of the different local communities and geographical regions should not be overlooked. Likewise, understanding the processes occurring in different contexts has been a central topic of analysis all over the world, with particular emphasis on the design of models that could explain, especially in Latin America, the reasons and circumstances that motivated the migratory peaks characteristic of the 1970s and 1980s.

In spite of this, it is interesting to note that the focus on the exodus of scientists, or more generally skilled personnel, in recent literature on international migration has been significantly less than on the analysis of mass movements of population. Evidence of this is provided by Pellegrino and Cabella (1996: 2), who point out that

> in the POPLINE bibliographic base developed by the John Hopkins University only 252 of the 6,771 records on international migration for 1975–1995 refer to an intellectual exodus. Similarly, in the DOCPAL analysis compiling data for Latin America, only 20 of the 1,400 records for 1972–92 refer to international migration of talents. Moreover, the cumulative index of the International Migration Review (1954–89) has only 4 headings specifically dealing with 'brain drain' and 6 with 'professionals'.

Migration of highly qualified personnel is known to be of utmost significance for the current development of scientific and technological activities in Uruguay. Starting from such an assumption this study examines the community of basic scientists given their particular articulation around the so-called 'Programa de Desarrollo de las Ciencias Básicas' (Basic Sciences Development Programme, henceforth PEDECIBA). To begin this analysis some special features of the successive waves of Uruguayan qualified migrants will be discussed. Then the discussion will focus on the reasons that, according to the scientists themselves, induced them to return to Uruguay.

The migrations which took place during the 1970s and 1980s were a result of the dictatorial regime which came to power in Uruguay in 1973. Particularly noteworthy are the implications of the new political atmosphere on teaching practices and on the dismantling of the local scientific system in view of the exodus of contingents of eminent scientists and researchers who left the country to do work in other latitudes.

When the opportunities for reversing the adverse conditions appeared, the Uruguayan community of basic scientists undertook the rearticulation of the knowledge generation system through the creation of PEDECIBA. This programme emerged in the mid-1980s as an outcome of the decisive intention to establish and consolidate a stable infrastructure aimed at strengthening an interdisciplinary research system in the following basic sciences: Biology, Chemistry, Information and Computer Science, Mathematics and Physics.

The establishment of the programme was an achievement by itself since, still during the period of the authoritarian regime, an increasing number of scientists germinated and were able to carry on the programme. These include recovering the time lost for scientific activities for more than a decade; establishing contacts with international organisations in order to obtain support and make the programme viable; giving prominence to graduate education as a means of training human resources through the creation of the first and only Master's and doctoral programmes in the country; reaching a critical mass for research which would make possible the generation of knowledge and the original creation in frontiers of knowledge; and restoring the exercise of a scientific practice intended to achieve academic excellence in Uruguay (PEDECIBA 1985).

It is worth emphasising that the establishment of PEDECIBA was a particularly significant event not only because it was the result of an agreement between the Ministry of Education and Culture and the University of the Republic, but also, and mainly, because of the unique structure which it received from the scientists themselves. Such a structure included a concern for the university tradition of direct democracy and for the creation of a space that would serve as a nucleus around which both the scientists who had remained in the country during the military dictatorship and those who had migrated and were working abroad could combine their efforts.

Some general aspects and some data on the emigration of Latin American scientists during the 1970s and 1980s will be discussed here. This information, we believe, may provide the reference and the framework to understand the exodus and return of Uruguayan scientists.

This is followed by an analysis of what some participants and 'top personnel' of PEDECIBA—decision makers and first level researchers[2]—have said about their own motivations to return to Uruguay as well as the significance of the programme in this process. Basically, the aim is to find an answer to two different but related questions: Why and for what purpose to return? How and by what means to make such return a reality? Finally, data on the impact of PEDECIBA on the training of future scientists since its inception up to the present are presented.

Departures and Returns

The Migration of Latin American Scientists

The analysis of the trends in international migration of Latin American scientists is a current concern of scholars from different disciplines: demography, sociology, etc. They consider the study of this phenomenon to be decisive for what it implies in terms of 'brain drain'. Consequently, they believe that it is necessary to frame the question within the current historical context and to provide a sustainable theoretical approach for an enhanced understanding of the phenomenon.

The exodus of qualified personnel became a subject of study in Latin American countries many years ago. Pellegrino (1993) points out that in the pioneering works reference was made to the extent and importance of emigration to the US. In a recent study, she has referred to data provided by the Latin American Center of Demography (CELADE) about the percentage variation, seen between 1970 and 1980, in professionals and technicians of Latin American origin living in that country. These data are partially reproduced in Table 1. The data reveal not only the number and variation of Uruguayans in the group of emigrated professionals, but also the fact that they recorded the highest rate of increase among professionals coming from neighbouring South American countries.

TABLE 1
Professionals and Technicians of Latin American Origin Living in the USA (Censuses 1970 and 1980, USA)

Countries of Birth	*1970*	*1980*	*Percentile Variation*
Argentina	4882	7766	59.1
Brazil	2138	3474	62.5
Chile	1984	1809	−8.8
Uruguay	488	919	88.3

Source: Pellegrino (1993). Derived from annexures.

The lack of complete and detailed statistics on the migratory phenomenon makes the analysis and assessment of its impact on the development of Latin American countries somewhat difficult. On the basis of data provided by the Immigration and Naturalization Service of the United States of America, Cardoza and Villegas argued that in the three decades from 1961 to 1990 approximately 500,000 professionals and highly qualified personnel from the countries of the region emigrated to the US. In addition, they underline that

> it is legitimate to think that this tendency may have accentuated with the aggravation of the economic crisis during the 1990s since productive investments that generate employment have been reduced and important reductions in the research and development budgets in some countries of the region have been made (Cardoza and Villegas, 1996: 4).

During the past decades migration was due to several and diverse causes and purposes that it is difficult to establish the limits between the political and the economic reasons that promoted emigration from different countries in South America and the Caribbean area. Examples are migrations from Cuba during the 1960s and from Argentina, Chile and Uruguay during the 1970s. More recently, as the policies of various governments indicate the tendency to promote migration has declined. Their tendency is to introduce programmes for temporary migration targeted to specific market demands. The programmes of 'selective migration' for highly qualified workers are currently well established in developed and

developing countries; and, as has been suggested by Pellegrino (1993: 9),

> . . . we need to be prepared to modify our present ideas in relation to what must be considered as international migration. The development of transportation and communication systems will allow a greater incidence of transitory mobility. It is possible now to think of labor mobility evolved without residence changes and of tasks performed by direct connections to neuralgic centers through telemetric communications. This modality of technology and information transfer does not necessarily entail people's displacement.

International programmes exist to encourage the return and reincorporation of skilled migrants to their countries of origin. Most of them have been successful and Marmora points out that so is the programme introduced by the International Migration Organization (IMO) at the request of its member states. This programme is based on the idea that international migrations may be an important socio-economic factor that could contribute to evolution in developing countries much like the evolution between 1970 and 1989, where over 11,554 people returned to Latin America. Besides that,

> a mass exodus occurred following the military dictatorships of the 1970s and 1980s. Examples of this are the emigration rates during the last fifteen years: in Argentina 0.98–1.3 per cent of the population had emigrated between 1970–1985 and in Uruguay the figure varies from 10 to 13 per cent . . . . In Central America, displaced persons and refugees range from 250,000–600,000 in Guatemala, 350,000–500,000 in Nicaragua, and 1,100,000–1,600,000 in El Salvador. The return of democracy to these countries brought back most of these exiles although, in general, there are no efficient mechanisms for their repatriation (Marmora 1996: 21).

In most Latin American countries, and specially in those traditionally considered as receptors of immigration, there was during the 1965–85 period an outstanding increase of migrants from other Latin American countries. Data presented in the research report 'Professionals and Technicians Born in Latin America and

the Caribbean Living in Latin American Countries Others' from Those of Birth and in the USA', show that migration to other countries in the region was higher than that compared to the USA. That is specially true in the case of bordering countries where the mobility has a structural character and where the displacements were intensified by the magnitude of specific conditions, for example, the Uruguayan scientists who flew to Argentina immediately after the military dictatorship assumed power in 1973.

It is also important to recall that South American nations have maintained, to a greater extent than Central American and Caribbean countries, permanent cultural and economic ties with Europe thereby creating another pole of attraction for scientists. Other reasons, related to the economic and political circumstances, have also led to occasional waves of migration; for example, in the case of the dictatorial regimes installed in Argentina, Chile and Uruguay. In Uruguay, the migratory trend had begun some years before as a result of a severe economic crisis and the deterioration of the political situation. During 1974 and 1975 the rate of migration was so high that the absolute population figures diminished in the whole country and particularly in the capital city, Montevideo.

In relation to the economic circumstances, it is important to point out that

> the increase of oil prices in the international market caused the development of an unusual economic growth in oil exporters' countries in the region. Venezuela[3] took the place of Argentina as the most important migrant receptor in Latin America followed, to a lesser extent, by Ecuador and Mexico. Even if this phenomenon can not be compared with the one in the Middle East, it is evident that oil prices influenced the direction and composition of migratory movements in the region (Pellegrino 1993: 12).

Within the framework of these general considerations, the mobility of qualified human resources inside the region can be explained by different factors, some of them typical to the 1970s, others following long-term structural trends. In the first case, we can include Venezuela. Following its transformation it attracted migrants and it implemented specific policies to incorporate qualified human resources. It is equally important to point out that the various dictatorial regimes established in the southern part of the

continent at that time, promoted not only the persecution of political opponents, but also the destruction of the educational and research systems. The consequence was the inclusion of a large number of scientists, professors, technicians and other members of the Academia in the flux of qualified emigrants.

Exodus and Return of Uruguayan Scientists

Uruguay, the country of emigration is, since the last few decades, a well known statement often used to describe this small South American country, because of the fact a large percentage of its original population lives permanently elsewhere. In the first half of the twentieth century, Uruguay was considered to have a privileged economic and social situation because of decades of political stability and remarkable development. Nevertheless, economic difficulties appeared in the 1960s giving rise to a major emigration movement. This situation was exacerbated in the 1970s following the establishment of the military dictatorship in the country. At the end of that decade the number of Uruguayan émigrés reached the annual and dramatic figure of 30,000, a very high proportion considering the total national population of 3 million people.

Different countries facing similar crisis situations developed different migration trends. In the case of Argentina and Uruguay there are political and historical factors which influence the current situation of the emigration phenomenon. The population formation in these countries had its origin in the successive waves of European migrants, basically Spaniards and Italians but also Armenians and Jews among others. This background influenced the tendency to consider emigration as an actual alternative among a spectrum of possibilities available not only at the individual level but also at the collective imagery of these societies.

In the case of Uruguay, and particularly relevant to the scientific community, the development of the educational system catalysed the opportunities for people to find better prospects elsewhere. At the same time, this development led to the possibility of considering education as a factor of social mobility. However, the inconsistency between the expectations and its viability, the small volume of investments to retain qualified human resources, the economies of scale, and the problems stemming from the dictatorial regime, all contributed to a significant emigration wave.

The number of Uruguayan professionals and technicians living in other Latin American countries in the 1980s is shown in Table 2.

TABLE 2
Professionals and Technicians Born in Uruguay and Living in Other Latin American Countries and in the Caribbean Area (around 1980s)

Country (Year)		*Country (Year)*	
Argentina (1980)	4372	Ecuador (1982)	80
Brazil (1980)	1596	Costa Rica (1984)	36
Venezuela (1981)	740	Bolivia (1976)	19
Paraguay (1980)	202	Panama (1980)	14
Chile (1982)	133	Guatemala (1981)	10

Source: Pellegrino (1993). Derived from annexures.

In order to estimate the number of Uruguayan professionals returning from Europe, we will refer to data provided by the National Repatriation Commission. This organisation was created at the governmental level in March 1985 with the purpose of facilitating and supporting the return of those Uruguayans who wished to do so. The total number of people assisted by the Commission was 14,004 and this figure included repatriation of family groups, including teenagers and children. The data are analysed in the Report on Assisted People produced by the Commission (Comisión Nacional de Repatriación 1989: 4–6). It provides evidence that those who returned were from the following geographical areas: neighbouring countries (26.5 per cent), other countries of South America (8.5 per cent), Central America and Mexico (13.0 per cent), the United States and Canada (2.7 per cent), Europe (41.4 per cent), Israel (0.6 per cent), Australia (1.9 per cent), Asia and Africa (0.4 per cent), others (5.0 per cent).

It is important to note that 75 per cent of the total number of repatriated people came from the following countries in Latin America: Argentina (22.0 per cent), Brazil (4.5 per cent), Cuba (3.7 per cent), Mexico (7.5 per cent), and Venezuela (5.9 per cent); and in Europe: Spain (7.5 per cent), France (6.8 per cent) and Sweden (16.8 per cent). The remaining 10.3 per cent included in the 41.4 per cent returning from Europe were from Belgium, Denmark and England. But even more important is the fact that of the total number of adults assisted by the National Repatriation

Commission, 2,167 had a university degree before emigrating, 1,822 had completed their undergraduate studies after leaving the country, and 36.5 per cent of those who returned had completed their graduate studies while abroad. It should also be pointed out that of those repatriated by the CNR, 3,989 were university professionals at the time of returning to the country and at least 2,230 had a doctoral degree.

Assuming a considerable margin of error—that the distribution of Uruguayan professionals in the countries indicated above is the same as that for the total number of those assisted by the Commission—it is possible to estimate the number of professionals who lived in other countries and regions, specifically in Mexico (299) and in Europe (1,651). Handling a different kind of data, namely, professionals counted as living in some Latin American countries and in the USA around 1980 and estimates of professionals returning from Mexico and Europe between 1985 and 1987 by the CNR, we can arrive at some approximate values. At least 10,071 professionals were living abroad, 2,230 of them had a doctoral degree.[4]

According to Francisco Sagasti and Cecilia Cook (1985: 20), and in order to justify the common or frequently used concept of a 'massive exodus', it is important to note that in 1980 there were 1,500 scientists and engineers engaged in research and development activities in Uruguay.[5] Even if the 2,230 doctors living abroad did not necessarily perform those type of activities, when their number is added to the other returning professionals (7,841) one can realise the importance and quality of the Uruguayan human resources distributed around the world over the years. Many of them did return to the country; we will discuss their reasons and expectations for their decision to return.

Motivations Inducing the Return of Scientists

As seen earlier, many of those who left Uruguay either pursued higher studies (doctoral and postdoctoral degrees) or completed their undergraduate studies abroad. Before emigrating, those who were already engaged in research, they completed their courses and either obtained an MSc or had a specialisation.

Most of the people who completed their education beyond the country's frontiers can be grouped into one of the following categories: being too young at the moment of emigration, being deprived

of liberty for political reasons (political prisoners) or deliberately and freely choosing to go abroad to pursue specific courses not offered by the Uruguayan university system.

The fact is that in one way or another, leaving the country resulted in knowledge enhancement of the emigrants. Thus, both at the individual and at the collective levels, the Uruguayan scientists who were located all over the world in a sort of national diáspora, developed a new scientific vision through shared experience and interrelationship with foreign colleagues. In addition, working in environments or loci with different practices and attitudes from the ones current in Uruguay was another factor contributing to major intellectual improvement. This was translated into the development of certain research lines or disciplinary approaches that previously did not exist in the country.

Following the return to democracy there was a renewed concern for science and technology. There was also a renewed concern about the future of the country and the actors involved oriented their interests through paths that had to be reconstructed after many years of compulsive interruption. The scientific community was activated as soon as there was an indication of a return to democracy. Researchers in different fields joined back institutions in a sort of spontaneous affinity which in turn facilitated the return of other scientists who were abroad, showing their concern for a country that was left in the periphery of the scientific and technological advances achieved in the world.

In this context the establishment of PEDECIBA highly favoured the solidification of the process, not only because it offered conditions for the return, but also because it created the opportunity for the organisation of joint activities and projects. In fact, most of the interviewed researchers indicated the importance attached to this project.

> I returned after the PEDECIBA was created, because all science was being recreated in Uruguay; and that helped me to return, thinking that I had to and could collaborate. There was a promise that it was going to be possible to make science. Even international organizations like UNDP and UNESCO were participating in that effort.

It was observed that although in some cases the motivations that induced the Uruguayan scientists to return to the country were

individual, in others they had a collective nature. The latter was seen in the case of academic communities which had been almost fully transplanted to other places. For instance, the group of mathematicians who remained anchored in Venezuela. The actors themselves gave an account of the existence of a sort of articulated group that discussed and decided on the options and intentions that determined not only the individual destiny but also the academic objectives of the group.

> The exile was due to political reasons and lasted the same time that lasted the impossibility to return to the country for political reasons, a little more than ten years. The group of mathematicians was not only a group of friends but also a group who felt that had a mission to fulfill. They saw themselves as the old Institute of Mathematics (founded years ago by Rafael Laguardia), in exile, and the possibility arose of re-establishing it and to have a common project, not being anymore just a small group. The PEDECIBA project was then immediately discussed and the intention to return and recreate mathematics activities in the country, was adopted (from the interview data).

Even though the researchers who had remained in the country during the dictatorial regime, did not effectively establish themselves abroad, they had strong links with what was happening beyond the country's frontiers. Such links, to a large extent, were due to the good relationships between young researchers, who did not emigrate, and their former advisors and professors, who fled the country. This is clearly revealed by the following statement from the interview data:

> Although I stayed in the country, the presence of my professor abroad meant a sustained support for my work here; his backing from Mexico was decisive for many of the things I was able to obtain, like traveling abroad and fellowships. Thus even remaining in the country during the dictatorship period I was a recent graduate that had the opportunity to travel and to make several sojourns in France. My situation is that of a scientist that worked in Uruguay under severe isolation but with certain support from people living abroad (from the interview data).

Returning to the analysis of the motivations for coming back to their country, it is obvious that even though the emigrants enjoyed

better working environments than the one they were likely to find in Uruguay, most of them never doubted that they would return as soon as they could. The resolution is a blend of personal reasons, longing for the roots abandoned by imposition, and the willingness to contribute to the reconstruction of the scientific activities of the country. As an example, and also as a way to assess the affectionate elements that underlay the returns, we will cite a statement made by an eminent member of the basic sciences community:

> . . . I know that for many people, coming back was a complex option; families with grown up children for whom another migration was very complicated; but for me it was natural. I was waiting for that moment. I was working, gathering information, studying, because I knew that it would be very useful upon returning. On the other hand, in France I was assuming tasks of scientific management that took me away from the laboratory work and this is frustrating. My dream was to go back to Uruguay, to my tiny laboratory, my old lab; work with two or three young people and be very quiet, coming back to my workbench, working with my hands, being able to do science. I thought about it as something very rewarding. It will be a festivity . . . . I saw all aspects of the biotechnology challenge and I thought that I could contribute, collectively, to that effort (from the interview data).

In other cases, the absence of previous traditions in some areas and the existence of a fertile environment for the development of new activities worked as an additional incentive for returning:

> I could have remained abroad but I was always attracted by the idea of coming back because there was space for giving some contribution, and this contribution would be always significant; in countries with a more developed scientific system you just participate with a small share to something that is already constructed. Here, it was different, everything was still to be done, there was nothing; only the embryo of something that was being created with the aid of the PEDECIBA project and with the collaboration of other colleagues that were returning. Particularly in my research area, Experimental Physics, there was absolutely nothing and is always a great challenge to create something,developing science in our own country (from the interview data).

While abroad fellow countrymen gathered themselves together very often, exchanged information regarding knowledge generated in each of the disciplines, evaluated needs and possibilities. They developed and shared the idea that all research work that was being done abroad could be carried out in Uruguay and this feeling had a significant incidence on the return of the scientists:

> . . . . Since our first encounter I was struck by the fact that all the people, all of us, were convinced that the work we were doing could be useful for our country. A mathematician, a physician, a chemist, a physicist, they all thought 'this can be done in my country'. The biologist, looking at the revolution taking place in Biology felt the same. We imagined that our country could go ahead and thought that the scientific and technological development would really be the most important instrument (from the interview data).

The PEDECIBA as an Inflection Point

Thus, the motivations inducing the return of scientists were mainly related to the contribution that the whole group, sharing a common objective, believed it could make towards the rebuilding of the meagre scientific activity in Uruguay. The confluence of hopes expressed individually, together with the collective motivations, prepared the setting and raised hopes for those who returned.

The role played by PEDECIBA as the pivot for members of the basic sciences community was of great importance. The belief that it was feasible and possible to undertake in Uruguay those same activities that were appreciated in other places and that they would lead to the common well-being was one of the main driving forces for the return. The confluence of objectives and the harmony between the primary aspirations of the scientists anxious to return and the priorities or guidelines established by PEDECIBA reveal the extent to which it paved the way for the returns.

Towards the middle of 1984, in the midst of the re-democratisation process, and in a climate of uncertainty and hope related to socio-political options and economic and cultural reactivation, the scientific community reacted. They proposed to restructure the institution 'of science'. There is a rich process of joint efforts for the re-establishment of the scientific activity related to basic sciences

research and the training of high level human resources. Researchers who at a given moment had chosen (or not) to migrate, decided to return and develop the basic sciences together with those who had remained in the country. They brought back not only pure academic knowledge but also the experience of having worked in the laboratories of different countries. They also brought back the working ethos of a foreign country which reflected a certain degree of dynamism.[6] These scientists are the ones who, in dialogue with the few who had stayed and promoted in situ actions, made their return effective. It was possible with the invaluable contribution of some international and national organisations, namely, the International Organisation for Migrations (OIM), the programme implemented by the Comisión Nacional de Repatriación (CNR) and the collaboration of the national University with the Sectorial Commission for Scientific Research (CSIC). These organisations and institutions facilitated the return of a group of eminent scientists who, together with those who had remained in the country, assumed the responsibility of rebuilding the basic sciences in Uruguay; possibilities, tasks and efforts that were grouped under PEDECIBA with a proposal designed by the scientific community and shaped by its own parameters.

During the dictatorial regime science was one of the institutions that suffered the most, particularly the basic sciences. Thus, the necessity of reversing this situation was widely acknowledged for which many joint actions were proposed. Meetings at different schools, establishing networks, renewing ties, were measures often proposed to change the prevailing situation. At that time the idea of a project for the Development of the Basic Sciences within the UNDP was proposed with the aim of organising postgraduate programmes. Logistic and technical support was provided by ORCYT (Oficina Regional de Ciencia y Tecnología de la UNESCO para América Latina y el Caribe).

It was essentially the self-management spirit of the scientific community, combined with other initiatives, which provided the initial impulse for new actions. Given the evident interest on the part of the scientific community to undertake tasks for the re-establishment of high level scientific activities, many actions were discussed and designed. Over a period of two or three months several meetings were held at UNESCO's headquarters with the aim of studying the viability of the Programme. The initial meetings clearly revealed a manifest disposition on the part of all participants

to cooperate in the preparation of a project compatible with the democratisation process already in progress.

Apart from the fact that the return of the scientists was an objective by itself, the committed task was of such a magnitude that it could only be accomplished with the cooperation of Uruguayan scientists settled abroad. Thus, it became imperative to establish repatriation mechanisms to facilitate the return of a large number of emigrants to the country.

> The selection of these scientists was carried out based on several criteria. These required the scientist: a) to develop scientific activity in universities or equivalent centers; b) to have an outstanding research production in his/her area of specialization; c) to be disconnected from groups performing research activities and higher education teaching in Uruguay; d) to be aware of the difficulties faced by research activities in developing countries and particularly in Uruguay (UNDP-UNESCO 1984: 5).

Gradually, and largely due to the economic resources provided by UNDP, it was possible to include in the discussions some of the scientists who, despite being abroad, were in a position to visit the country again, even if only occasionally. In his study on the scientist members of the 'basic' community later grouped around PEDECIBA, Silveira (1994: 6) gives an account of the return of 133 scientists. They were the first group to be repatriated and were inducted into the university system in a permanent category. All of them became researchers in the Programme and the return proved effective through an agreement between the National Repatriation Commission and the European Economic Community on the project 'Return and Reinsertion of Qualified Uruguayans for National Development'. The agreement was intended to facilitate the return and reinsertion of nearly 200 scientists already in the country or still living abroad. They were supposed to have European experience and qualifications according to the country's particular interests (Commission of the European Communities 1986). The identification of such specialists was done on the basis of the 'Preparatory Action Plan'. Later, the PEDECIBA group began to articulate actions with the University of the Republic, some governmental agencies, the European Economic Community (EEC) and the Development Interamerican Bank (DIB) to obtain the funds needed to implement postgraduate programmes in basic sciences.

Further, to facilitate the return and reinsertion of the emigrants, the European Economic Commission saw the necessity of providing air tickets (extensive to the family) and a monthly stipend of US $250 for one year in addition to the salary. This was supplemented by local assistance from the Repatriation National Commission which included: guarantee of six months' minimum wages during the time necessary to complete personal administrative formalities and assistance for customs clearance of imported equipment, customs taxes, diploma's validation, coverage under the health system and schooling formalities. All this emerged from a consensus in considering basic sciences as absolutely necessary for the technocultural and educational restructuring of the country.

The Links Around PEDECIBA

Besides promoting the development of science per se, PEDECIBA has the more general objective of using the research results as a pivot for development. It assumed that:

> . . . the advancement of the sciences and specifically of the basic sciences is absolutely necessary for the progress, modernization and independent development of a country. They are also considered essential for technological advance and influence in a very positive way—through cultural diffusion and learning channels—collective life (PEDECIBA 1985: 4).

Following the inclination to create, transmit and develop knowledge as a concept that rules scientific activity and in an attempt not to depend on the trends dictated by the financial agencies, the scientific community devoted itself to examining closely the actual conditions prevailing in the different fields: existing human resources, who and how many scientists were willing to return, which fields they belonged to, alternative priorities, etc.

Thus, several preliminary studies were carried out analysing the characteristics of the different areas and actors involved. After outlining some policies on the orientation programme, a more unified dialogue was established not only among the people directly involved, but also with the government and university authorities. With the latter these contacts were very weak and exclusively

informative as there was high incompatibility or variance with the authorities since the country was still under a military dictatorship.

For the formulation of the policies and trends to be adopted, the opinions and experiences of the scientists who had returned from abroad were of great help. Greater insight into the 'state-of-the-art' of the different disciplines was provided by them. Such information was often reinterpreted in the light of the local reality. Obviously, it was not an easy task and differences emerged regarding the importance attached to the different fields, the relative importance of applied and fundamental research (as in Physics and Mathematics), different perceptions of what is science for development, etc. The obvious differences in perception between those who remained in the country and those who had experienced science in other latitudes had an important bearing on the formulation of the basic science system. We can see that the problems and themes inherent to the migration of scientists arise not only from the 'migration waves', as has been discussed earlier, but also from what the migrants add to their intellectual repertoire when living in different places.

We will now analyse the accomplishments and successes of PEDECIBA over the last ten years.

PEDECIBA Today

As discussed earlier, PEDECIBA was created in 1986 to assist in the establishment of a permanent infrastructure in Biology, Physics, Mathematics, Chemistry and Computer and Information Science, which would contribute to the resolution of the country's main development problems. The programme was oriented specifically towards promoting basic scientific research as the basis for technological development with the corresponding emphasis on the training of human resources through graduate programmes.

During the initial years of the programme its essential objectives were achieved. These objectives included the establishment and development of research groups, capacitation of human resources, creation of the necessary infrastructure for such activities, encouraging scientists' return, improvement in science teaching at all levels, organisation and collaboration of regional centres, and the establishment of cooperative networks with scientists living abroad. After three years, despite the differences in the various disciplines,

the minimum conditions for the execution of scientific activities were almost met. Tremendous improvements in library conditions, addition of many new books and periodicals, laboratory equipment and consumable goods and, most importantly, the return of human resources had been achieved.

At present, PEDECIBA has 248 researchers performing their activities as 'honorary' researchers.[7] They are classified by their peers into two levels[8] in accordance with their scientific and academic performance as measured by the usual quantitative indicators of developed research projects and publications in international refereed journals.

At the beginning of 1995, the Programme had 95 research groups distributed as follows: 52 in Biology, 19 in Chemistry,[9] 10 in Physics, 7 in Mathematics, and 7 in Computer and Information Science (PEDECIBA 1994). Teaching and laboratory activities related to the graduate programmes are carried out within these groups.

As mentioned earlier, the Programme was outlined in 1984 and was launched in 1986; in 1987 efforts were made to facilitate the scientists' return and to locate international financial support. Teaching and research activities only began in 1988 when the available material and human resources conformed to the necessary minimum for regular and permanent functioning. There was an influx of graduate students during 1988 and 1989, especially 'licenciados' and engineers who were waiting for the opportunity to complete higher education. The number of students and researchers who performed their activities within the framework of PEDECIBA did not fluctuate over the years. Nevertheless, there was a systematic growth of research activities as a consequence of the number of projects developed by the young students while studying for their graduate diplomas. In Tables 3 and 4 the latest available data (March 1994) on the composition of human resources for research in basic sciences in Uruguay are presented. The tables show the number of current students, Master's and doctoral degree holders and graduate programme researchers. The data give an idea of the number of graduates and tutors involved. They also reveal the positive results of the efforts in each area, considering the poor situation of the basic sciences at the beginning of the programme.

TABLE 3
Graduate Students and Researchers Involved in PEDECIBA by Field of Knowledge

Area	*Students*	*Researchers*
Biology	205	134
Physics	20	27
Information Science	25	11
Mathematics	17	18
Chemistry	67	58
Total	334	248

Source: PEDECIBA (1994).

TABLE 4
Degree Candidates and Awarded Degrees

	Current Students	*Graduated*
Master	203	117
Doctorate	129	25

Source: PEDECIBA (1994).

The number of graduate students who completed their studies is a partial indicator of the achievements of the programme in various areas. In Physics and Computer and Information Science that do not offer doctorate programmes, the academic quality of the students is recognised through their acceptance to graduate studies in first rate foreign universities. Using Physics as an example of rapid and successful development, PEDECIBA informs that:

> at present, 11 master dissertations are in progress and 7 were finished; 10 young researchers are following complete doctorate courses abroad (4 in USA; 3 in Brazil; 2 in Spain and 1 in Italy) and 2 are staying for just a few months in Germany and Brazil as visiting researchers. With no intention of doing projective analysis and considering only the number of students up to now, it can be anticipated that in this year of 1996, the number of M.Sc. will duplicate. The same will eventually happen with the Ph.D. recipients. In the last quinquennium the first four Ph.D's graduated abroad (in Argentina, Germany, Sweden and Spain) returned to Uruguay. Up to now all the students that got their

doctoral degrees outside the country, have returned[10] (PEDECIBA-Física 1994: 3–9).

For those who obtained lower grade (that is, grade III) marks, PEDECIBA has supported and encouraged, through specialisation courses, the qualification and enhancing the level of primary and secondary school teachers. It has also fostered the relationship between the academia and private and state-owned firms with the ultimate objective of creating a permanent channel for the transfer of technology.

It may be concluded that the PEDECIBA project succeeded in being the nexus that allowed the unification and consolidation of the Uruguayan basic sciences community, creating the conditions and motivation for the return of many scientists and giving priority to the training of human resources for research. It also succeeded in the establishment of a stable, permanent and high level inter-disciplinary system dealing with education in a broader sense.

Concluding Remarks

This study highlights the importance of the scientific migration process for the development of the Uruguayan academic community in the field of basic sciences. Emphasis was on the conformation by the same community of PEDECIBA—Program for the Development of Basic Sciences. This programme enabled many scientists living abroad to return to their country. It was around these former emigrants and with the instruments made possible by the Programme, that the scientific activities in the country were re-organised and the generation of knowledge and expertise was included in the policy agenda.

It is important to recall here that, as revealed in many interviews, there was a common desire to give the utmost importance to collective work, to work together for the re-creation of science as a social institution and to collaborate for the economic, social and cultural development of the country.

The articulations created around PEDECIBA show the enduring effort undertaken by a small community in a complex and difficult social situation to establish a permanent and reliable scientific and technological infrastructure.

NOTES

1. A different version of this study was presented at the Symposium on 'International Scientific Migrations Today: New Problematic', Santa Fé de Bogota, Colombia, 24–26 June 1996. The authors acknowledge the valuable comments of Hebe Mitlag, Department of Science and Technology Policy, State University of Campinas/UNICAMP, Brazil.
2. It should be pointed out that in order to elicit the opinions and statements to which we will refer in the course of this paper, we interviewed a total of nineteen researchers directly involved with PEDECIBA. The interviews were semi-structured and the scientists selected belonged to the different research fields included in the programme: 8 Biologists, 3 Chemists, 3 Physicists; 4 Mathematicians and 1 Information Scientist.
3. Venezuela in particular constituted an attractive pole for Uruguayan basic scientists, specially those who had specialised in mathematics. Thus, a large number of Uruguayan mathematicians were engaged in research and teaching activities in that country.
4. It should be noted that it is very difficult to prove that there are 2,230 doctors working in research and development in Uruguay. We believe that the figure, as it is derived from the primary data compiled in the publications mentioned, may be an overestimation. Also, we would like to highlight that the figure included lawyers, physicians, dentists, and veterinarians under the category of doctors even if they did not hold a doctoral degree.
5. Likewise, it should be acknowledged that this figure rose sharply as a result of the returns announced. According to 1986 data, there were 2,093 scientists and engineers working in Uruguay and were distributed as follows: 1,181 in higher education, 707 in public services, and 64 in the private production sector (McLauchan and Torero 1991: 25).
6. Note that

> the ethos of science is that affectively toned complex of values and norms which is held to be binding on the man of science. The norms are expressed in the form of prescriptions, proscriptions, preferences and permissions. They are legitimatized in terms of institutional values. These imperatives, transmitted by precept and example and reinforced by sanctions are in varying degrees internalized by the scientist, thus fashioning his scientific conscience or, if one prefers the latter-day phrase, his super-ego. Although the ethos of science has not been codified, it can be inferred from the moral consensus of scientists as expressed in use and wont, in countless writings on the scientific spirit and in moral indignation directed toward contraventions of the ethos (Merton 1973: 269).

7. Their salaries come from the activities they execute in the 'Universidad de la Republica'. They also receive extra money when they are engaged in projects in connection with the productive sector. In this case they can receive up to 70 per cent of their regular salary.
8. The classification of researchers in PEDECIBA is as follows: two levels (1 and 2) and five ranks; level 1 denotes independent or senior researcher; level 2 denotes junior researcher. Level 1 corresponds to ranks four and five (highest)

depending on experience. Level 2 corresponds to rank three for junior researcher, rank two for doctorate student and rank one for the Master's student.

9. Research groups in chemistry are accurately assessed by the number of laboratories involved. At the beginning of the Programme, there were 12 groups and 9 laboratories and in 1994 (following the 'Quinquennial Report and Evaluation' of October 1994) there were 60 groups and 19 laboratories. Obviously some of the groups are composed only of 2 or 3 members but nevertheless they show a clear growth and development of different areas (PEDECIBA-Química 1994: 6).
10. It is important to note that almost half of the foreign students who are enrolled in graduate and postgraduate programmes in the USA are planning to remain in the United States (National Science Board 1993: 52).

REFERENCES

BARREIRO, A. (1996), 'A formação de recursos humanos para pesquisa no Uruguai, a partir da experiência do PEDECIBA'. M.Sc. dissertation on Scientific and Technological Policy. State University of Campinas (UNICAMP), Campinas, São Paulo.

CARDOZA, G. and R. VILLEGAS (1996), 'Scientific Migrations, Cooperation and Development Networks in Latin America and the Caribbean'. Paper presented at the Symposium on International Scientific Migrations Today: New Problematic, Mimeo. Santa Fé de Bogota.

COMISION NACIONAL DE REPATRIACION (1989), *Informe sobre asistidos*. Mimeo. Montevideo.

COMMISSION OF THE EUROPEAN COMMUNITIES (1986), 'Documents of the Dossier NA/RR/3//86'. Brussels.

MARMORA, L. (1996), *Policies and Programs for Migration of Skilled Human Resources*. Paper presented at the Symposium on International Scientific Migrations Today: New Problematic. Mimeo. Santa Fé de Bogota.

MCLAUCHAN, PATRICIA and MÁXIMO TORERO (1991), Indicadores de Ciencia y Tecnología para América Latina y el Caribe. Grupo de Análisis para el Desarrollo-GRADE. Lima.

MERTON, R. (1973), *The Sociology of Science*. Chicago: The University of Chicago Press.

NATIONAL SCIENCE BOARD (1993), *Science & Engineering Indicators*. Washington, D.C. US Government Printing Office.

PEDECIBA (1985), Documents of the Proposal URU/84/002/L/01/99 Titled 'Progama de Desarrollo de las Ciencias Básicas'. Ministry of Education and Culture, Montevideo.

——— (1994), Folleto divulgativo, 1987–1993. Ministry of Education and Culture, Montevideo.

PEDECIBA-FÍSICA (1994), Resumen de actividades y evaluación, 1989–1994. Ministry of Education and Culture, Montevideo.

PEDECIBA-QUÍMICA (1994), Resumen de actividades y evaluación, 1989–1994. Ministry of Education and Culture, Montevideo.

PELLEGRINO, ADELA (1993), La emigración de professionales y técnicos latinoamericanos. 'Documentos de Trabajo' of the Multidisciplinary Unit, Faculty of Social Sciences, University of the Republic, Montevideo.

PELLEGRINO, ADELA and WANDA CABELLA (1996), *Emigration of Scientists: The Uruguayan Case*. Paper presented at the Symposium on International Scientific Migrations Today: New Problematic. Mimeo. Santa Fé de Bogota.

UNDP-UNESCO (1984), Documents from the Seminar 'Evaluación propuestas para el desarrollo programado de las ciencias básicas'. Montevideo.

SAGASTI, F. and C. COOK (1985), Tiempos difíciles: ciencia y tecnología en América Latin durante el decenio de 1980. Grupo de Análisis para el Desarrollo-GRADE. Lima.

SILVEIRA, R. (1994), *Científicos uruguayos en el exterior: presente y perspectivas de uno de los problemas básicos de la comunidad científica nacional*. Mimeo. Montevideo.

Turning Brain Drain into Brain Gain: The Colombian Experience of the Diaspora Option

JEAN-BAPTISTE MEYER, JORGE CHARUM, DORA BERNAL, JACQUES GAILLARD, JOSÉ GRANÉS, JOHN LEON, ALVARO MONTENEGRO, ALVARO MORALES, CARLOS MURCIA, NORA NARVAEZ-BERTHELEMOT, LUZ STELLA PARRADO and BERNARD SCHLEMMER

An increasing number of developing countries are considering their highly qualified citizens living abroad as a potential asset for national development. Renewed policies are consequently designed in order to ensure the return of this expatriated talented group. Besides the repatriation-return-option generally enacted in these policies with varying success, a second one has recently emerged: the diaspora option. It consists of the remote mobilisation of intellectuals abroad and their connection to scientific, technological and cultural programmes at home.

At the beginning of the 1990s, Colombia began to systematically and consistently apply this option, through the creation of 'the Colombian Caldas' Network of Scientists and Engineers Abroad'. The experience of this strategy has been studied during the last four years by a Franco–Colombian research team. The paper discusses the results of this study. It first contextualises the diaspora option and the Colombian experience by putting it in historical perspective along with the other policies designed to tackle the issue of professionals' migration. It then describes the S&T diaspora in terms of actors and dynamics. The way it works through the Caldas network is presented in terms of an analysis of three major aspects: the electronic list through

Jacques Gaillard, Jean-Baptiste Meyer and **Bernard Schlemmer** are scientists at the Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM), LSSD, 32 avenue Henri Varagnat, 93143 Bondy Cedex, France.
Jorge Charum, Dora Bernal, José Granés, John Leon, Alvaro Montenegro, Carlos Murcia and **Luz Stella Parrado** are at the Universidad Nacional de Colombia (UNC), Department of Mathematics and Statistics, Department of Physics, Cuidad Universitaria, Bogota, Colombia.
Alvaro Morales is Professor at the Universidad del Valle, Department of Engineering, Cali, Colombia.
Nora Narvaez-Berthelemot is at the Universidad Nacional Autonoma de Mexico (UNAM), AA 105–218, 11581 Mexico D.F., Mexico.

Science, Technology & Society 2 : 2 (1997)
SAGE PUBLICATIONS NEW DELHI/THOUSAND OAKS/LONDON

INTERNET, the local associations (network's nodes) and some joint projects between diaspora and the home community members. The concluding part draws the significance of the experience, its achievements as well as its limitations, and suggests indicators and methods that could help develop it elsewhere.

The Diaspora Option in Historical Perspectives

THE SPECIFICITY OF the diaspora option is obvious when compared to other policies. But it is not an isolated phenomenon without antecedents. Its emergence is the result of a gradual process.

Evolution of Policies with regard to Professionals' Migration

The policies adopted by developing countries with respect to the migration of their highly qualified citizens may be classified and summarised in two basic approaches, according to the interpretation given to this phenomenon. The first one, the brain drain approach, considers the negative effects of migration—a loss of skills for the country of origin—and reactions to these. The second one, the brain gain approach, focuses on the positive aspects—the existence of highly trained national human resources abroad—to use them as opportunities.[1] Both approaches have generated policy options. The countermeasures to the problem of brain drain have basically focused on three options: taxation (compensatory financial measures), regulation of flows through international norms, and conservation (control of emigration).

Taxation has received much attention and culminated during the second part of the 1970s and the first part of the 1980s (Bhagwati 1976). However, it has not been translated into actual decision-making and virtually disappeared at the end of the 1980s.

Regulation through international norms had early been proposed by organisations within the United Nations system (Pires 1992; UNCTAD 1983, 1984). These recommendations have not been enforced and the developed countries still apply selective immigration policies with regard to highly qualified manpower (Simon 1995).

Conservation (restrictive) policies aiming at the retention or recuperation of skilled people have been implemented in many

developing countries. But their scope as well as success has been limited, since they intended to stop or reverse the outflows without addressing the cause of the problem, that is, the absence of a S&T base that would absorb this manpower (see Mesa et al. 1978 on Colombia).

Brain gain strategies were increasingly developed as the limitations of the above-mentioned options became apparent. Their emergence may also be linked with the new status of science and technology in development planning for an increasing number of countries from the South. The first alternative to emerge has been the return option. Though this option appeared at the beginning of the 1970s (Kao 1971), it increased gradually through the decade (Glaser 1978) and was extensively developed in the 1980s and 1990s (Swinbanks and Tacey 1996; Song in this issue). The return option deviates from the conservation policies in a crucial aspect: the recovering of highly qualified professionals is part of a comprehensive development policy, including and often integrating scientific, technological and economic dimensions. It is not by random that the most successful cases of return policies have been seen in the NICs, in countries with S&T and industrial sectors already quite advanced, where the manpower may effectively be employed (for example, India, Singapore, South Korea and Taiwan).

The diaspora option is the most recent policy that has been fully implemented with regard to the migration of highly qualified human resources. As a brain gain strategy it differs from the return option in the sense that it does not aim at the physical repatriation of the nationals living and working abroad. Its purpose is the remote mobilisation of the diaspora's resources and their association to the country of origin's programmes. Scientists and engineers may stay wherever they are; what matters is that they work for their mother nation in some way. This is done through a formal, institutionally organised, networking.

Each of the brain gain options have theoretical advantages as well as limitations.[2] Both are not self-sufficient strategies: their success and effectiveness depend largely on the internal dynamics of the native scientific community. The scientists, either physically reintegrated or connected through networking, must find in it the relevant professional and specialised groups with which they can constructively and concretely interact (Gaillard, Krishna and Waast 1997).[3]

Antecedents of the diaspora option may be seen as early as in the 1870s during the Meiji era in Japan where expatriate students in Europe were organised to channel scientific and technical knowledge to their country. Later, from the same perspective, foreign students in the United States or in Europe have often come together, in terms of nationalities, within on campus associations. They often included some kind of commitment to the mother country. Interestingly enough, this has been the case in Colombia. In 1956, graduate students from the University of Leuven (Belgium) decided to form an association that soon became the 'Colombian Team for Studies and Progress' (ECEP). The ECEP aimed to move beyond the local level and set up an extensive and organised association. It survived for half a decade and included all the Western European countries as well as people in the United States. It operated through regular meetings of local groups, mail exchange and temporary visits, a general file of members and meetings of local groups coordinators (*Semana* 1959). Though technically different, these are the features that the Colombian 'Caldas' network also adopted some 35 years later.

Around the same time, India initiated the first national effort to locate and follow national intellectual resources abroad. It opened an 'Indians Abroad' section in the National Register of Scientific and Technical Personnel of India with the purpose of collecting information on qualified Indians in foreign countries. This register has mainly been used to feed the 'scientists' pool' of long-term appointments in India, which is considered more as a return option: It did not help to set up a network or another form of permanent intellectual diaspora as such. But, in the 1970s, 'the Council of Scientific and Industrial Research instituted a scheme for offering short-term appointments as research associates or visiting scientists' to Indians abroad (UNCTAD/CSIR 1977). This has been an intermediary mode between return and diaspora options: resorting to external skills for temporary employment at home.

The TOKTEN (Transfer of Knowledge through Expatriate Nationals) programme of the UNDP has worked the same way for two decades; it was launched at the end of the 1970s. It channels expertise required by a specific country, looking for an expatriate of the same country possessing the appropriate skills, through the UNDP network of regional offices all over the world (Courrier

1996; TOKTEN 1988). Undoubtedly, these programmes have developed the practice of using high qualified human resources abroad without having to think in terms of permanent and costly reinstallation. But they have not gone as far as to constitute a diaspora, an authentic community beyond the borders, as they relied on temporary and individual connections. The truly continual and collective commitments occurred only in the beginning of the 1990s when the diaspora option became an autonomous and complete strategy, organised as part of the national planning policies.[4]

There cannot be a model of what the diaspora option is or should be. The Caldas network experience, however, refers to its distinctive nature from the partial experiences that preceded the complete actualisation of the option in Colombia. It has three characteristics: worldwide permanent communication, autonomous peers' organisation, orientation towards joint projects and realisation. The first refers to the fact that the widespread diaspora and the national academic community in the country of origin share a common source of relevant information and have a space where they can develop direct and consistent exchanges. The second refers to the autonomy of the groups composing the diaspora: they do not depend on institutions of the country of origin or the host countries for existence; they have their independent statutes, juridical personality, auto-recruitment, selection and functional rules, etc. Third, this organisation, global and local, has a definite purpose of work sharing, or academic, technological and intellectual concrete cooperation. These combined features have been presented in the Caldas network through an electronic list, the local associations of Colombian scientists and engineers—the 'network nodes'—and joint projects or activities led collectively by the diaspora and home community members. This institutionalisation of an expatriates' network departs from anterior, more limited experiences of the diaspora option.

Colombia: Specifics and Generics of the Case

The so-called 'Caldas network' or 'Colombian Network of Scientists and Engineers Abroad' was officially established in November 1991, when Colciencias—the Bogotá based governmental agency incharge of national research management and funding—decided

to launch it as a programme to which one person of its staff was appointed. This was part of a dynamic process in which the institutional decision represented an important step but far from an isolated one.

The Caldas network is a hybrid construction, comprising diverse contributions. Apart from the decisive initiative from Colciencias, various interdependent actions, within and without Colombia, have had crucial significance. There was a clear political will, a central decision, from a public organisation in Colombia which combined with local, often individual, expectations and attempts that existed outside.

The network's members often claim that, even before its creation, they had personally tried to forge scientific and intellectual links between themselves and Colombia. They attribute the frequent failure of such attempts to the lack of reaction, decision and consistency from the country's institutions. Thus, for many people, these attempts to help had already been frustrated and deceived by the earlier plans which had fallen through. The Caldas network was established with this ambivalent feeling: on the one hand, a spontaneous motivation from the intellectuals abroad to contribute to the development of their country of origin and, on the other hand, the bitterness and pessimism generated by previous failures. These are the paradoxical tensions at work in the construction of the diaspora: a positive identification to the country—a constructive nationalism—but a negative appreciation of its responsiveness, a deleterious suspicion of national commitments.

What convinced some of the Colombian expatriates to participate in a new attempt in 1991? What is at the origin of the collective dynamics that emerged from various parts of the world at the same time? It is a combination of symbolic signals and concrete measures, coherently articulated in a highly publicised policy planning. At the beginning of the 1990s, the Colombian society was indeed in the so-called 'apertura' (opening up) period, ending an isolationist and protectionist era. Science and technology were for the first time accorded major importance especially because they were considered as the main vectors to upgrade the general competitiveness of the country. The idea that Colombia was undergoing an historical shift was well received by the intellectuals abroad. First, because the basic concept of 'apertura' semantically provided a retrospective

and definite recognition to those who had previously been exposed to the outside world: the expatriates. Second, because the emphasis on science and technology completed this general recognition with an operational value: they had a virtual, totally new role to play in their country's development.

These changes were not only occurring at a discursive level; they were embedded in concrete moves sustaining their credibility. In 1989–90, the academic community in Colombia undertook an extensive and far-reaching examination of the country's scientific directions. With the so-called 'Mission of Science and Technology' all the public research programmes came under review and their orientations toward the rest of society were reconsidered. This effort has placed the S&T sector at the heart of national development and it has achieved significant results. A law on science and technology was enacted leading to the creation of a National System of Science and Technology. A new institutional framework was designed. Colciencias, which formerly was mainly a fund for financing research projects, became a central agency whose mandate was to organise the activities within the National System of Science and Technology and to ensure that they were organised in accordance with general planning in other areas (Charum et al. 1996). Last but not least, public funding for R&D activities increased by 400 per cent in the following years. These aspects are fundamental to the understanding of the diaspora option: its emergence is not an isolated phenomenon; it is intrinsically tied to the international dynamics of the national community. A network of expatriate skills is an extension of it, not a substitute (Gaillard, Krishna and Waast 1997).

Since an early stage of this process, various Colombian experts living abroad have been involved, providing ideas and suggestions to their peers in the country. Sometimes these expatriates met informally in the resident countries to discuss the changes occurring in Colombia at the time. They were creating local groups of Colombian scientists and engineers, which constituted the nuclei of what soon became the 'nodes' of the 'Caldas network'. But these individuals and small groups completely overlooked the fact that others were engaged in similar pursuits in other parts of the world. May be after some time and without any particular long term collective purpose they would have simply vanished. But a

phenomenon aggregated these particular endeavours and integrated them into a cumulative mutually reinforcing process—the electronic connection.

At the beginning of 1990, an electronic list of Colombians abroad, 'Colext' began to list an increasing number of expatriates connected to bitnet, an exclusively academic electronic network. The history of Colext is an heroic one, a kind of a fairy tale in which a personal initiative taken by an isolated doctorate student located in CERN—a general call in the cyberspace to all compatriots abroad—was met by numerous immediately positive responses, to the surprise of the founding father. Colext is a list dedicated to social rather than professional—science and technology—exchanges in which every message sent to the server is automatically distributed to all the listed members, allowing a general and collective communication. Its first major debate dealt with the opportunity of returning to Colombia, at a time when the country seemed so well disposed to receive its expatriate, intellectual nationals. The electronic discussion was passionate and ultimately ended in a highly symbolic result: a large part of the listed members believed that they could better help the country from outside than from inside. Retrospectively, it appears like an opinion poll validating the diaspora option even before it formally existed.

The electronic list has had a tremendous impact. It constituted a real social space that generated a collective self-consciousness of a worldwide intellectual expatriate community. The communication through Colext allowed mutual identification of the actors and eventually suggested their association. This system led to the institutionalisation of the network from the diaspora. It is through its electronic reflection that its members became aware of its global dimensions.

The Colext effects have been translated into effective actions fairly rapidly. At the end of 1990, on Christmas, the listed members located in New York city decided to organise a meeting. They found 'PECX'—the association of Colombian students and professionals abroad—which some months later became the node of the Caldas network in the United States. At the beginning of 1991, the list was used by the general manager of Colciencias to hold the first round of meetings with expatriates in Paris, Madrid and Mexico. He actually visited these people in spring 1991 and returned to Bogotá with the conviction that a network was feasible. In

November, it was institutionalised under the auspices of Colciencias and it quickly developed through both the contagious examples of the first significant nodes (Paris and New York) and the massive political investment made by the staff of this governmental agency.

Obviously, the construction of the Caldas network has not been the result of a lineal and top-down administrative decision. On the contrary, it is the progressive implementation of an idea through a collective and iterative process, between a governmental agency and various expatriate actors. It has achieved consistency and credibility because it was tied to the structural institutionalisation process of the research community through the creation of the National S&T System. Other cases of the diaspora option may develop under different conditions. The broad political context may not be similar in other countries. However, the history of the Caldas network reveals a basic fact: if it has achieved initial mobilisation it is because it has been shaped through a collective process, which has assigned roles and interests to the numerous actors.

Actors and Dynamics of the Diaspora

When Colombia initiated the diaspora option, it had a vague idea of what its national intellectual community outside actually was. Consequently, the appraisal of what it could offer to the country was anything but precise. From this history of empirical construction, the Caldas network has always maintained an intuitive more than a rational management. In 1994 and 1995, the ORSTOM–UNC research team carried out a detailed and general survey in order to obtain a picture, as precise and as complete as possible, of the diaspora. More than 500 responses were received from a total of a little more than 1,000 identified and located people.[5] The answer rate was high, especially for a migrant population. Sophisticated statistical checking procedures confirmed the validity of the sample with the largest possible population—in our knowledge—of Colombian intellectuals, students, engineers and scientists abroad.[6] This permits an understanding of who the diaspora's members are and what are their involvements.

Who are the Members of the Diaspora? A Survey

According to the survey, the Colombian intellectual diaspora is spread today in, at least, 25 countries and in the recent past was spread in up to 43 countries. The United States constitutes the most important part of it as a single country but North America (the US and Canada) is second behind Western Europe in terms of regional importance (Spain, France, United Kingdom, Germany, Belgium, Italy and Switzerland). Latin America comes third; Eastern Europe, fourth; Asia-Oceania, fifth.

What is the age profile of the members? The average age is 37 years and a large majority of the population is between 24 and 44 years of age. The peak, however, is constituted by people between 30 to 40 years of age, who represent more than half of the total population. Most of them are either enrolled in doctoral programmes, or pursuing postdoctoral studies or even in a rising professional position in a definite career. The diaspora is neither a student population nor an executive. But it is a highly qualified community: 71 per cent of its members have obtained or are pursuing doctoral studies and 80 per cent have a Master's degree or higher qualification.

Almost three-fourths completed their undergraduate studies in Colombia but the proportion is completely reversed for graduate studies (27 per cent for the Master's, 7 per cent for doctoral programmes). Doctoral programmes are pursued outside the country, in the US (25 per cent), France and the UK (12 per cent), and Spain (11 per cent).

Of the 76 per cent who declared they had left Colombia to study abroad only 11 per cent migrated for professional reasons. Further, 8 per cent mentioned personal reasons and 5 per cent socio-political or other reasons. Three-fourths of them left for pursuing higher studies and most of them left after obtaining their Bachelor's degree for postgraduate studies. The argument that this is the result of the bottle-neck in higher education (the absence of advanced studies in many fields) is only partly relevant: it is true at the doctoral level but not the Master's level in most of the disciplines. The fact that the majority decided to leave the country before reaching the ultimate, locally available, stage in her (his) field seems more to be a choice than an obligation imposed by the conditions prevailing in Colombia or even other countries as other studies show (Gaillard 1991). People have largely acquired their

skills abroad. At the best, they had a general qualification when they left; today, after completing the major part of their studies and professional training abroad, they are highly skilled in very specialised areas.

Emigration is not a definitive evasion; it is a life sequence for professional and personal enrichment. When asked if they would return home and live in Colombia, three-fourths responded positively. Only 20 per cent believed that they would not live again in their country of origin. This result is confirmed by a survey of a small sample of people who have actually returned to Colombia since 1990: almost all of them declared that they would stay in the country and not return abroad. This clearly shows that the emigration is not a permanent one, it is temporary. This evidence coupled with the age distribution of the emigrants confirms that such a migration refers more to 'delayed return' than to the brain drain phenomenon (Pedersen 1993). People expect to return even if they spend a significant number of years abroad, as pointed out in other studies (Glaser 1978). However, the longer they stay abroad, the less likely they are to return (Gaillard 1991). This also has a bearing on the design of both—return and diaspora—brain gain strategies. First, if the majority of expatriates are expected to return, providing strong incentives to them may not be the major issue; on the contrary, providing adequate conditions for them reinsertion is indispensable in order to optimally benefit from the skills they have acquired abroad. Second, the diaspora is not a totally stable population and entity on which one can rely indefinitely; once the connections have been made its moving configuration has to be managed dynamically through on-line, non-static indicators and data.

At the time of the survey, the average number of years each person spent abroad was 5.5 years. There may be considerable variations between those who left some months ago and those who migrated more than 15 years ago. But the general figures give an idea of the kind of migration under consideration. There is a durable and effective settlement in the foreign countries, propitious to the development of strong links with their environment.

The Diaspora's Dispositions towards Colombia

What are the members of the Colombian intellectual diaspora able and ready to provide to their country of origin? This depends on

their socio-professional insertion abroad as well as on their individual and collective attitudes towards Colombia.

Half of the population surveyed had a student status, of which 74 per cent had enrolled in a PhD programme, 18 per cent Master's degree programme and 8 per cent in undergraduate studies. Two-thirds were under professional contracts; one-fourth were both studying and working; 83 per cent declared that they were involved in research activities, either as advanced students or as professionals. The intellectual diaspora is a real potential of knowledge and practice and it covers many fields. But this broad and complete coverage is also an expression of the extreme dispersion: there were as many as 290 thematic specialities for the sample of the survey, revealing that very few people shared the same field of research. This poses both an opportunity and a problem for the diaspora and for Colombia. On the one hand, it is a tank of expertise which is very extensive and can respond to many cases; on the other hand, the construction of teams, of collective—even virtual—work is hampered by cognitive distances between potential partners.

The socio-professional involvement of the intellectual diaspora's members is clearly academic. The majority of them work in a large public institution whose primary purpose is higher education, that is, a university. These features are similar to those of the scientific community in Colombia where the bulk of research is carried out within the large universities of the public sector (Meyer et al. 1995). In terms of general orientation, the diaspora does not complement the internal community. It especially lacks involvement in the R&D of the private productive sector. But in terms of capacity mobilisation, it is potentially quite strong as most of its members belong to large institutions involved in knowledge generation and diffusion.

The professionals enjoyed their job and positively evaluated the labour conditions in the foreign country. The aspects they valued most in their position abroad in descending order were access to international contacts and mobility, access to technical capacities, support of qualified personnel, intellectually stimulating professional relations, career prospects and job prospects in Colombia. The only aspect regarding which the majority (51 per cent) responded negatively was the income they earned. Regarding their professional relations, an overwhelming majority perceived them to be friendly,

productive, intellectually stimulating, non-hierarchical and non-precarious.

The positive evaluation of their environment by the diaspora's members reveals the potential resources that they may provide to their peers in Colombia: good and extensive social networks as well as technical and professional facilities.[7] Are these potential resources actually exchanged between the diaspora and the internal community? Is the Caldas network really effective, in its attempt to connect the two?

The membership of the Caldas network provides an answer to these questions: 90 per cent of the respondents mentioned that they were aware of the Caldas network, but only 68 per cent had sought membership. This means that 22 per cent did not want to get involved in this institutional effort to associate the diaspora with the national community, even if they knew about its existence. This is an important fact: some people may not be willing, for a number of reasons (lack of time, indifference or critical stance toward the country), to be formally part of a collective and regular commitment to their nation of origin. Moreover, a significant part of the members had recently joined the network. Therefore, the sample is not adequate for an evaluation of the durability, consistency and intensity of the members' involvement. But an appraisal of their propensity and their capacity to develop actual links with Colombia may be made.[8] In order to do so in an exhaustive and systematic manner, a multivariable correspondence analysis was applied to the responses given by the expatriates to a large number of questions about their expectations regarding the network, the benefits and contributions that they would draw or make through it. The analysis clearly identified and distinguished three groups—statistical clusters—with typical attitudes toward the network. The three groups were approximately the same size: 144, 149 and 160 individuals, respectively, that is, 32 per cent, 33 per cent and 35 per cent of the sample.

The first group comprised those who did not expect any particular benefit from the network. They did not evince a keen interest in establishing professional or academic links with Colombia by participating in training sessions, project assessments and evaluation, or receiving researchers or providing them with facilities. They were far removed from the needs of the country and did not wish to visit it. They did not have any relationships with the

expatriate community either. They did not think that the network would enable them to acquire recognition or strength either in the resident country or in Colombia and that they could tap new and interesting work opportunities through it.

The second group was characterised by an attitude of hesitation: its members did not clearly express expectations regarding the benefits they could possibly derive or the contributions they could make. But they were not indifferent either; they wished to visit Colombia and share activities with the researchers there. They believed that the network had opened new opportunities for them in terms of projects realisation, access to funding and possibilities to influence science policy decisions.

The third group was far more affirmative. It expressed an interest in forming an association with the national local community and a desire to strengthen the expatriate community, to establish exchanges with their peers of the internal community by participating in training sessions, project assessments and evaluation, or receiving researchers or providing them with facilities. Participation in the network, they believed, could enable them to get recognition for their work and they wanted to contribute to the country's development. Their experience and knowledge, they believed, would have a positive influence on the design of science policy.

The diaspora is anything but a homogeneous community. Its members' attitudes vary from indifference to commitment with hesitation in between. There are thus three concentric circles: a core group, actively involved; a medium group of favourable but uncertain people; and a periphery of distant members. The survey reveals an instantaneous picture of the diaspora at one point in its history. The distribution of the groups may change and individuals may pass from one to another according to the dynamics of the network. Its management thus requires appropriate incentives to make it attractive and to stimulate activities.

Global and Local Dimensions of the Network

A population of expatriate individuals does not automatically constitute a diaspora. It becomes one when it is a community whose members are in communication, have built and institutionalised a

collective autonomy, and share some goals and activities. This is what the Caldas network provides through its electronic list, local nodes and joint projects.

Electronic Worldwide Communication

According to the survey, the majority (58.5 per cent) of the diaspora's members have access to the Internet and use it as a communication medium; this proportion, however, may vary from one country to another.[9] In 1993, an electronic list—'R-Caldas'—was created, exclusively dedicated to academic exchanges and independent of the original Colext list, more oriented towards social and trivial matters. R-Caldas is the only common space, the unique permanent meeting point, shared by the diaspora's members wherever they are and therefore it constitutes the mould of its identity. The list and its activity have been systematically observed over a period of three years, from its inception in the early part of 1993 up to the beginning of 1996 (Meyer and Granés 1996).

The development of participation in R-Caldas revealed an exponential growth during most of the period, slowing down towards the end of the period because its field of expansion came to exhaustion. The participation in the list was not characterised by volatility. The electronic population of the diaspora was quite stable: though many people joined and some left after a while, the rate of stability (permanence between several electronic censuses) was high. It showed as increasing trend over the period, thereby indicating that people were generally faithful to the list, at least during the period under study.

The subscribers are geographically and institutionally dispersed, except in Colombia where the concentration is in some universities. The proportional importance of this country has dramatically increased over the years, from 11 per cent in 1993 to 26 per cent in 1996, partly due to the local extension of the Internet through its national representation RUNCOL and the CETCOL. An increasing number of people in Colombia are connected to R-Caldas and are able to communicate with the expatriates. The increasing concentration in Colombia in contrast to the initial dispersion worldwide changes the shape and perhaps the nature of the diaspora: from an original nebula it is being transformed into a centred system.

The number of message emissions has grown in the same proportion as the number of participants. There has been a twofold increase every year, from 160 in 1993 to 311 in 1994 and further to 620 in 1995. The list R-Caldas appears to be quite dynamic: participation and communication have increased significantly during the period. However, the emitting activity is concentrated: 63 per cent of the participants on the list never sent a message. These people are 'lurkers'—invisible users—a silent majority which appears to be a general characteristic of the electronic lists (Simon 1996). They are obviously not indifferent since they remain on the list and keep receiving without posting. On the other hand, the 5 per cent frequent senders during the period under study, represented 63 per cent of all the electronic communication posted. After a while, these people and their ideas or inputs are identified and recognised by others. The list is not an anonymous place. It has built its internal references determining the scope of communication for others as well as newcomers.

The bulk of messages is emitted from Colombia, that is, almost half of the total. This has much to do with the fact that the coordination of the Colciencias network in Bogotá uses the list as its major instrument for the dissemination of information to the diaspora. It represents half of the contribution from Colombia. Apart from Colciencias, many other Colombian institutions and individuals send messages, far more than in any other country including the United States though it has twice the number of Colombia's subscribers. There are more lurkers in the diaspora than in the national connected community. Colombia is an emitting centre; it is not only a centre of attraction of the diaspora's information.

What do the people exchange in this list? Definitely, substantial messages. A large majority of them are between 1 and 5 pages, thereby indicating that the messages are prepared, they are elaborated and dense. This is different from other academic electronic lists, where the frequency of messages is higher than in R-Caldas, but the density is lower. Unlike the other lists, R-Caldas is not concerned about scientific debates; in fact, it is not a discussion list: its use is more instrumental than social. It is also far more utilised to provide (information, announcements, opinions, call for tenders, warnings, offers, suggestions and congratulations) than to look for something (requests, inquiries). The list is a

diffusion place from which the silent majority get fed with information from the network and may use it to determine their professional strategies in relation to Colombia.

Messages are sent to every subscriber to the list, as the distribution is automatic through the server. But they generally have particular implicit receptors: only 36 per cent of the messages are directed to all the list members, while 4 per cent to individual receptors (open letter with copy to the list), 7 per cent to institutional ones, 7 per cent to receptors of a specific geographic zone and the majority (46 per cent) to particular thematic (specialised) groups. The importance of specialised information distributed through the list highlights its professional character. R-Caldas is like a flow of information in which one selects and uses what is of personal relevance. No less than 71 specialised groups have been identified through the message contents showing the cognitive dispersion of the population and confirming the conclusions of the survey.

The large areas of knowledge covered by electronic communication may be compared to their respective production in Colombia, as defined by the PASCAL publications database (Meyer et al. 1995). The following phenomenon is evident: the hierarchy is diametrically opposed. High technology, hard sciences, natural, earth–environment and health sciences is the decreasing order in the R-Caldas electronic communication while it is the increasing one in the Colombian scientific production. Therefore, the stronger a field in one part, the weaker it is in the other. The activity through the network is complementary to the one developed internally in Colombia. It may especially help to upgrade the technological innovation capacity which has become extremely important for industrial competitiveness in the newly opened economy.

The electronic activity through the list also has an impact on the institutional setting of the scientific community within Colombia. Its actors emitting messages in the frontier fields of high technology are those who are not very much visible in the traditional production of knowledge as revealed by the PASCAL database. As if the electronic network was used to open new spaces, to address new professional groups and thus change the patterns of recognition and the disciplinary trends within the national community. The diaspora is not an appendix of the latter; it develops new activities and orientations that some actors—expatriate or not—may take as opportunities to develop original strategies.

Local Nodes and Activities

The diaspora is organised in local groups, the network's nodes. They are associations of scientists, engineers, students and professionals officially working for the development of Colombia under an NGO status in the resident country. They have an executive committee and a president representing the node of the Caldas network and acting as its local coordinator and direct contact for Colciencias. There are 21 nodes which have successively emerged between 1991 and 1995 in the following order: the United States, France, Spain, Canada, Switzerland, Sweden, Belgium, Italy, Australia, New Zealand, Puerto Rico, Venezuela, Argentina, Mexico, Austria, Poland, Japan, Germany, the United Kingdom, Russia, Brazil and Hungary. There are also small local groups or isolated individuals in other places, without formal recognition. The overall population is approximately 1,000 but the participation and involvement are very diverse and the level of activity and integration of the nodes may vary considerably from one country to another.

Every node organises its associative life as it wants. The membership has been the first issue: should the association include scientists and engineers from every field or be restricted to some fields or at the opposite, extended to intellectuals and professionals without any limit? Should it include students or be restricted to senior? In general, sometimes after strong debates, the nodes have chosen a non-selective, wide open, policy. Today, most of them are actually associations of Colombian intellectuals even if the professionals and doctorate students specifically involved in the research sector represent the majority.

The general orientations of the nodes may vary according to influences emanating from the particular features of the resident country or from the very history of the local association. The nodes may thus be classified along an axis with two poles: the 'exo-centred' nodes (outward-oriented) at one end and the 'auto-centred' (inward-oriented) at the other (Schlemmer et al. 1996). Belgium could be placed at the former end. Its activities and members are oriented toward international practice. For example, they have organised a meeting of all the European nodes in Brussels to discuss Colombian science policy and cooperation with the Commission of the European Union. They believe that many

activities of the network should be set up at the European—instead of the national—level, for economies of scale and the achievement of a critical mass that they do not have in a small country like Belgium. For them, the local node is just a part of the whole. This is in contrast to what happens in the UK association which does not maintain many contacts with the other nodes and develops its own, independent activities, like the scientific meeting of Colombian biologists in the country.

Other nodes have more balanced orientations and/or a different configuration. The German node, for instance, has adopted the federative organisation that is also seen in the country: it is decentralised, with local groups in the various 'lander' universities. The New York group has tried to spread and to find subsidiaries in other US cities with little success. The French and Spanish nodes were sometimes bicephalous with concentrations in Paris and Madrid as well as in Grenoble and Barcelona, respectively. The members in Australia and New Zealand are scattered while those in Venezuela are largely concentrated in the same institution in Caracas.

The evolution of the nodes has been as diverse as their origin and configuration. However, a general pattern may be described. Initially, there was enthusiasm. The inception of the network has generated an inflation of expectations from the diaspora's members who have joined the proliferating nodes in significant numbers. Colciencias' propaganda for the network has met with high receptivity and participation. The initial mobilisation has operated even beyond what the first actors would have thought, in many cases. In the second phase, part of the population of the older nodes has gone through a period of doubts and disillusions because the network did not respond to their particular concerns. Some nodes have never really taken off, to expand beyond the nucleus of the original founders. In fact, many people critically view Colciencias' role in this process. According to them, the agency has not been able to respond to the expectations that it had raised when it had invited them to participate. These people often demand greater support from Colciencias to the node's life and activity, through direct funding of infrastructures (permanent secretariat) of the association. Others, however, are highly sceptical about Colciencias' involvement, fearing what they perceive as an inefficient bureaucracy. Therefore, the situation is somewhat ambiguous

considering the contradictory opinions and behaviours being expressed.

Efforts have been made to overcome the difficulties. A symposium of the network was held in Bogotá in July 1994, at which the nodes' coordinators were invited for discussion, under the auspices of Colciencias. The symposium provided a forum for addressing the various issues at stake and for maintaining the dynamics. Nonetheless, crucial problems like the nodes' capacities and resources have not found definite solutions. Another meeting has been planned in the near future in order to define a precise policy regarding the network's objectives and necessities.

Till date, the nodes have developed activities taking advantage of casual opportunities and without a general plan for the diaspora. The results are plentiful and dispersed. Several scientific meetings have been organised at the local level with fertile exchanges. Diffusion of information through the network's coordinators has allowed the expatriates to be increasingly in touch with the opportunities in Colombia. International cooperation in favour of Colombia has been enhanced through the network's members acting as 'scientific ambassadors'; expertise has been mobilised for the advancement of particular studies. But the ultimate and major purpose of the Caldas network is the concrete realisation of joint projects between the diaspora's and Colombia's research teams. This is what truly justifies the very existence of the network: an active contribution eventually internalised in Colombia. This has occurred in a small number of cases.

Joint Projects

Joint projects were first launched in 1994 and some of them have already been completed. They particularly demonstrate the multiplier effect of the diaspora option. They also highlight some of the difficulties, limitations and shortcomings to initiate and implement on a sustainable basis collaborative research projects between Colombian scientists at home and abroad (Granés, Morales and Meyer 1996). Three such projects will be discussed in the following which had different results and implications.

The first is the so-called Bio-2000 project which highlights the ambitions and deceptions that may accompany the evolution of multilateral cooperation through the Caldas network. This project

was launched in 1993 when European and North American based Colombian researchers wanted to explore the possibility for Colombia to launch a R&D project in biomedical applications of physics. With the support of the Universidad del Valle (Cali), a specific electronic list, originating from R-Caldas, was put in place with the purpose of defining the programme. It initially mobilised several nodes (Switzerland, New York and Houston). At the first meeting, held in Cali in July 1994, the most interested and competent people in the area participated. The project network was initiated with the goal of a concrete, multidisciplinary study (physics of particle detection, electronics, informatics, biology, nuclear and molecular biomedicine) to develop high level/low cost research capacities in a field manageable for countries such as Colombia. Fairly early, the project encountered two contradictory forces:

1. On the one hand, the slow pace of development in Colombia where the institutions supposed to provide the administrative basis for the project had difficulties in meeting the expectations of the diaspora.
2. On the other hand, a 'push forward' from the expatriates who were expanding the project with the hope of pressing the Colombian authorities by the inclusion of eminent scientists or with some commitments from funding organisations (UEC, Philips).

After two years, an equilibrium was found. Partners from the North would cooperate but not by creating new areas of research: teams from the South would have to adapt and select the fields they could manage. The 12 associates abandoned the idea of a unique federating objective and chose to develop several joint studies, each of which had various laboratories and teams. A year later, the project was still in progress but in a limited form: 5 universities participated along with the CERN and outside Colombia (in Spain, Italy, Brazil and Peru) with individual researchers from Bogotá and Cali and without the expected regular involvement of Colombian institutions. Though those who stayed realised a coherent project, some discouragement could be seen. Compared to the initial ambitions, the scope of the project was substantially reduced to bilateral, at the best trilateral, cooperation instead of the broad-based mobilisation envisioned at the beginning.

Moreover, the role of Colombia became paradoxically, comparatively minor in the project.

This example has been chosen to illustrate the extent to which the setting up of a project may be confronted by different logics: scientific and national, North and South, logics proper to a given institution or an individual researcher. Furthermore, while a project may be successful, its promoter may not necessarily be rewarded for it. As a way of illustration another example is discussed in the following.[10]

Jorge, a chemist from the National University in Bogotá, went to Sweden to complete his MSc and PhD. He married a Swedish woman and decided to stay in Swedan where he is engaged in contract-based research work in a public medical laboratory. Though he does not participate in the activities of the Swedish node of the Caldas network he knows most of its members. Along with a former friend, a microbiologist based in Bogotá, Jorge designed a collaborative project which he launched in Bogotá during a 6 month stay thanks to the support of Colciencias. According to both of them, the Caldas network has not been instrumental in establishing the connection since they knew each other earlier. But Jorge's visit was funded through the network's short time exchange programme. The collaborative work in Bogotá was productive and successful. It led to the development of a 'user friendly' technique for separating proteins. The results were presented at several international conferences and were published in a joint paper in a reputed journal.

For Jorge, the difficulties began when he returned home to Sweden. His laboratory in Sweden was pursuing a completely different line of research and he had a hard time trying to catch up and to submit research proposals in order to obtain research grants on which his salary depended. What he had accomplished in Colombia was hardly rewarding for him in Sweden even if he acquired increasing international visibility. On the contrary, it nearly jeopardised his precarious research career. Since he returned to Sweden he had virtually no connection with his friend in Colombia. Clearly, research agendas and constraints in Colombia and in the North do not necessarily match in the long term.

The third project focuses on transfer of technology in robotics and automation between a university centre in Paris and another one in Cali. The objective was to build in Colombia a robot for

industrial purposes. As expertise in this field in Colombia was limited, the idea was to utilise French experience, through a member of the network, and develop it with his knowledge. What was to be transferred were some pieces of the robot—to be assembled in Colombia—and the sophisticated know-how to make it work. The expatriate Colombian engineer in France was successful in involving in the project the manager of his institution, several French colleagues, knowledge and equipments, funding from the French government, which in a cumulative process, convinced Colciencias in Bogotá to co-finance the project; the project involved doctoral students from the Universidad del Valle (where there was no doctoral programme) under dual guidance from one professor in Colombia and another one in France. The robot is functioning in a mechanical engineering firm in Cali and may even be alternatively activated from Paris through the Internet. The multiplier effect worked efficiently and generated unexpected developments in Colombia. The country now has a dynamic group in automation and robotics which is able to take its own initiatives for further cooperation. It has started to develop programmes with German teams, for instance.

These projects are isolated examples of spontaneous initiatives made by individual actors. Without their firm commitment and consistent determination, the projects would not have taken off and expanded. The Caldas network directly or indirectly helped them to build the proper connections. But it could do much more: it could generate and multiply the associations through available relational methods and indicators.

Lessons and Instruments Derived from the Colombian Experience

Today, many countries and organisations are putting into practice the diaspora option under various modalities (Portnoff 1996): the UNESCO with a database of Latin American expatriate scientists and engineers (Cardoza and Villegas 1996), Chile and Croatia through e-mail lists (Rojas and Palacios 1996; Cano and Pifat 1996), Venezuela with a scheme comparable to the Colombian one (De la Vega 1996), Arab countries with a US based association, Tunisia through local associations (Belgacem 1996), China in biological sciences (Stone 1993), Hungary (Halary 1994), Argentina

(Rudin 1990) and Uruguay (Pellegrino 1996). Such countries as Ethiopia, Eritrea, India, Israel, Singapore, Taiwan, South Africa, Morocco and Rumania are actively considering it in one way or another (Gaillard and Meyer 1996). There are many ways to implement the diaspora option. However, two basic, related questions remain: does it actually transform the negative effects of migration into positive ones? What are the possibilities to ensure its optimal utilisation? The Colombian experience offers a clear positive answer to the first question and provides concrete perspectives on the second one.

The study of the Caldas network presented here has been limited to the discussion of the preliminary results of this experience. Its complete evaluation and the full impact of the diaspora option on scientific development will have to wait a few years and comparative studies are needed to assess their importance. However, the results may be summarised under five types of contributions made by the expatriates, which would not have been possible without the network:

1. Policy design and implementation.
   The National System of Science and Technology has called on specialists abroad to participate in their eleven disciplinary councils for designing the policies in each of these eleven fields. The network has permitted experts to appraise or evaluate projects funded by Colciencias. It is thus a pool of expertise for independent peer review to assess the scientific quality for the agency that has to select projects.
2. Scientific and technological training.
   Specialists from abroad have been invited for short visits to Colombia (1 to 8 weeks) for training sessions in their area of specialisation. Graduate students have been linked with institutions abroad through the network members.
3. Animation and communication.
   Local nodes of the network have organised scientific meetings on various subjects and have invited Colombian scholars to participate in these meetings. They often invite members of the network, not only members of their node but also of other nodes. The electronic list R-Caldas, to which many members of the network are connected, is a major source of

shared information on meetings in any area, professional positions, grants or training available in Colombia or in any part of the world, or on contacts, bibliography, references or resources to carry out a specific project.

4. Programmes and projects.
   Some research projects have begun to link people outside with the people in Colombia in such areas as physics, biotechnology, automation, psychiatry and biochemistry. These projects are often of one to several years in duration or may even aim to establish a permanent structure such as the creation of an academic centre with a doctoral programme in a provincial university. From the list of the local nodes' members, Colciencias has been able to build a central database of the expatriate human resources worldwide. This is a powerful tool to generate new projects in strategic fields for the country's development.
5. The Caldas network facilitates the return and reintegration of expatriate scientists and engineers under good conditions.

The above-mentioned results of the Caldas network reveal that the diaspora option is a real and workable proposition to transform the negative effects of emigration into actual benefits. It concretely addresses the problems that the brain drain countermeasures were unable to solve:

1. Instead of hardly feasible taxation policies it uses migrants'—substantial though non-financial—remittances: intellectual, technical, relational.
2. It does not depend on long-term regulations since it is a pragmatic, independent, national policy with some immediate dividends.
3. Instead of a conservative, restrictive policy toward the local community, it expands its capacity through the network evolved from the diaspora.

With regard to the other brain gain policy—the return option—the use of the diaspora is a complementary, not a contradictory, strategy. In Colombia, the Caldas network has been successfully

used in combination with the 'repatriation programme' of Colciencias and other institutions. People have been contacted and have negotiated the conditions of their return through it. It is well known that adequate reintegration is more likely when the expatriates have maintained and developed working relationships with their national professional community (Glaser 1978). As the location of the diaspora and the migrant status are not permanent features, the network is an excellent way to manage highly qualified domestic labour market issues with better knowledge, as much for the expatriates as for their local potential employers. The evidence that the return and diaspora options may be conceived in complementary, even synergetic, dynamics is that the NICs (Far Eastern countries) with strong repatriation programmes are today involved in decisive networking actions with regard to their professional expatriates.

The crucial advantage of the diaspora option resides in its flexible networking component. It does not require massive infrastructural investment beyond the reach of many developing countries. But it does require a firm commitment with regard to policy and strategic thinking in relation to management. The first ensures the initial mobilisation of the diaspora and the second its optimal use and sustainability. The Colombian experience has been positive in relation to the first and short on the second. This illustrates the obstacles that some developing countries would have to overcome when applying the diaspora option strategies. The acquisition of technical and administrative capacities that they require would probably only be achieved through international cooperation.

In Colombia, the strong political signals sent to the expatriates at the beginning of the decade have led to the creation of a real intellectual diaspora. But it has fallen short of defining a strategy about their use, their contribution to and their retribution from the country. Consequently, the diaspora is left to individual—often isolated—spontaneous actions instead of capitalising on the vast available field of expertise. It relies on occasional initiatives from the more active participants—the first circle of the diaspora—without any capacity to extend or generalise them within this circle or to reach and mobilise the second and third ones. To develop such a capacity, more than policy decision is required; it is a question of strategic management and technical instrumentation.

The major difficulty of the diaspora option is linked to the very nature of the expatriate population: it is heterogeneous and dispersed. This has various interrelated consequences. First, the precise identification, location and qualification of the diaspora's resources are difficult. Second, the determination of their possible contribution, their association within national programmes and their actual linkages with local teams have to be thoroughly investigated. Third, their dispositions or availabilities and, therefore, the modalities to foster their active involvement, are unknown. These three types of difficulties point to the dispersion of information that characterises the diaspora option and that fundamentally affects decision-making about it. Answers to these issues have been explored through the Colombian case study. It is seen that precise and reliable maps may be designed, permitting the country to locate actors, cultivate dynamics, generate policy orientations and channel resources accordingly, in the almost unlimited field of the extended national community and its networks.

These mapping techniques are now well known and in permanent development (Callon et al. 1986; Polanco et al. 1995; Vinck 1991). They have been applied to the research database of the Caldas network and a study to integrate them into a comprehensive package with multidimensional—not only cognitive—information, is being designed (Charum 1996; Montenegro et al. 1996). Obviously, these navigation tools need adequate formalisation and presentation in order to be accessible by researchers, institutions and managers on a daily basis.

The systematisaton of the diaspora option through these techniques would lead to an optimisation of its potential. The cross-fertilisation of the national, internal community and the diaspora are no longer left to random and unlikely encounters. They may be planned, managed and worked out by the actors themselves, once the scope of the virtual partnerships has become apparent through the maps.

The Colombian experiment has not gone as far as to develop an optimal use of the diaspora it has achieved to create. It has remained at the stage of empirical, 'blind' management. But the case study has pointed out the necessity of systematic methods and has generated the design of appropriate indicators. The next stage in the development of the diaspora option could be its rational though flexible implementation through such kinds of instruments.

NOTES

1. On the theoretical aspects of this question, see Meyer and Charum (1995).
2. While the return option may fully use the professional repatriate, the network diaspora must partially rely on the expatriate who can only marginally dedicate its activity to it. But while the return option mostly takes advantage of the 'embodied knowledge' of the person reintegrated into the national community, the diaspora option benefits from all the heterogeneous resources to which the network's actor is locally connected (equipments, colleagues, data, documentation, institutions, funds). Return and diaspora options have different impacts on the development process of national scientific communities: the first has a definite additional effect while the second has an aleatory multiplier effect.
3. Brain drain and brain gain options may sometimes overlap. For instance, the principle of resorting to the diaspora's skills and resources had been intuited within the Reverse Transfer of Technology, a typically brain drain approach. But, it was not explored to the extent of traditional options (UNCTAD 1983).
4. Other examples may be mentioned of countries having resorted to the use of their intellectuals abroad (France, Greece, Israël, Peru, the Philippines, Turkey, for instance). None of them have gone further than the ones presented here and they all have fallen short of the Colombian case.
5. According to governmental sources, the S&T Colombian diaspora would be around 2,000 people. This represents more or less 0.5/1000 of the overall Colombian migrant population in the world and a little less than half of the people officially involved in R&D activities in Colombia.
6. Identification and location of these people was done through numerous census and membership lists emanating from Colombian institutions (Colciencias, Icfes, Icetex, embassies), from the network's nodes coordinators and individuals, from the British Council and from electronic lists. Nevertheless, there cannot be any evaluation of the absolute representativity of the sample since the exhaustive population—if it could supposedly be defined—is unknown.
7. The propensity of the expatriates' partners in the host countries to work with Colombia is an interesting aspect. It seems that cooperation offers prestige, recognition, access to funding through cooperation agencies or programmes, etc. But this may be different according to the actors: private firms may be reluctant to relinquish information. Also, some countries have expressed concern (the USA, for instance) about 'knowledge drain' in strategic sectors and tend to limit the access of foreign students to these. The development of the diaspora option may be altered by this current phenomenon of privatisation and restrictions to information in S&T activities.
8. When asked to describe the difficulties to be overcome in Colombia in order to improve relationships with the country, the majority of the people mentioned more technical problems than social ones. In terms of possible advantages existing in Colombia for joint projects with the diaspora, the survey emphasised two points: on the one hand, the existence of personal contacts (mainly in the academic sector) for identifying and locating potential partners, and on the other hand, the absence of institutional support for projects realisation. This obviously provides a space for the Caldas network as an instrument aiming to fill this institutional vacuum by offering facilities for shared activities.

9. In the New York Caldas node, it was observed that at the time of the survey only one-third of the members has access to the Internet.
10. Names have been changed to ensure anonymity.

REFERENCES

BELGACEM, H. (1996), 'Tunisian Competences Overseas: A Greater Contribution to the National Development', in J. Charum and J.B. Meyer, eds, *Proceedings of the International Symposium on International Scientific Migrations Today*. Symposium jointly organised by ORSTOM, Paris and National University of Colombia, Bogotá, 23–26 June.

BHAGWATI, J.N. (1976), *The Brain Drain and Taxation—Theory and Empirical Analysis*. Amsterdam: North-Holland Publishing Co., p. 292.

CALLON, M., J. LAW and A. RIP (1986), *Mapping the Dynamics of Science and Technology*. London: MacMillan.

CANO, V. and G. PIFAT (1996), 'Information Technology as a Search Mechanism for Brain Gain', in J. Charum and J.B. Meyer, eds, *Proceedings of the International Symposium on International Scientific Migrations Today*. Symposium jointly organised by ORSTOM, Paris and National University of Colombia, Bogotá, 23–26 June.

CARDOZA, G. and R. VILLEGAS (1996), 'Scientific Migrations, Cooperation and Development Networks in Latin America and the Caribbean', in J. Charum and J.B. Meyer, eds, *Proceedings of the International Symposium on International Scientific Migrations Today*. Symposium jointly organised by ORSTOM, Paris and National University of Colombia, Bogotá, 23–26 June.

CHARUM, J. (1996), 'Migration and the Construction of Scientific Cooperation: The Case of the Caldas Network', in J. Charum and J.B. Meyers, eds, *Proceedings of the International Symposium on International Scientific Migrations Today*. Symposium jointly organised by ORSTOM, Paris and National University of Colombia, Bogotá, 23–26 June.

CHARUM, J. and J.B. MEYER, eds (1996), *International Scientific Migrations Today*. Proceedings of the International Symposium organised jointly by ORSTOM, Paris and National University of Colombia, Bogotá, Colombia, 21–26 June.

CHARUM, J., J. GRANÉS and J.B. MEYER (1996), 'Le science en Colombie', in Blanquer J.M. Gros Ch., ed., *La Colombie à l'aube du troisième millénaire*. Paris: Editions de l'IHEAL, pp. 423–38.

COURRIER, LE (1996), 'Arrêt à la fuite des cerveaux: le programme efficace du PNUD', *Le Courrier*, 159 (September–October).

DE LA VEGA, I. (1996), 'The Venezuela Program: In Contact with Venezuela', in J. Charum and J.B. Meyer, eds, *Proceedings of the International Symposium on International Scientific Migrations Today*. Symposium jointly organised by ORSTOM, Paris and National University of Colombia, Bogotá, 23–26 June.

GAILLARD, J. (1991), *Scientists in the Third World*. Lexington: The Kentucky University Press.

GAILLARD, J., V.V. KRISHNA and R. WAAST, eds (1997), *Scientific Communities in the Developing World*. New Delhi: Sage.

GAILLARD, J. and J.B. MEYER (1996), 'Le brain drain revisité: de l'exode au réseau', in J. Gaillard, ed., *Coopérations scientifiques internationales*. Paris: ORSTOM éditions, pp. 331–47.

GLASER, W.A. (1978), *The Brain Drain: Emigration and Return*. Oxford: Pergamon Press.

GRANÉS, J., A. MORALES and J.B. MEYER (1996), 'Potential and Limits of the Caldas Network of Colombian Researchers Abroad: International Joint Projects; A Case Study', in J. Charum and J.B. Meyer, eds, *Proceedings of the International Symposium on International Scientific Migrations Today*. Symposium jointly organised by ORSTOM, Paris and National University of Colombia, Bogotá, 23–26 June.

HALARY, C. (1994), *Les éxilés du savoir; les migrations scientifiques internationales et leurs mobiles*. Paris: L'Harmattan.

KAO, C. (1971), 'Brain Drain Revisited: The Case of Taiwan', *International Development Review*, 13(3), pp. 23–24.

MESA, G., C. CRUZ, A. SCHIKLER, C. MONTOYA and E. GOMEZ (1978), *Evaluación del programa de retorno de professionales y tecnicos; decreto No 1397 del 16 de Agosto de 1972*. Bogotá: SENALDE-COLCIENCIAS.

MEYER, J.B. and J. CHARUM (1995), 'La fuite des cerveaux est-elle épuisée? Paradigmc perdu et nouvelles perspectives', *Cahiers de Sciences Humaines*, 31(4), pp. 1003–17.

MEYER, J.B., J. CHARUM, J. GRANÉS and Y. CHATELIN (1995), 'Is it Opened or Closed? Colombian Science on the Move', *Scientometrics*, 34(1), pp. 73–86.

MONTENEGRO, A., J. LEON and C. MURCIA (1996), 'Prospects for Statistical Analysis in the Research on Scientists Migrations. The Case Study of the Caldas Network', in J. Charum and J.B. Meyer, eds, *Proceedings of the International Symposium on International Scientific Migrations Today*. Symposium jointly organised by ORSTOM, Paris and National University of Colombia, Bogotá, 23–26 June.

in the Research on Scientists Migrations. The Case Study of the Caldas Network', in J. Charum and J.B. Meyer, eds, *Proceedings of the International Symposium on International Scientific Migrations Today*. Symposium jointed organised by ORSTOM, Paris and National University of Colombia, Bogotá, 23–26 June.

MURCIA, C. and L.S. PARRADO (1996), 'Labour Migration of Colombian Professionals. Neither Brain Drain nor Brain Gain: The Caldas Network Diaspora Alternative', in J. Charum and J.B. Meyer, eds, *Proceedings of the International Symposium on International Scientific Migrations Today*. Symposium jointly organised by ORSTOM, Paris and National University of Colombia, Bogotá, 23–26 June.

PEDERSEN, P. (1993), 'The New China Syndrome: Delayed Return as an Alternative to the "Brain Drain"', *International Educator* (Spring), pp. 31–33.

PEDERSEN, P., L.T. HU, K.K. HWANG, A.B. PEDERSEN, P.J. GREY, J.N. MARTIN and B. FLORINI (1990), 'The Reentry of U.S. Educated Scientists and Engineers to Taiwan: An International Cooperative Research Project', *Journal of National Press: Academia Sinica*, 19(2), pp. 1–138.

PELLEGRINO, A. (1996), 'Emigration of Scientists: The Case of Uruguay', in J. Charum and J.B. Meyer, eds, *Proceedings of the International Symposium*

on International Scientific Migrations Today. Symposium jointly organised by ORSTOM, Paris and National University of Colombia, Bogotá, 23–26 June.

PIRES, J. (1992), 'Return and Reintegration of Qualified Nationals from Developing Countries Residing Abroad: The IOM Program Experience', *International Migration*, 30(3–4), pp. 353–76.

POLANCO, X., L. GRIVEL and J. ROYAUTÉ (1995), 'How to do Things with Terms in Informetrics: Terminological Variation and Stabilization as Science Watch Indicators', in *Proceedings of the Fifth International Conference of the International Society for Scientometrics and Informetrics*. Medford: Learned Information, Inc.

PORTNOFF, A-Y. (1996), 'Les diasporas scientifiques modèlent l'avenir', *Futuribles*, 210, pp. 57–59.

ROJAS, F. and A. PALACIOS (1996), 'From Brain Drain to Brain Gain: Social Profiles of Chilean Researchers in Foreign Countries', in J. Charum and J.B. Meyer, eds, *Proceedings of the International Symposium on International Scientific Migrations Today*. Symposium jointly organised by ORSTOM, Paris and National University of Colombia, Bogotá, 23–26 June.

RUDIN, E. (1990), 'Scientific Brain Drain in Argentina', National Scientific Foundation, *Insight* (Winter).

SCHLEMMER, B., J. GAILLARD, N. NARVAEZ-BERTHELEMOT and D. BERNAL (1996), 'The Dialectics between Virtual and Concrete Ends in the Caldas Nodes, Colombian Network of Expatriate Researchers', in J. Charum and J.B. Meyer, eds, *Proceedings of the International Symposium on International Scientific Migrations Today*. Symposium jointly organised by ORSTOM, Paris and National University of Colombia, Bogotá, 23–26 June.

Semana (1959), 'Educacion: Organizacions, control remoto', 14 April.

SIMON, B. (1996), *Welcome to Sci-Tech-Studies, Introductory Message to the List of Science and Technology Studies*. STS@CCTR.UMKC.EDU.

SIMON, G. (1995), *Géodynamique des migrations internationales dans le monde*. Paris: PUF.

STONE, R. (1993), 'The China-America Connection', *Science*, 262.

SWINBANKS, D. and E. TACEY (1996), 'Chinese Scientists Drawn Back to Asia', *Nature*, 383 (September), pp. 11–13.

TOKTEN (Transfer of Knowledge through Expatriate Nationals) (1988), *A Ten Years Brain Gain*. New York: UNDP.

UNCTAD (1983), *Towards an Integrated Approach to International Skill Exchange Proposals for Policy and Action on Reverse Transfer of Technology*. Study of the UNCTAD Secretariat, UNCTAD doc. TD/B/AC.35/2, Geneva.

——— (1984), *Establishment of an Internationally Agreed Set of Definitions, Principles and Standards for All Facets of the Reverse Transfer of Technology*, UNCTAD doc. TD/B/AC.35/7, and Corr. 1, Geneva.

UNCTAD/CSIR (1977), *Case Study in Reverse Transfer of Technology: A Survey of Problems and Policy in India*. Doc TD/B/C/.6/AC.4/6.

VINCK, D., ed. (1991), *Gestion de la Recherche, Nouveaux Problèmes, Nouveaux outils*. Brussels: De Boeck.

*From Brain Drain to Reverse Brain Drain: Three Decades of Korean Experience**

HAHZOONG SONG

This paper examines three decades of the Korean experience of brain drain, that can be termed 'from brain-drain to reverse brain-drain', and governn.ent policies to deal with this phenomenon.

The results confirm the major role of economic factors in return-or-stay decisions of Korean scientists and engineers (KSEs) who earned PhDs in the US. And yet, when the difference in economic conditions between alternatives is narrowed, psychological and emotional factors are identified to be important. In particular, this study suggests that some Confucian values work as an underlying element in KSEs' decisions. Consequently, this study indicates the importance of including a cultural analysis in the study of brain drain issues.

The Korean government tried to repatriate as many scientists and engineers as possible in the 1960s and 1970s. Yet, the effectiveness of policy measures during that period was limited. As the Korean economy continued to improve, many of the foreign educated scientists and engineers intended to return to Korea by the 1980s. From this time on, the Korean government adopted a policy to utilise the needed expertise of Koreans abroad, while helping them choose their residences by themselves.

Introduction

OVER THE LAST three decades, the Korean economy has grown at an average annual rate of 9 per cent. Per capita GNP rose from $87 in 1962 to $10,076 in 1995 (see Table 1). Exports increased from $55 million in 1962 to $125 billion in 1995. Following this remarkable economic performance, Korea became the 29th OECD member country in November 1996.

* An earlier version of this paper was presented at the symposium on 'International Scientific Migration Today: New Problematic', Bogotá, Colombia, June 1996. I am grateful to Jacques Gaillard (ORSTOM) and anonymous reviewers for their comments and help.

Hahzoong Song is Professor, Department of Public Administration, College of Law, Kyung Hee University, 1 Hoeki Dong, Dongdaemoon-Ku, Seoul, 130–701, Korea.

Science, Technology & Society 2 : 2 (1997)
SAGE PUBLICATIONS NEW DELHI/THOUSAND OAKS/LONDON

TABLE 1
Selected Statistics on Korean Economy, 1962–95

Year	*GNP (current US$ bil.)*	*Per Capita GNP (current US$)*	*Export (Current US$ mil.)*
1962	2.3	87	55
1970	8.1	252	835
1975	20.5	580	5,081
1980	61.8	1,620	17,505
1985	95.5	2,340	30,283
1990	233.8	5,450	65,015
1995	451.4	10,076	125,058

Source: Economic Planning Board, Korea, *Yearbook*, each year.

While trying to maintain this economic momentum, Korea hopes to join one of the advanced countries within a decade or two. Human resources, a key to the past economic development, will remain a critical factor in achieving this goal. A corps of scientists and engineers are at the centre of efforts to enhance the national capacity to design, market and manufacture products as well as teach students and carry out research and development activities. Although a majority of them were brought up in Korea, foreign educated scientists and engineers constitute an invaluable source of high quality manpower to lead the country's science and engineering.

In recent years, there has been a massive influx of US trained Korean scientists and engineers into Korea. The USA is the home of more than 80 per cent of expatriate Korean scientists and engineers. Two-thirds of Korean scientists and engineers who obtained their doctorate in the US in the 1980s returned to Korea within three years after graduation. Considering the fact that the proportion of returning Koreans who earned their doctoral degrees in the 1960s was less than 10 per cent, the difference indicates a drastic change in the pattern of migration among highly educated and skilled Koreans during the past three decades. Since the US is the single most popular destination of graduate studies abroad among Korean students, Korea is now in a position to enjoy 'reverse brain-drain' or 'brain-gain'—an inflow of high quality human resources.

During the brain-drain controversy of the 1960s, some analysts believed that social and economic incentives would drive talented people away from developing countries towards advanced countries (Adams 1968). Given resource shortages of the developing countries, this problem seemed unlikely to be solved soon (Bhagwati and Hamada 1989). Today, many Third World countries still lose their best talent to advanced countries (Cannon 1988; Finn 1985; IIE 1995; NSF 1985, 1986, 1993). Korea's case, however, demonstrates the possibility that the brain-drain curse might turn into a blessing. Taiwan has also experienced a similar exodus of expatriates. This phenomenon can be attributed primarily to the booming economy in both countries.

However, this goes beyond simple economy: talented people are returning despite the fact that the economic structures and living conditions of their home countries are weak compared to those of the advanced countries. As the economic conditions of the home country reach a certain level, however, psychological and emotional factors also play an important role (Dunn 1995; Gittelsohn 1989; Yoder 1989). Although the Korean case is an exception rather than the rule, it should shed light on the issue for other developing countries. It is in this regard that the developing countries should carefully design and implement their policies for utilising the repatriated talents.

This paper examines Korea's experience: 'from brain-drain to reverse brain-drain' over a period of three decades (1960–88). The paper is divided into three parts. The first describes Korea's past economic development, the state of science and technology, and values and norms of Korean society. Against this background, the choices facing Korean scientists and engineers can be clearly understood. The second part examines the changing trends in the residence choice of Korean scientists and engineers (hereinafter KSEs). Factors that affect an individual's choice of residence are identified and analysed. The analysis is based on a survey of two groups of Korean scientists and engineers: those who decided to stay on in America, and those who returned to Korea. The last part describes the Korean government's policies to cope with the brain-drain phenomenon from the 1960s through the early 1990s.

Trends in Economic Development and Science and Technology of Korea[1]

The 1950s and 1960s: Korean War and Gearing up for Economic Development

In the 1950s, Korea was one of the poorest countries in the world and relied heavily upon foreign aid for most of its basic needs. The Korean War (1950–53) dealt a severe blow to the country's hope for the future, which was already devastated by the partition of the country following the end of Japanese colonial rule. The war was a tragedy not only because it caused enormous casualties (about one million lost their lives), but also because it was the first all-out civil war caused by a conflict of ideologies implanted by foreign powers. Most of the production facilities were destroyed and the country's poor economy was left in ruins.

President Park Jung Hee, upon assuming power following a *coup d'etat* in 1961, launched a nationwide drive for economic development. In this early stage of economic development (the 1960s), Korea had virtually no infrastructure or economic foundation. Therefore, the main goal of economic development was to establish an industrial foundation. The Korean government announced the 'First Five-year Economic Development Plan' in 1962 to promote import substitution industries and export-oriented light industries. Various policy measures such as exchange rate adjustment, tax incentives and preferential financing were adopted to support these industries (STEPI 1995).

While pursuing import substitution and export promotion policies, the technological expertise most in demand was the capacity to implement foreign manufacturing technology. Foreign technologies were obtained through reverse engineering, imitation, imports of capital goods, and licensing. Science and technology policy of the 1960s was regarded as part of the industrial policy and focused on better management of technology import process (Kim 1993; Lee 1991). During this period, the Korean government established organisations which came to play a significant role in the country's future science and technology development. The Ministry of Science and Technology (MOST) was established in 1967 to formulate and implement overall science and technology policies (STEPI 1997). In 1966 the Korea Institute of Science and Technology

(KIST) was established as the first government sponsored integrated research institution.

The 1970s: Transition of Industrial Policy

Until the mid-1970s Korea owed its economic development to the labour intensive manufacturing sectors. Light industries such as textiles and plywoods expanded very rapidly. Over time, however, pressure from developing countries that followed Korea's suit weakened Korea's position in the export market. At the same time, trade deficits caused by imported machinery and raw materials became a chronic problem. The Korean government sought to overcome these challenges by changing the industrial structure of the country. Accordingly, there was a shift in the industrial policy of the country—towards building up heavy and chemical industries. The government provided various financial incentives, including artificially lowered interest rates for bank loans and government guarantees for foreign loans (STEPI 1997).

The Korean government coerced big companies to commit to heavy and chemical industries by not only reducing the cost of capital investment, but also by exerting political pressure on the companies. At this stage, it was clear that a major bottle-neck in building up heavy and chemical industries was science and technology capacity. The strategy of the 1960s to copy or borrow foreign technologies was no longer appropriate. Licensing the leading edge technologies was both costly and complicated. Furthermore, advanced countries were increasingly reluctant to transfer technologies. There was a consensus among Korean policy makers that further economic development would not be possible without enhancing the domestic science and technology basis. Business leaders who also recognised the need had no other choice but to invest in their own R&D facilities and personnel. By this time, big corporations like Samsung, Hyundae and Daewoo had accumulated the necessary resources and capital to invest significantly in R&D. Given the financial capabilities, recognised needs and various incentives from the government, R&D capacity enhancement was pursued aggressively (CSTP 1988). As Table 2 shows, R&D manpower and R&D's share of GNP grew faster in the 1980s than the overall national economy.

TABLE 2
Selected Statistics on Korean S&T, 1962–94

Year	*R&D Expenditures*		*R&D Personnel*	
	As % of GNP	*Source of Funds Gov. & Pub.: Private*	*Number of Researchers*	*Per 10,000 Population*
1963	0.25	97:3	NA	NA
1965	0.26	90:10	2,135	0.7
1970	0.38	88:13	5,628	1.7
1975	0.42	71:29	10,275	2.9
1980	0.57	61.38	18,434	4.8
1985	1.59	20:80	41,473	10.1
1990	1.88	19:81	70,503	16.4
1994	2.61	16:84	117,446	26.4

Sources: Ministry of Science and Technology, Korea, *Yearbook*, each year. *Report on the Survey of Research and Development in S&T*, each year.

The 1980s and After: Commitment to the Advancement of Science and Technology

The massive mobilisation of investment capital for heavy and chemical industries during the 1970s led to a distortion in resource allocation and slowed down the economic growth of the country. The second international oil crisis which came in the midst of tremendous political turmoil following the assassination of President Park in 1979 aggravated the economic downturn of the country. In 1980, the Korean economy recorded a negative growth for the first time since 1961.

Amid these cloudy political and economic developments, the Fifth Republic was born and the government's top priority was to stabilise the domestic economy. Major stabilisation measures included financial and trade liberalisation, realignment of industrial incentive system, introduction of the Fair Trade Act, and devaluation of the Korean 'Won'. Policy loans were abolished, and government subsidies such as 'preferential' loans were reduced (OECD 1996). Industrial targeting was gradually phased out and functional incentives were emphasised. All these measures proved to be successful and the country's economy recovered accordingly.

In the mid-1980s, Korea enjoyed a favourable international environment which was characterised by the so-called three lows:

low interest rates, low oil prices, and low value of the US dollar. In 1986, Korea recorded a trade surplus for the first time since 1945.

In 1987, public demand and actions for democracy led to a significant political change—the popular presidential election was held for the first time in 20 years. What lay in store for the new government were active labour movements and demands for social welfare programmes. As a result, labour costs escalated rapidly, with its rate of increase exceeding that of labour productivity increases. Rising labour costs eventually accelerated an industrial restructuring toward automation and technology intensive industries.

In the 1990s, Korea continued to pursue liberalisation of industrial regulations in favour of market mechanism. By then, the Korean economy had achieved a remarkable growth in both volume and degree of sophistication. Although the government had played a key role in the initial stages, it is no longer possible for the government to manipulate industrial development. Instead of steering the industry in a particular direction, the Korean government provided various incentives for investments in R&D infrastructure and technology innovation, emphasising some high tech fields.

As described here, science and technology has become a major theme in Korea. It is clear from Table 2 that the nation's science and technology activities became a serious undertaking from the 1980s. R&D expenditures as per cent of GNP rose from 0.25 in 1963 to 0.57 in 1980 and further to 2.6 in 1994. Government and public R&D sources, that comprised 97 per cent of R&D expenditures in 1963, accounted for only 16 per cent of the overall R&D fund in 1994, reflecting the rapid shift of R&D activities to the private sector. The total number of R&D personnel was 117,446 in 1994, up from 2,135 in 1965 and 18,434 in 1980.

Human Resources for Science and Technology

One of the most important factors in Korea's industrialisation was its abundant and relatively well-educated human resources. In the early stages of development in the 1960s, workers who were able to acquire training in imported production technologies contributed to the massive growth of import substitution industries. Since the technologies of the time did not require sophisticated knowledge, a large number of workers became skilled workers after being

given a short vocational training (Lee 1995). Although their educational level was not high, those who had basic education were an important source of manpower mobilisation as technicians.

Owing of the Confucian tradition, Koreans regard education as the best asset for social excellence. This eagerness for education was the driving force for a massive cultivation of an educated manpower. Following the improvement in economic conditions, student enrolments at all levels in schools increased. As Table 3 shows, high school enrolment in 1990 was 87 per cent of the age cohort, compared to 28 per cent in 1970. With the increase in overall student enrolment, the number of domestically trained scientists and engineers also increased. In 1995, Korean higher education institutions produced 72,012 BA, 10,090 MS and 1,621 PhDs in science and engineering. Throughout the 1970s and 1980s, most of the manpower needs were met by this group of domestically trained scientists and engineers. They formed the basis for science and technology development, mostly engaging in production and management.

TABLE 3
Education Enrolments 1960–90

		1960	*1970*	*1980*	*1990*
	Age	*Number of Enrolments (1,000)*			
Elementary School	6–11	3,623	5,749	5,658	4,869
Middle School	12–14	528	1,319	2,471	2,276
High School	15–17	273	590	1,696	2,283
College/Graduate	18+	101	201	625	1,511
	Age	*% of Enrolments by Age Group*			
Elementary School*	6–11	NA**	100.7	102.9	100.9
Middle School	12–14	NA	51.2	95.1	96.3
High School	15–17	NA	28.1	63.5	86.8
College/Graduate	18+	NA	8.8	16.0	37.6

Notes: * Since some elementary school students are over or under the typical age, the percentage of enrolment exceeds 100.

** Since the statistical record of the age cohort in the year 1960 is not available, the percentage of enrolment has not been calculated.

Source: Korean Educational Development Institute (1993).

A critical contribution to Korean science and technology development came, however, from foreign sources. While technology transfer through overseas licensing or direct investments helped Korean companies build up their technology basis, the utilisation of foreign trained manpower also played an important role. Foreign trained scientists and engineers adopted and refined imported technologies in Korea, taught students and engaged in R&D activities. Their knowledge and experience became a key element in upgrading the level of sophistication in overall science and technology in the country. In particular, Koreans working for overseas institutes were readily available, when Korea tried to introduce leading edge technologies or new industry. For instance, it is well known that the Korean semiconductor industry, through the utilisation of Korean engineers recruited from America, has saved at least 10 years in catching up with the Japanese and American companies.

Values and Norms of Korean Society

Korea has transformed from an agrarian society to an 'industrialised' society in less than a century. The transformation of the country's economic structure was accompanied by a change in the value structure and norms of Koreans. Its bitter experiences in recent history—loss of independence to Japanese colonial rule (1910–45), the partition of the country and the subsequent civil war (Korean War, 1950–53)—shattered the rigid social system and norms of traditional Korea. The drive for economic development of the last three decades also significantly contributed to the transformation of Koreans' values and norms. At present, many of traditional rituals and customs are either no longer practised, or have been replaced by newly adopted Western ones. It is observed, however, that many of the inherited norms and values are still reflected in the Koreans' behaviour, intertwined with newly acquired Western ideas. Sometimes they are manifested in modified forms, and at times they lie dormant, but still remain powerful (Song 1991). In the following we will examine traditional Korean values and some of the newly adopted Western ideas.

The Confucian Social Structure and Norms

For more than five centuries, Confucianism has been the ruling philosophy of Korean society. The influence of Confucianism was so profound that it is difficult to explain the political, social, and economic conditions of traditional Korea without referring to it. Confucianism, as the moral standard and political framework of the country, was never challenged and when anything went wrong the blame was ascribed to men, and not to Confucian ideas. Although Korean culture was also influenced by other ideas and religions, the underlying values and behavioural patterns of modern Koreans are dominated by Confucianism.[2]

Among the elements of present-day Korean values carried over from traditional society, filial piety remains an undeniable personal virtue. Even though the modern father–son relationship is not as absolute as that of traditional Korean society, a father as the head of family has the authority to dictate his son's decisions and behaviour. A relaxed form of filial piety operates as the basic behavioural norm or code of conduct in social organisations. The concept of hierarchy, combined with other components of traditional familism or communitarianism, also dominates the Koreans' way of thinking.

The concepts of stability and harmony, although tainted by overuse for political ends, are still cherished virtues in Korean society where individuals are expected to subordinate their interests to those of the community. While these values—filial piety, stability and harmony—are the sustaining norms for the hierarchical social structure, egalitarianism is an accepted goal to be achieved through political and economic democracy. Whether egalitarianism is interpreted as 'equality of opportunity' or as 'equality of result' will shape the future framework of Korean norms.

Although the class system has been officially abolished, elitism abounds in the Korean social systems—academia, business, military, and government bureaucracy alike. Many characteristic phenomena of elitism in Korean society are rooted in Confucian values and norms. Consideration of 'face' and formalism (or ritualism) still influence the behaviour of Korean people. The strong achievement motivation or desire for 'success' is combined with the Confucian ideal of excellence through education, which is exhibited in the feverish drive for education in modern Korean society.

Materialism and Individualism

The apparent components of Western culture found in modern Korea are materialism and individualism. As rapid urbanisation accompanied the transition of family structure from a large extended one to a nuclear one, these ideas deeply penetrated into the Korean values and norms. As a result of industrialisation, the pursuit of material well-being has rapidly replaced the disregard for practical matters maintained in traditional Korean society. While some aspects of individualism are still loathed, it is manifested in many ways in the personal behaviour of Koreans.

One of the drastic changes observed in the modern value system compared to the traditional one is the attitude toward materialistic well-being. After the class structure of *yangban* (the nobles) and the commoners was formally abolished in 1894, people with previously unaccepted backgrounds emerged at the top rung of the social ladder.[3]

Korea's economic development over the past decades was led by a group of military careerists and businessmen who had a goal-oriented mentality. These power elites emphasised efficiency, under the slogan of 'modernisation of the nation'. Although it came into conflict with traditional values, the remarkably enhanced economic status of the country was enough to win public approval of efficiency goals. The strong efficiency incentive combined with the desire for success gave materialism a solid ground in the mentality of the Korean people. The relentless drive for materialistic achievement explains the hardworking attitude of Korean workers, as they are willing to sacrifice immediate benefits for long-term betterment.

Following the introduction of Western democracy and Christianity, Koreans accepted individualism as an essential step toward modernising the country. With the adoption of the nuclear family structure by many urban families, children in such families tend to exhibit more individualistic behaviour. The diversification of values in Korean society also fostered individualistic attitudes. Self-satisfaction regardless of position and title is becoming increasingly acceptable among the new generation. Some professions which were traditionally looked down upon, such as artistic performances, are highly valued by the younger generation. Individualism allows

them to claim rights in the organisational or community settings, instead of subordinating their interests for the sake of the organisation.[4]

It is true that modern Koreans exhibit 'new' behavioural patterns. However, it is an undeniable fact that a deep-rooted traditional value structure still influences Koreans' behaviour and attitudes in many respects, both implicitly and explicitly. Even in the case of the younger generation, there is evidence of traditional family orientation and communitarian (and authoritarian) ideas. Within the context of family relations, young Koreans maintain an attitude of communitarianism, while exhibiting a more individualistic value orientation with regard to social relations. This value structure combining both traditional and Western norms raises the question of how much change has really occurred. If cultural integrity can be achieved by retaining some traditional values as well as by adopting some newly acquired ones, the eventually stabilised Korean value structure will only be identifiable after the country has passed through the present period of rapid social transformation and industrialisation.

Residence Choice of Korean Scientists and Engineers

The preference of KSEs' residence choice changed dramatically over the three decades under study—preferring America in the 1960s and Korea in the 1980s. The pattern of change in their residence choice and explanations for this will be discussed in the following. Explanations are based mainly on the survey conducted in America and Korea. Assuming that the KSEs take into account various factors while making their residence choice, the survey covered not only their education and career paths but also their attitude and values. In analysing and interpreting the survey results, the information provided earlier—the cultural background and socio-economic changes of Korea over the three decades—should be taken into consideration.

Korean Students, Scientists and Engineers in America

The number of Korean students who went abroad for higher education rose sharply in the 1980s. While this phenomenon was supported by the strong economic performance of the country, it

was facilitated by a change in the Korean government's policy on foreign study.

Throughout the 1960s, the Korean government took a restrictive position on sending students abroad. In 1964, for example, eligibility for foreign studies was restricted to college graduates. Students who wanted to study abroad had to pass a government-sponsored qualification exam and men had to complete three years of military service. Because of chronic foreign exchange shortage, Korean students did not have enough foreign currency to be able to finance their studies abroad. Besides, the Korean economy of the 1960s was so poor that only a few students could afford to pay the cost of foreign studies through their own savings or family support. Without a scholarship or fellowship from a foreign institution or international organisation, most Korean students could not pursue higher education abroad.

Another major difficulty was the lack of reliable information on foreign institutions' programmes and entrance requirements. Since information on America was easily accessible and because of the availability of various financial aid programmes, the majority of Korean students who studied abroad went to America.

These trends continued throughout the 1970s. Although the Korean economy was growing rapidly and domestic higher education was expanding, foreign education was still regarded as a privilege. Minor changes were made in the regulation of study abroad during the late 1970s, followed by a major liberalisation in 1981. Minimum domestic education requirement was reduced to the completion of high school; men who had not yet completed their tenure of military service were allowed to study abroad; and the foreign study qualification exam was abolished. These changes led to a large increase in the number of students going abroad for higher education.[5]

As Table 4 shows, liberalisation of the rules governing studies in foreign countries was followed by a large increase in the number of Korean students in America. In 1993, the number of Korean students enrolled in American institutions was 31,080, the fifth largest group of foreign students in America. The number of Koreans receiving doctoral degree in the US also increased rapidly. In 1993, 1,118 Koreans had a doctorate in science and engineering. This surge in the number of Korean doctorates has a significant influence on the composition of Korea's professional workforce.

TABLE 4
Korean Students and PhD Recipients in America and Korea, 1960–93

Year	*Korean Students in America**		*Annual Korean Science and Engineering PhD Recipients*	
	Number in the USA (All Fields)	*Rank as Foreign Students*	*From US Institutions**	*From Korean Institutions*
1960	2,310	6	28	NA
1965	2,666	7	66	6
1970	3,857	10	107	76
1975	3,260	11	105	259
1980	6,150	14	131	168
1985	18,660	3	323	562
1991	25,720	5	1,107	1,355
1992	28,520	5	1,119	1,402
1993	31,080	5	1,118	1,832

* For years before 1980, the figures shown are the average for the five years following the years in question (1960–64 for 1960).

Sources: Institute of International Education (1995).
National Science Foundation, Ministry of Education, Seoul, Korea.

In this regard, an examination of their return or stay choice patterns will help to understand the Korean science and engineering manpower situation.

Changing Trend in Residence Choice of Korean Scientists and Engineers (KSEs)

Even though the migration of scientists and engineers has been analysed as a whole, the phenomenon is fundamentally composed of individuals' residence choice (Borjas and Tienda 1987; Katz and Stark 1987; Kwok and Leland 1982). Therefore, identification of the individual's choice pattern and affecting factors will assist in determining the implications of the issue and to design policies to cope with it. Song (1991) studied the choices of Korean scientists and engineers and obtained personal information through a mail questionnaire survey. The survey was conducted on a sample of 1,981 individuals from a population of 3,242 KSEs who were identified as having obtained their doctorate in America between 1960 and 1987. In this mail questionnaire survey, 838 people responded and

their answers were analysed.[6] Although the survey could have a bias (such as omissions in population), non-response from nearly half of the sample was the prime source of the bias, as is true with most mail surveys. The validity of the survey results was checked by comparing some key characteristics of the sample directly with those of the mother population, for instance, by comparing the respondents' major fields by their PhD years with that of the population. In general, no noticeable discrepancy that could jeopardise the validity of the results was observed.

The survey results revealed a shift in the residence choice of Korean scientists and engineers from America to Korea over the last three decades. Most of the KSEs who received their doctorate in the 1960s chose to stay in America, only 16 per cent of them returned to Korea eventually. In contrast, nearly two-thirds of the KSEs who earned their doctoral degree in the 1980s returned to Korea by 1987. A substantial proportion of the 1980s group returned after a short stay in America, mainly after securing postdoctoral appointments (see Table 5).

TABLE 5
Changing Trend in KSEs' Residence Choice of 790 Survey Respondents

PhD Year	*Number of Respondents*	*Stay in the USA*	*Return to Korea just after PhD*	*Return to Korea after Work in the USA*
Before 1970	118	83.9%	3.4%	12.7%
1970–79	276	67.8%	10.1%	22.1%
1980–87	396	31.6%	39.4%	29.1%
Total	790	411	188	191

When the KSEs first arrived in America, a majority of them expected to return to Korea after obtaining their doctoral degree. A higher population of the 1960s group changed their mind and stayed in America, whereas a smaller proportion of the 1980s group changed their mind.

Factors Affecting Individual KSEs' Choice

During the period under study there were no significant differences in the personal conditions and perceptions of the KSEs when they first came to America. The background of the KSEs who received

their doctoral degree in the 1960s was similar to that of the 1980s group when they first came to America: their average age was around 27 years; 52 per cent were single; 86 per cent came to America as students; 62 per cent had worked in Korea for four years on average before coming to America; and more than 60 per cent intended to return to Korea after obtaining their degrees. However, their experience and changes in personal situations during and after graduate work seem to have played a major role in their residence decisions. Apart from changes in personal situations, the most important factor which affected their choice was the difference in economic conditions between America and Korea at the time of making their decision.

Following the improvement in Korea's economic conditions, as was the case in the 1980s, the value framework stemming from cultural differences between the two countries became more apparent as a determinant of the return rate. High prestige attached to teaching in Korea was a major factor influencing the KSEs' decisions. Under the Confucian hierarchical value structure of Korean society, teaching jobs have traditionally been regarded as very prestigious and, thus, teaching has been the most preferred occupation of the educated elite. Whether the KSEs have major family related responsibilities (either in Korea or America) is another critical factor affecting their decision.

Job and Career

After obtaining their doctorate, the KSEs' need for training/experience and desire for accomplishment were the primary reasons for staying in America. Also, if they found good jobs in America, they were more likely to stay. If, however, they were sent by Korean organisations, especially educational institutions, their obligations seemed to influence their immediate return.

While the need for experience naturally decreased as they stayed longer, many KSEs in America found that the opportunity for career growth in their present jobs was lower than what they had initially expected, and they expected better career prospects if they returned to Korea. However, a majority of them expressed difficulties in finding desirable jobs in Korea. This is clearly reflected in their identification of having a good job in America as a major reason for staying in America. More than half of the KSEs in

America were willing to accept jobs in Korea, provided they were their preferred jobs, mostly teaching jobs. A slightly lower but still a substantial proportion of the KSEs in America responded favourably to accepting temporary jobs in Korea.

Among the KSEs who worked in America after obtaining their PhD, a higher number returned to Korea when they felt that their further career development was blocked. Although their self-evaluation of accomplishment in America did not differ from that of KSEs in America, a higher number of the KSEs who returned to Korea compared to those who stayed in America reported that they felt that their career prospects in America were unfavourable. In addition, race or national origin was more commonly identified as a serious disadvantage by the KSEs who returned to Korea than those who stayed in America.

Among the KSEs who returned to Korea, a significant pattern of job change was observed in favour of teaching jobs. A high proportion of the KSEs in Korea holding teaching jobs (84 per cent) did not wish to change their jobs. On the other hand, corporate research jobs that have the opposite characteristics of teaching jobs have more defectors than other jobs. The main attraction of teaching jobs is social prestige and job security, while corporate research jobs are paid higher (about 50 per cent more than teaching jobs) but have less security and far less social prestige or honour. The same preference for teaching jobs and their merits were identified by the KSEs in America while describing their preferred jobs in Korea.

The KSEs' reported income in America in 1988 was two to three times higher than that in Korea. Since their reported income in America was ten times higher than that of Koreans in 1960, the KSEs' income in Korea has improved considerably over the three decades.[7] Differences in prevailing salaries for an individual's present job in America and Korea do not appear to be a major factor in the KSEs' residence choice. Besides specific job characteristics in Korea and other personal considerations seem to offset the income difference between the two countries.

While the KSEs in America reported diverse jobs and work activities, more than 90 per cent of the KSEs in Korea were engaged in teaching and R&D activities. The recruitment of KSEs by private companies is increasing in recent years, with higher income being the major attraction.

Family, Personal Situation and Children's Education

The KSEs in America cited their family situation as another major reason for staying in America. However, for those who returned to Korea, being reunited with family and friends in Korea was a major motivation for their return. Since most of the KSEs in Korea had lived in America for a relatively short period, their concern about their family in Korea (for example, parents) was a serious consideration. When the KSEs stayed longer, family's adjustment and assimilation to the American way of life were likely to make them shift their family concerns from Korea to America (Zeckhauser and Samuelson 1988).

The family situation of the KSEs who stayed longer is reflected in the problem of their children's proficiency in Korean language. In particular, when their children reached middle or high school (11 to 18 years), the problem of Korean language proficiency was a serious consideration in their return decision. About one-third of the KSEs in America expected their children to face serious adjustment difficulties if they returned to Korea. A high proportion of the KSEs who had returned to Korea in spite of their children's Korean language problem wanted their children to live in America.

Few of the KSEs were women. This reflects the bias of Korean society which discourages women from pursuing professional careers in science and engineering. Surprisingly, there was no significant difference in residence choice among eldest sons. As eldest sons are primarily responsible for taking care of their parents and family, it was expected that a higher proportion of eldest sons would return to Korea.

On an average the KSEs took five years to complete their doctoral studies and received degrees at the median age of 32. Reflecting the increasing tendency for recent graduates to return, the KSEs in America were seven years older on an average than those in Korea. There was no noticeable difference in the quality of KSEs' PhD awarding institutions between the KSEs in America and Korea.

The KSEs financed their graduate study mainly through university related support. In recent years, more KSEs have received financial support from Korea. If they are financially supported by Korean institutions, they are more likely to return to Korea.

Many KSEs who came to America as students changed their immigration status to permanent residents during the period of

their doctoral work and they are likely to stay in America. This tendency was stronger among those who got married during the period of their graduate work.

Perception and Attitude

Both groups of KSEs, in America and Korea, evaluated America more favourably than Korea in various aspects—work attitude, education system, trustworthiness of people, fair evaluation of job performance, work environment, and resources for work. However, they agreed that Korean 'personal relationships' were better; each group favoured the way of life in the country where they were living at present. This implies that KSEs preserved their intrinsic emotional framework regardless of their assimilation to the American way of life.

Both groups of KSEs expressed a belief in American dominance as a political power in the world and as a leader in science and engineering. They expressed doubts, however, about the future improvement of the American economy and social situation. Opinions about the prospects for improvement of the Korean social situation were mixed; the KSEs in Korea had a more positive attitude than those in America. Both groups were strongly optimistic that the economic and political development of Korea would continue for the next ten years. Although Korean science and engineering is not expected to be a major contender for world leadership, a small but significant proportion of the KSEs believed Korea has the potential to be a major player at the world level. They had a reserved view on the possibility of Japan's emergence as a new leader in science and engineering.

The KSEs in America generally perceived their friends in Korea as being satisfied with their return, and evaluated their accomplishments in Korea more favourably than did the KSEs in Korea. In contrast, a smaller proportion of the KSEs in Korea thought that their friends in America were satisfied with their life in America.

In recent years, many KSEs in America have visited Korea to either meet their family or friends or to do business. Before they returned, they maintained contacts with their friends in Korea. As a group, the KSEs who remained in America did not maintain as much contact with their friends in Korea as the returnees did. The information the KSEs in America have about Korea is largely acquired through American sources.

Simulated Probability Assessment of Factors on the KSEs' Residence Choice[8]

The simulated probabilities of the KSEs' return to Korea reveal the significant role of economic conditions. At the time of receiving their doctoral degree, the probability of their return to Korea was quite low: 1 per cent for 1963 (Korea's per capita GNP was 5 per cent of that of America) and 19 per cent for 1983 (Korea's per capital GNP was 12 per cent of that of America). But, three years after completing their doctorate, the probability of the return of the two groups to Korea varied greatly: only 7 per cent among the 1963 group, and 47 per cent among the 1983 group. This variation reflects the effect of changing economic conditions in Korea on the KSEs' decision.

Poor economic conditions in Korea during the 1960s may have forced majority of the KSEs to stay in America after they earned their PhD. Moreover, KSEs who decided to stay temporarily in America may have found it difficult to return to Korea after the originally intended stay: they either changed their mind or expected to remain in America for a long time. Among those who earned their doctorate in recent years and decided to stay temporarily in America, however, there is a growing tendency that they would return after a short period of time. Although most KSEs do not return home immediately after receiving their PhD, the improvement in Korea's situation seems to work against an extended stay in America.

The effects of personal conditions are different, depending on the economic situation at the time of taking the decision. At the time of receiving their PhD, job availability and concern for career development accounted for 14 per cent difference in the probability of return to Korea for the 1963 cohorts, and 58 per cent for the 1983 cohorts. The KSEs who perceived some kind of obligation to their home country and regarded lifestyle an important aspect of their lives were more likely to return to Korea: 7 per cent among the 1963 cohorts, and 37 per cent among the 1983 cohorts. Whether the KSEs strongly identified personal or family matters in Korea accounted for 2 per cent difference for the 1963 cohorts, and 22 per cent for the 1983 cohorts. Other personal attributes revealed similar patterns of differences between the two cohorts. These results and analyses at other decision points reveal two major

issues in explaining KSEs' choice behaviour. First, when KSEs received their PhD, economic conditions and career related concerns were the main factors affecting their residence choices. In fact, Korea's poor economy in the 1960s was a dominant factor inducing KSEs to stay in America. Second, as Korea's economy made substantial progress, the KSEs' choices were significantly affected by their personal characteristics or perceptions.

Government Policies: Underlying Assumptions and Policy Leverages

Maximise Benefit Generated by the KSEs in Korea: Korean Policies in the Earlier Period

Innovation and improvement of production are mostly carried out by those with formal education. Therefore, training and education are indispensable for enhancing the capacity of talented human beings. Government policies in the 1960s and 1970s were directed to 'repatriate as many KSEs as possible in the earlier period of their careers'. Though the government devised and applied various incentives to this end, they were effective only in a limited sense.

One of the measures taken by the Korean government to counter the problem of brain drain was to provide financial support to the KSEs. From 1968, the Korean government financed moving expenses of those KSEs who were planning to return to Korea and living costs of temporary visitors. Even though these financial incentives were beneficial to the KSEs, they failed to significantly affect the KSEs' residence choice itself: Most KSEs who temporarily visited Korea returned to America just after a short stint. Another measure adopted by the Korean government to counter the problem of brain drain was to provide strings-attached financial aid to those going abroad for studies. But that obligation was occasionally disregarded by the aid recipients. Lack of effectiveness of the earlier incentives cannot be attributed to the Korean government's ineptness. Rather, the reason must be traced to a fundamental problem—their reluctance to return to the then economically less preferable Korea. In the light of this situation, all that the Korean government could effectively do at that time was to impose rather stringent qualification requirements for Korean students to go abroad.

Value of not having All KSEs Return: Policy Direction in the 1980s and on

If Korea's economy maintains its current pace of expansion, the gap with the American economy will be steadily narrowed. In addition, if the present momentum of Korea's political development sustains, the proportion of KSEs who intend to return to Korea should grow. In spite of these favourable trends, however, some KSEs may still prefer to remain in America for a variety of reasons: some may be compelled to stay in America for professional career development; others may find the American lifestyle more attractive; and still some others may find it economically more lucrative to remain in America. Thus, as long as America's science and engineering sectors continue to recruit foreign students, some KSEs will choose to remain in America (APAPPI 1994; De Palma 1990; Mann 1990; Stark 1984). It is neither desirable nor realistic for all Korean students to return immediately upon completion of their studies. Since the pro-stay KSEs can serve as a well placed channel to funnel the advances of American science and technology to Korea, they can be considered an important component of Korea's overall scientific and technological development.

The reversal of the trend in the 1980s highlights both the increasing leverage of government incentives and the importance of government role in 'controlling' the flow. The study reveals that the KSEs' choices are no longer dominated by economic considerations alone. Their choices are also affected by numerous other concerns, including family, personal compatibility, and career prospects. Some of these concerns are susceptible to policy incentives. Thus, the Korean government at this point has important leverages to control the KSEs' decisions. From the mid-1980s onwards, the Korean government's policies in relation to the KSEs have been changing in accordance with this line of logic: scout the most needed among the experienced KSEs and let the remainder decide for themselves.

Giving Emphasis to Temporary Visitors

In 1990, the programme to finance the moving expenses of returning KSEs came to an end. It was recognised that travel expenses did not work as a significant factor in residence decisions. On the contrary, the policy to fund the living expenses of temporary visitors was expanded. This policy applies not only to prominent

KSEs but also to foreigners who are likely to make contribution in Korea to international cooperation in R&D activities.

Introduction of 'Brain Pool'

In 1994, the Korean government introduced the so-called 'Brain Pool' programme. This programme is aimed at enabling local universities and government sponsored research institutes to hire overseas trained KSEs for short periods. Invited KSEs, funded by the government, are supposed to teach or engage in R&D for one year and may renew their contract up to three years. These temporary positions are intended for mid-career scholars with research or teaching experience (presumably more than five years). During their stay in Korea, they have the opportunity to become acquainted with the Korean situation and may even seek permanent positions.

Allowing Research Institutes to Establish Independent Graduate Schools

Beginning 1997, government funded research institutes are allowed to establish their own education branches (at the graduate level). Surveys reveal that most KSEs prefer domestic university positions rather than those in private companies or research institutions. In fact, every year a substantial number of the KSEs who hold positions in research institutes, public or private, quit their jobs in favour of university positions. They prefer the high prestige and social status attached to professorship rather than the lucrative economic incentives of private sector jobs. The market mechanism and the changing public perception may eventually correct this imbalance, but only after a considerable period of time. The education branch of research institutes will grant the KSEs the title of a professor and researcher at the same time. This will enable the KSEs to enjoy both the prestige of professorship and the opportunity for career development in research.

Postdoctoral Appointment for Junior KSEs

Korean institutions are encouraged to offer postdoctoral positions to the KSEs who are seeking employment in Korea. While enhancing their competency, it is believed that the KSEs under this arrangement have better chances of finding permanent positions. The policy also includes measures to support overseas postdoctoral

appointments for the KSEs who received their doctorate in Korea. These measures are useful in laying the foundation for international exchange and cooperation among junior scientists and engineers.

Helping KSEs Organisations' Activities and Networking

The Korean government is reinforcing the support for Korean scientists and engineers' organisations abroad. Certain activities of associations in America, Japan, and Europe are sponsored by the Korean government. It was found that the KSEs who maintained good contacts with Korea were more likely to return to Korea. A useful information channel has been effectively constructed through these professional organisations. The database of these organisations serves to connect domestic demand and the KSEs with the needed expertise. These organisations also disseminate information on Korea's progress in the members' fields as well as general changes in the country's situation. More complete information on Korea would help the KSEs in their decision by removing sources of misjudgment and bias. An established channel also enables the Korean industry or academia to keep track of experts in various fields and to recruit them when specific needs arise.

Policy Shift over Three Decades

As indicated by the fact that these policies were introduced largely in the 1990s, it was not until recently that the Korean government's shift on the position regarding brain drain has become a reality. Even though the need for change was recognised during the 1980s, the government took time in implementing specific policy measures. New policies are basically designed to help the KSEs decide for themselves, but also allow them to have enough information and chance for choice. These policies are based on somewhat different ideas from those of the 1960s, that is, those of nationalists (Adams 1968). While the nationalists' view is supported by countries experiencing brain drain, Korea's new policies may have been formulated encompassing the reverse brain drain phenomenon.

Concluding Remarks

It should be reiterated that economic factors are central to the understanding of the brain drain phenomenon. Differences in the structure and level of economy between the host and home countries are the starting point of the problem. In the case of several newly industrialised countries (NICs), the return of expatriate scientists and engineers seems to be due in large part to the establishment of science and engineering infrastructure, coupled with substantial progress in their economies. But given the fact that, even though there still exist substantial discrepancies in living standards and social infrastructure between the advanced countries and the NICs, a large proportion of overseas trained professionals return to their country of origin, the effect of non-economic factors cannot be ruled out. It must be stressed that the cultural background that determines the frame of reference was found to be particularly important in the KSEs' choices.

Both traditional brain drain and the unanticipated return of long-time expatriates ('reverse brain drain') raise some complex policy issues. Although developing countries are trying to retrieve the talent educated abroad, it is difficult for these countries to ensure proper jobs for returning expatriates. Instead of focusing simply on potential losses of the talent, discussions of brain drain must consider another aspect of the issue: how to optimise the expertise of available human resources to meet the goals of national advancement. To the extent that policies are designed to maximise the number of returning students, they must rely on incentives rather than command-and-control approaches. As demonstrated by the Korean experience in the 1960s, however, incentives are effective only in a limited sense. It will not be until overall economic conditions of the country reach a certain level—not necessarily equivalent to that of advanced countries—when well designed incentives may work as useful policy leverages. It is from that point on when policies reflecting country specific aspects (culture, lifestyle, family relations, etc.) may begin to work effectively. In order to be able to design such policies, a comprehensive investigation should be conducted on related issues.

The Korean case demonstrates the significant role of culture specific aspects in the KSEs' decisions. This may be the case in countries with similar cultural backgrounds, such as the Far Eastern

countries. Many students-turned-immigrants from Asia took up professional jobs in America over the last three decades, constituting a substantial part of foreign scientists and engineers in America currently. Despite their stable social and economic status, their assimilation into American society and their attitudes toward their native countries seem to differ significantly from those of European immigrants. Because many aspects of the underlying orientation of the KSEs will not be much different from other Asian scientists and engineers (especially those from countries influenced by Confucian ideas), the findings of this study should be pertinent to them.

A particularly relevant group to which the findings of this study are applicable is Chinese students in America (Oh 1977; Mann 1990). At present, the number of Chinese students in America is far greater than those from most other countries (44,380 in 1994). Many Chinese students who obtained their doctoral degrees expressed their intention to stay in America. They face a dilemma comparable to that of the KSEs in the 1960s and 1970s. Although they want to return to China, poor living standards and inappropriate working conditions in China compel many Chinese students to stay in America. In addition, political concerns also influence their decision to stay in America. Their comparison of option would involve many aspects that are identified in the KSEs' decisions in the earlier years. If so, the Chinese government could utilise information from the present study to offer incentives to Chinese students to lure them back home.

NOTES

1. This description of Korea's past economic development and science and technology situation is based upon following reports: Linsu Kim (1993); Chong-Ouk Lee (1991); Won-Young Lee (1995); OECD (1996); Science and Technology Policy Institute (1995, 1997).
2. Ingredients of Buddhism, Taoism, and Shamanism have their roots in Korean tradition. Christianity was legalised in Korea in the latter part of the nineteenth century and was instrumental in modifying the values and behavioural patterns of modern Koreans.
3. Arts, business and manufacturing were professions of the lower class in traditional Korean society. Law, foreign languages, medicine and astrology were

inherited professions of a small group whose class was placed between *yangban* and the commoner. Military career was also regarded inferior to those of Confucian scholar-officers.

4. In Korea, individualism is sometimes interpreted as self-centredness, defying duty to the community.
5. This reversal of the Korean government's position on foreign study was one of the hastily planned reform policies of the Fifth Republic (1980–87). Although many of those reform measures were later criticised and repealed, the 'liberalisation of foreign study' survived with a few minor modifications. Because the policy was an effective way to meet Korea's explosive demand for higher education, the government is unlikely to revert to its former restrictive position.
6. Data presented here were obtained through a survey conducted by Song. Samples were drawn from a population of 3,242 US trained Korean scientists and engineers—those who identified themselves as a Korean or being of Korean origin, and had earned their doctoral degree in the US in the fields of natural sciences and engineering between 1960 and 1987. According to the US National Science Foundation data, there were 3,242 such Koreans. At the time of the survey in 1988, 1,545 of them were identified as living in America and 1,411 in Korea. Song mailed 998 questionnaires in America and 983 in Korea. Of these, 432 and 406 questionnaires were returned. Song personally interviewed 87 KSEs to supplement the mail survey. While the survey data provided information on individual KSEs' family situation, job and career, and perception and attitude, indicators of the external situation (economic, social, and political) in America and Korea were derived from published statistics. The data were analysed using several complementary approaches—descriptive comparison of the KSEs who returned to Korea and those who stayed in America, analysis of an observed discrepancy between intention and action, and discrete choice analysis.
7. The salary gap between the two countries narrowed continuously. In 1996, a recruiting director of a Korean chaebol (conglomerate) reported that the annual salaries offered to KSEs in Korea in high tech fields were equivalent to, or even higher than those of the KSEs in America. At present, the average income of the KSEs in Korea is about two-thirds of that of their counterparts in America.
8. To assess the effect of each factor on the residence choice of KSEs, a discrete choice analysis using maximum likelihood estimation was done. It was assumed that the KSEs' decision depended upon both personal conditions and external situations. Indicators for external conditions were selected to represent the political–economic conditions, and science and technology activities in both Korea and America. Most variables on personal characteristics were constructed using the KSEs' responses to survey questionnaires. Probit regressions for the KSEs' choices at the time of receiving PhD, and three years after receiving PhD were done.

REFERENCES

ADAMS, WALTER, ed. (1968), *The Brain Drain*. New York: Macmillan Company.

ASIAN PACIFIC AMERICAN PUBLIC POLICY INSTITUTE (APAPPI) (1994), *The State of Asian Pacific America: Economic Diversity, Issues & Policies*. Los Angeles, California: APAPPI.

BHAGWATI, JAGDISH and KOICHI HAMADA (1989), 'Tax Policy in the Presence of Emigration', in John D. Wilson, ed., *Income Taxation and International Mobility*. Cambridge: The MIT Press.

BORJAS, GEORGE J. and MARTA TIENDA (1987), 'The Economic Consequences of Immigration', *Science*, 235 (6 February).

CANNON, PETER (1988), *Foreign Engineers in U.S. Industry: An Exploratory Assessment, Foreign and Foreign-born Engineers in the United States*. National Research Council. Washington, D.C.: National Academy Press.

CENTER FOR SCIENCE AND TECHNOLOGY POLICY (CSTP) (1988), *A Study to Enhance the R&D Capacity and Utilization of R&D Manpower in Universities*. Seoul, Korea: KAIST.

DE PALMA, ANTHONY (1990), 'Foreigners Flood U.S. Graduate Schools', *New York Times* (17 November).

DUNN, ASHLEY (1995), 'Skilled Asians Leaving U.S. for High-Tech Jobs at Home', *New York Times* (21 February).

FINN, MICHAEL (1985), *Foreign National Scientists and Engineers in the U.S. Labor Force, 1972–1982*. Oak Ridge, Tennessee: Oak Ridge Associated Universities.

GITTELSOHN, JOHN E. (1989), 'Surging Economy Spurs Many Asians to Return Home', *The Chronicle of Higher Education* (15 November).

INSTITUTE OF INTERNATIONAL EDUCATION (IIE) (1995), *Open Doors: 1960/61 to 1993/94*. New York: IIE.

KATZ, ELIAKIM and ODED STARK (1987), 'International Migration under Asymmetric Information', *The Economic Journal*, 97.

KIM, LINSU (1993), 'National System of Industrial Innovation: Dynamics of Capability Building in Korea', in R.R. Nelson, *National Innovation System: A Comparative Analysis*. Oxford: Oxford University Press.

KWOK, VIEM and HAYNE LELAND (1982), 'An Economic Model of the Brain Drain', *The American Economic Review*, 72(1).

LEE, CHONG-OUK (1991), 'Stages of Economic Development and Technology Policy', *Science and Public Policy*, 18(4).

LEE, WON-YOUNG (1995), *Building Korea's Scientific and Technological Infrastructure*. Seoul: Science and Technology Policy Institute.

MANN, JIM (1990), 'China's Lost Generation', *Los Angeles Times Magazine*.

NATIONAL SCIENCE FOUNDATION (NSF) (1985), *Immigrant Scientists and Engineers: 1987*, NSF 88–329. Washington, D.C.

——— (1986), 'Survey of 300 U.S. Firms Finds One-half Employ Foreign Scientists and Engineers', *Science Resources Studies Highlights*, NSF 85–336. Washington; D.C.

——— (1993), *Immigrant Scientists and Engineers: 1990*, NSF 93–317. Washington, D.C.

OECD (1996), *Review of National Science and Technology Policy: Republic of Korea*. Paris: OECD.

OH, TAI K. (1977), *The Asian Brain Drain: A Factual and Casual Analysis*. San Francisco: R&E Research Associates.

SCIENCE AND TECHNOLOGY POLICY INSTITUTE (STEPI) (1995), *Review of Science and Technology Policy for Industrial Competitiveness in Korea*. Seoul: STEPI.

——— (1997), *A History of Korea's Science and Technology Policy*. Seoul: STEPI.

SONG, HA-JOONG (1991), Who Stays? Who Returns? The Choices of Korean Scientists and Engineers. PhD dissertation, Harvard University, Harvard.

STARK, ODED (1984), 'Discontinuity and the Theory of International Migration', *KYKLOS*, 32.

YODER, STEPHEN K. (1989), 'Reverse "Brain Drain" Helps Asia but Robs U.S. of Scarce Talent', *Wall Street Journal*, 18 (April).

ZECKHAUSER, RICHARD and WILLIAM SAMUELSON (1988), 'Status Quo Bias in Decision Making', *Journal of Risk and Uncertainty*, 1, 7–59.

Phasing Scientific Migration in the Context of Brain Gain and Brain Drain in India

V.V. KRISHNA and BINOD KHADRIA

Five decades of India's experience of migration of highly qualified personnel (HQP), as presented in this paper, broadly falls into three distinct but overlapping periods, namely: 1940s to 1960s; 1970 to 1980s; and 1990s and beyond. In the post-independence period up to the 1960s, India did not really experience the trend of brain drain. The demand pattern created by the official policies to expand the university sector and strengthen the infrastructure in science and technology determined the human resource policies in training, higher education and even attracted some established Indian scientists from abroad during this early phase. Beginning with the 1970s, India began to experience the problem of brain drain, for which several economic and sociological factors were responsible including the oversupply of HQP and the lack of demand for these personnel. Even though different trends are discernible during the 1980s and 1990s, the case discussed here illustrates that India continues to lose its scientific and technical human resources—despite the new opportunities created by the present trend of globalisation. Any relative short-term gains visible in the form of brain gain and arresting the process of brain drain are likely to be neutralised by the lack of appropriate long-term policy measures. The paper calls for such policy interventions, rather than ad hoc measures, to address the problem of India's brain drain.

V.V. Krishna is Senior Scientist, NISTADS, Dr K.S. Krishnan Road, New Delhi 110 012, and Associate Professor of Science Policy, Centre for Studies in Science Policy, School of Social Sciences, Jawaharlal Nehru University, New Delhi 110 067.

Binod Khadria is Associate Professor of Economics at the Zakir Husain Centre for Educational Studies, School of Social Sciences, Jawaharlal Nehru University, New Delhi 110 067.

Science, Technology & Society 2 : 2 (1997)

SAGE PUBLICATIONS NEW DELHI/THOUSAND OAKS/LONDON

Introduction

A COMPARISON OF India with other countries of the developing world such as Brazil, China, Uruguay, South Korea and Argentina gives a contrasting historical account with regard to international migration of highly qualified personnel (HQP). In several of these countries, the political context in varying forms had a primary and direct bearing on the emigration and return migration of scientific and technical personnel. In the case of India, no such primary political reasons determined the trends in migration of its scientific and technical human resources. There were multiple sources of influence, both national and international, which acted on the migration of India's HQP. Five decades of India's experience of migration of HQP, as conceptualised in this paper, falls into three distinct but overlapping phases or periods: (*a*) 1940s to 1960s; (*b*) 1970s to 1980s; and (*c*) 1990s and beyond. Based on the trends and main discourse on migration of scientific and technical personnel in the country, these three phases are characterised as—brain gain, brain drain and the impact of globalisation.[1] Even though different trends are discernible during these different periods of time, the case presented here suggests that India, as in the previous decades, continues to lose its scientific and technical human resources in the face of new opportunities opened through the globalisation process. This is perhaps because any relative gains and benefits are likely to be neutralised by the lack of appropriate long-term policy directly relevant to this issue.

The 1940s to 1960s: 'Policy for Science' in Human Resources and Building S&T Infrastructure

India established a moderate number of universities at the time of independence in 1947 but lacked highly trained scientific and technical human resources and an institutional base in science and technology (S&T) to embark upon the industrialisation and modernisation programmes planned under the Nehruvian political leadership of the early decades after independence. As is well known, Nehru played an important role in the affairs of science and technology including higher education during these initial years. Rather, Nehru presided over important science agencies

such as the CSIR, atomic energy, defence and later space research, and is said to have recurrently monitored their workings. Nehru forged a close alliance with a group of elite scientists such as Homi Bhabha, S.S. Bhatnagar, D.S. Kothari, P.C. Mahalanobis and granted them considerable autonomy to promote the development of higher scientific research and education. An optimistic perspective was evident among the scientific and political leadership with regard to the role of science and technology in development. What governed the development of science, technology and higher S&T educational structures was the perspective of 'policy for science'—which meant policy support for the promotion and establishment of an infrastructure base in science and technology.[2] As noted elsewhere, implicit in the 'policy for science' perspective was the view that once the infrastructure for research and development was created, personnel trained and a set of institutions established, problems inherent in relating science to development would be resolved to a large extent (see Krishna 1993a, 1996b). One of the first priorities under this policy perspective followed by the Nehru government was the human resources in science and technology and the expansion of the university sector including engineering, agriculture and medical sciences. The first systematic effort in this direction was the constitution of a Scientific Manpower Committee (SMC) in 1947 which submitted its report in 1948.[3] The main mandate of this Committee was to assess the demand for highly trained scientific and technical personnel in the following decade. As pointed out by the recommendations of this Committee, in this early phase of development, the country required around 60,000 engineers of all categories, 20,000 doctors, 25,000 scientists in various physical and natural sciences and a large number of other technical, teaching and student populations as shown in Table 1.

Another important committee constituted by Nehru after assuming office as Prime Minister was the Education Commission under the chairmanship of Dr S. Radhakrishnan in 1948 to 'report on Indian university education and suggest improvements and extensions' that may be desirable and suited to the requirements of the country in the 1950s. Not long before the Education Commission and the SMC were established in 1947, the Viceroy's Executive Council constituted what is known as the Sarkar Committee in 1946 which submitted its report the same year to the Department

TABLE 1
Estimates Given by the Scientific Manpower Committee (1948)

S&T Personnel & Categories	*Senior Grade*	*Junior Grade*
Engineers, Architects, Technologists	29110	30660
Doctors	19740	–
Scientists	18490	890
Nurses	32510	–
Science Graduate Teachers	16220	–
Intermediates in Science	182800	–
Other Technical	3820	

Source: Krishna (1993b: 110–12).

of Education, Health and Agriculture. The main recommendation of the Sarkar Committee was the setting up of no less than four higher technical institutes. The origins of the five Indian Institutes of Technology go back to the recommendations of the Sarkar Committee. Both the SMC and the Education Commission endorsed the recommendations of the Sarkar Committee (Jha 1989a). Following these initial efforts, the 1950s witnessed the constitution of official committees by various government departments to deal with the issue of harnessing human resources. The Planning Commission which swung into action with the first ever India's Five-Year Plan in 1951, set up a Manpower Studies Committee to look into the demand pattern of skilled personnel in various development programmes to meet the shortage of personnel. The River Valley Projects Technical Personnel Committee (1954); the Engineering Personnel Committee (1955); the Agricultural Personnel Committee (1957); and the Steering Group on Manpower of the Cabinet Committee on Manpower (1957) were set up. All these committees provided the legitimation to expand the higher scientific and technical education sector for the two decades following 1950. As shown in Table 2 there was almost a threefold increase in the number of universities from 37 in 1950 to 109 in 1970, and a similar trend was observed in the increase of engineering, agriculture and medical colleges. Further, Table 3 shows that the outturn of the student population in various disciplines witnessed a phenomenal increase by the late 1960s, surpassing the estimates given by the SMC in 1948.

TABLE 2
Growth of Universities/Institutions Concerned with Tertiary Education in Natural, Engineering, Medical and Agricultural Sciences from 1950 to 1993

Year	*Universities***	*Agricultural Colleges*	*Engineering Colleges*	*Medical Colleges*
1950	37	33	58	33
1955	44	49	80	46
1960	65	77	118	66
1965	89	96	151	94
1970	109	102	163	110
1975	129	111	179	118
1980	140	117	226	125
1985	165	130	358	144
1990	179	136	424	175
1993*	206	141	440	213

Notes: ** Includes universities awarding degrees in arts and human sciences.
* Estimated.
Source: HRD Division, CSIR.

Along with the focus on human resources, the perspective of 'policy for science' led to the establishment and expansion of various science and technology institutions during the two decades from 1950. As noted earlier, the close alliance between Nehru and a small group of elite scientists in the CSIR, the atomic energy and defence establishments and the Planning Commission facilitated the growth and expansion of the national laboratories under these science agencies by providing human resources and financial budgets. For instance, the CSIR, created in 1942 with no full-fledged laboratories until 1947, housed only about 100 scientists. But by the end of the 1960s, the chain of national laboratories under the CSIR system in physical, chemical, earth, engineering and biological sciences expanded to 28 national laboratories where around 4,500 scientists were engaged in research. The planning and rapid expansion of the CSIR during this period, was due mainly to the efforts of S.S. Bhatnagar who was the founder head of the CSIR. The growth of the CSIR is often referred to as 'Nehru-Bhatnagar effect' (see Krishna 1993b). This in fact has a parallel in the growth of the atomic energy establishment under Homi Bhabha from 1954. Coupled with the close and easy alliance between science and politics in the Nehru era, the basic document that legitimated and charted out higher education, infrastructure

TABLE 3
Trends in Outturn of S&T Personnel in India (1950 to 1992)

Degree	*1950*	*1960*	*1970*	*1980*	*1982*	*1983*	*1986 to 1992*
Sciences							
BSc	9628	22693	82610	124800	129000	131400	–
MSc	1438	5365	13215	19973	23064	22989	–
PhD	79	324	1163	2261	2846	2892	20248
Engineering and Technology							
BE/BTech/ BSc Eng	2029	5693	19249	19859	22035	22963	–
ME or MTech	39	512	1985	2642	3121	3388	32782
PhD	–	7	114	176	190	160	N.A.
Agriculture							
BSc	1099	2821	7080	5066	5061	5019	–
MSc	154	488	1342	1891	1963	1748	–
PhD*	4	26	217	478	564	639	4256
Medicine							
MBBS	1550	3119	9315	13083	12278	11900	–
MD/MS	28	343	1452	3948	4006	4663	34097
Total	16048	41391	137742	194177	204128	207761	–

Note: *Includes veterinary science.
Source: Manpower Division, CSIR, New Delhi; University Grants Commission Report 1984–85, New Delhi.

in S&T and state support to science and technology at the time was the Scientific Policy Resolution of 1958 passed by Parliament. The growth pattern of major science agencies in terms of financial support is shown in Table 4.

In the domain of higher technical education, the Sarkar Committee recommendations came into effect when the government passed the Indian Institutes of Technology Act 1956 in Parliament and set up the first Indian Institute of Technology (IIT) at Kharagpur in 1950. The second such institute was set up in Bombay in 1958; the third one in Madras in 1959; the fourth in Kanpur in 1960; and the fifth in Delhi in 1963. The IITs which were in a large measure inspired by the model of the MIT in the USA were created to train the best engineering students who would play an important role in assimilating technological change and revolutionising India's industrialisation programme. As is well known, the

TABLE 4
R&D Expenditure by Major Science Agencies

Agencies	*1958–59*	*1970–71*	*1980–81*	*1986–87*	*1990–91*	*1992–93*	*1994–95*
							Million Rupees
CSIR	51	215	690	1703	1893	2963	3699
DAE	76	287	734	1658	2755	3166	4181
DRDO	15	175	797	6586	7376	7930	12450
ICAR	37	183	974	1625	2762	3380	4376
ICMR	5	21	90	400	469	429	466
DOS	–	–	560	3095	3862	4909	7566
DST	–	84	406	1103	1235	1606	2194
DOE	–	–	54	56	61	180	382
MOEn	–	–	37	901	1620	2178	2769
DNES	–	–	41	240	160	138	72
DBT	–	–	–	105	413	588	688

Source: Department of Science and Technology, Research and Development Statistics, New Delhi, 1992–93, 1994–95.

IITs produced the best engineering graduates in India who were capable of finding placements in higher engineering courses and employment in the USA and other parts of North America and Europe. The five IITs together trained between 1,000 and 1,300 basic engineering graduates every year during the 1960s. Systematic data on the mobility and placements of IIT graduates for this period are not available but the existing reviews on the early growth of the IITs indicate that brain drain was not a major issue in the policy discourse of IIT administration at least till the end of the 1960s (see Indiresan and Nigam 1993; Jha 1989a, 1989b; Panikar 1985; Smillin 1989). However, the problem of brain drain in the IITs came into focus in the early 1970s, which will be discussed in the section dealing with the period 1970s–1980s.

Early Institutional Efforts on Brain Gain

The creation of an IIT system, modelled on the lines of the MIT, which was seen to usher in a period of excellence in the basic and higher engineering education in the 1960s, contributed in many ways to the process of brain gain. The five IITs not only created a space for hundreds of faculty members—thereby checking the process of drain—but also attracted a good number of their faculty

from abroad and initiated a policy of sending their faculty for training abroad in some specialised areas of research and teaching. As all the IITs in the beginning had intellectual and material support from various advanced donor countries such as the USA, the USSR, Germany and the UK, the IITs introduced the guest faculty system from the respective countries and this system contributed substantially to the introduction and implementation of several academic innovations. Further, the opportunity offered or the gain accrued to the IIT faculty for advanced training in donor countries also put the Indian scientists in touch with the cutting edge of technological research and advanced training to be transposed in the Indian conditions (see Indiresan and Nigam 1993).

The historical growth of other S&T institutions and the expansion of the university sector, legitimated by various committees set up by the government during the 1940s and 1950s, indicate that the problem of brain drain was not a major concern during this period. The same was true of the period ending the 1960s. This is borne out by some quantitative reports and studies. In fact, the rapid expansion of universities and colleges under the UGC during this period led to a shortage of professionals. The report of the Committee on Post Graduate Engineering Education and Research in the early 1960s indicated between 40 per cent and 50 per cent shortages of sanctioned positions. In 1963 Dr Humayun Kabir, Minister for Scientific Research and Cultural Affairs, speaking at a conference of scientists and educationists to review the implementation of the Scientific Policy Resolution observed, ' . . . from the figures collected over the past five years it is seen that out of some 8,000 men on the register of scientists abroad, about 50 per cent have already returned'.[4] Though a Round Table Conference called by the Prime Minister in 1967 recommended to make every possible effort to evolve institutional mechanisms to ensure the return of Indian scientists living abroad, the recommendations of this meeting did not dwell upon the problem of brain drain. Further, Gulati's (1990) study reveals a modest outflow of 850 to 900 Indian professionals to the US per year from the mid-1940s to the late 1960s compared to an average of 2,700 per year for the 1970s and beyond. Indian universities produced on an average about 35,000 graduates and postgraduates in sciences and engineering during the 1960s which rose to over 100,000 after 1970 (see Gujral 1987). Moreover, the problem of brain drain did not come into sharp focus either in the

literature on science and society studies or in the official discourse on science policy matters till the late 1960s.[5]

On the other hand, various institutional and individual measures were initiated and adopted by S&T institutions to attract the best talent. Moreover, the shortage of highly skilled scientific and technical human resources prompted science agencies to implement various measures on brain gain. Elite scientists such as Homi Bhabha, S.S. Bhatnagar, M.N. Saha and D.S. Kothari made relentless efforts to identify potential young Indian brains working abroad and persuade them to return for assuming responsible positions in Indian laboratories. It is well known that Homi Bhabha first identified a talent and then built the group or sub-area of research around that personality. The Tata Institute of Fundamental Research (TIFR) in Bombay which was founded and initially headed by Bhabha was built in this way. It is also known that various specialised areas of research in the physical and biological sciences at this institute were institutionalised in this way. For example, some time in the early 1960s four Indian radio-astronomers from abroad approached Homi Bhabha and the UGC to return to India as a group and initiate a new area of research. Bhabha immediately responded, leading to the institutionalisation of the radio-astronomy group in TIFR (see Udgaonkar 1993). Among the four scientists (Govind Swarup, M.R. Kundu, T.K. Menon and R. Krishnan) two have either gone back or their return did not fully materialise. However, Govind Swarup now heads the internationally recognised radio-astronomy institute in Poona.[6] What is of relevance here with regard to the issue of brain gain is that Bhabha attracted several well known scientists such as Obaid Siddiqui and M.G.K. Menon who in turn catalysed the process initiated by Bhabha. On the other hand, S.S. Bhatnagar adopted a somewhat different approach of first planning and building the institutional structures and then making efforts to attract the best talent to promote various fields of research during the initial years of the CSIR. Another important scientific agency which witnessed considerable growth and support and which evolved various measures to attract scientific and technical human resources in the 1960s is the Indian Council of Agricultural Research (ICAR). The beginning of the Green Revolution created an enormous demand pattern on the agriculture research and teaching system to streamline its human resource policies and institutional mechanisms. During the 1960s

the agriculture research system was revamped and the extension and agriculture education was closely networked with the research institutions. Scientific personalities such as B.P. Pal, M.S. Randhwa and M.S. Swaminathan played an important role in attracting various talent in the process of integrating the Green Revolution. Even though these elite scientists adopted different institutional strategies and perspectives, the overall efforts were directed towards attracting outstanding scientists and technologists during this period. As pointed out earlier, Nehru evinced a keen interest in the affairs of building various science agencies and as a part of this process he was instrumental in catalysing the process of brain gain during this phase. When science agencies such as the CSIR embarked on a programme of vigorous expansion in the 1950s, Nehru suggested various institutional measures to monitor, create database and make appropriate placements for Indian scientists trained in India and abroad.

The CSIR which instituted a National Register of Scientific and Technical Personnel in the late 1940s, created a special section—Indians Abroad Section of the National Register in 1957. A detailed review (Gujral 1987) reveals that this Special Section maintained, from 1957, the database for persons holding postgraduate degrees in science, engineering, medicine, agriculture and social sciences. Till 1986 the database showed an enrolment of 24,411 persons in all sciences and engineering and 1,262 persons in social sciences. In an effort to create avenues for attracting Indian scientists and technologists from abroad, the CSIR in 1958 launched a scheme called 'Scientists' Pool'. This scheme, which is in operation currently, provided temporary employment to persons returning from abroad. The Pool's office at the CSIR also assists in finding suitable placements in institutions in the relevant areas of research. The scheme was meant to eliminate the uncertainty and economic problems faced by potential returnees from abroad. It can be seen from Table 5 that even though 18,653 personnel were selected in the Scientists' Pool, only 9,506 (that is, less than 50 per cent) joined the scheme between 1959 and 1993. While the USA figures as the main country from where Indian scientists and technologists returned (33 per cent); the UK is second with 28 per cent; and the rest is accounted by Canada, Europe and other countries in the former Soviet Union.[7] In terms of areas, sciences account for 40 per cent; engineering 38 per cent and medicine 38 per cent (see Ahmed et

TABLE 5

Number of Indian S&T Personnel Who were Selected for the Scientists' Pool and Joined It

Period	*Foreign Trained Personnel*			*Indian Trained Personnel*					
	S	*J*	%	*S*	*J*	%		*Total*	*Ftj + Itj*
1959–65	4108	1690	41.1	118	74	62.7	4226	1764	22.8
1966–70	3116	1529	49.1	144	64	44.4	3260	1593	23.9
1971–75	3050	1286	42.2	788	442	56.1	3838	1728	2.9
1976–80	1868	818	43.8	786	478	60.8	2654	1296	1.7
1981–85	1199	664	55.4	858	557	64.9	2057	1221	1.2
1986–90	1040	705	67.8	1136	886	78.0	2176	1591	0.8
1991–93	158	96	60.8	28.4	217	76.4	442	313	0.4
Cumulative 1959–93	14539	6788	46.7	4114	2718	66.1	18653	9506	2.5

Notes: S: Selected; J: Joined; Ftj: Foreign Trained Joined; Itj: Indian Trained Joined.

Source: Ahmed et al. (1994).

al. 1994). Even though the Scientists' Pool scheme was specially designed for scientists and technologists returning from abroad, 25 per cent of the slots were reserved for persons from India who had outstanding academic achievements. However, this figure increased sharply to 50 per cent in the 1980s and to over 75 per cent in the 1990s. For instance, while 818 foreign trained scientists joined the Pool between 1976–80, during the same period 478 Indian trained scientists joined. Similarly, whereas 664 foreign trained scientists joined during the 1981–85 period, 557 Indian trained scientists joined during this period. Another interesting figure observed by Ahmed et al. (1994) is that while the ratio of foreign trained to Indian trained Pool officers was 23 for the 1959–70 period, it was only 0.4 for the 1971–92 period. Over the course of time from the 1950s to 1970s and beyond, the purpose of the pool scheme underwent a change from an institutional mechanism of brain gain to check the process of brain drain from India. As Ahmed et al. (1994: 176) note [this] 'trend indicates that (1) a smaller number of S&T personnel are returning to India after they have had training abroad and (2) the opportunities for absorption within India immediately after completion of doctorate or equivalent tertiary education in S&T have become scarer'.

1970s–1980s: The Brain Drain or the Reverse Transfer of Technology Phase

The rapid expansion of mission-oriented science agencies under the auspices of the government and the proliferation of different types of universities and colleges including those in agriculture, engineering and medical sciences in the 1960s created several thousands of positions and a demand for HQP. Historically speaking, political support and the expectations from scientific research and higher education as a means to achieve rapid industrialisation and modernisation of Indian society up to the 1960s was the most optimistic phase. As a reflection of the changing ground realities, this image of the 1960s began to lose its 'shine' at the beginning of the 1970s. Beginning with the oil crises of 1973, the optimistic assumptions about science and technology for development and growth became a matter of serious concern and criticism from various public quarters. Over three decades of S&T growth, according to various commentators and science policy related

writings, revealed in the 1980s numerous shortcomings in absorption and assimilation of foreign technology and local skills, re-innovation and its proliferation in expanding the industrial base. The failure of India's industrialisation programme to absorb the increasing numbers of HQP from educational institutes coupled with the shrinking of employment space in the science agencies led to a serious problem of supply and demand (see Blaug et al. 1969; Prasad 1979).

Even though the problem of brain drain persisted throughout the 1950s and 1960s (during which scientists like Hargobind Khorana and Chandrasekhar moved to the US and later received Nobel Prizes) it began to ring 'alarming bells' only from the late 1960s and early 1970s. Apart from material and economic reasons there were a number of sociological reasons. The relative underdevelopment of specialised research communities and intellectual climate coupled with the limited opportunities to pursue highly advanced scientific research, increasing bureaucratic and hierarchical climate of laboratories, the relative absence of government policies to restrict the outflow of HQP in a situation of soaring unemployment, motivated the emigration of HQP. This was complemented, most importantly, by the emergence of a new demand pattern of HQP in the developed countries as manifested in the introduction of the new Immigration Act of 1965 in the USA.[8] Since the USA accounted for over 80 per cent of Indian emigration it will be the focus of attention in this paper.

Indian Migration to the USA

The numbers of Indian immigrants to the UK, Canada and the USA for selected years between 1964 and 1993 are shown in Table 6. It is evident that the USA surpassed both the UK and Canada in the 1970s. Indian immigration, which constituted a minuscule of less than 1 per cent of total immigration from all countries to the USA during the 1950s and 1960s, registered a rapid increase from 1970 reaching a peak of 3.8 per cent that tapered off in the 1980s but continued to rise in 1993 reaching 4.4 per cent. As mentioned earlier, the new US Immigration and Nationality Act Amendment of 1965, fully brought into force in 1968, began to show its impact after 1970. Within the overall kinship emphasis of the amendments, the new legislation actually gave priority to highly

TABLE 6
Immigration from India: 1964–93 (Selected Years)

Year	*United Kingdom*	*Canada*	*(Number of Persons)* *United States*
1964	13000	1154	634
1965	17100	2241	582
1966	16700	2233	2458
1969	11000	5395	5963
1970	7200	5670	10114
1971	6900	5313	14310
1978	9890	5112	20753
1979	9270	4517	19708
1980	7930	8491	22607
1984	5140	5513	24964
1985	5500	4038	26026
1986	4210	6970	26227
1988	5020	10432	26268
1989	4580	8836	31175
1990	5040	10662	30667
1991	–	–	45064
1992	–	–	36775
1993	–	–	40121

Note: The above data on immigration are reported by the country of birth for the United States, by the country of last permanent residence for Canada, and by the country of nationality for the United Kingdom.

Sources: For the United States, US Immigration and Naturalization Service, *Statistical Yearbook*, annual numbers; cited in Khadria (1996).
For Canada, Canadian Employment and Immigration Centre, Ottawa; and for the United Kingdom, *Control of Immigration: Statistics*, annual issues (for the period after 1972), Research and Statistics Department, Home Office, London (for the period before 1973); cited in Deepak Nayyar (1994), Table 1.

trained and educated professionals, at least for the first seven to ten years *explicitly* (Khadria 1990). As a result, 'almost a hundred thousand (Indian) engineers, physicians, scientists, professors, teachers and their dependents had entered the US by 1975'.

After the mid-1970s the number of Indians entering the USA levelled off to an average of 20,000 per year till 1982 due to the 1965 amendments to the immigration law. However, Khadria (1990, 1991) has identified two more channels of immigration of HQP from India into the USA, both without such a numerical limit, as 'immediate relatives' of the Indian born naturalised US citizens,

and as 'non immigrant' temporary visitors including students and 'distinguished workers of merit' who stayed on. According to the US Bureau of Census data, the population of 'Asian Indian' ancestry in the US recorded an increase of about 125 per cent from 0.3 million in 1980 to 0.8 million in 1990 with an immigrant component of 25 per cent in the net addition over the decade. Indians ranked seventh in 1993 in terms of highly qualified immigration into the USA.[9] But amongst the developing countries, Indian immigration there was overwhelmingly due to the demand for its scientific and technical labour, whereas for other countries immigration was either due to illegal mobility of unskilled labour or to maintain ethnic balance in the population structure (Khadria 1996). This is reflected in the fact that in terms of the place in the US economy, indexed whether by levels of employment or occupation, education or income of the immigrants, India has continued to rank a distinct first through the 1970s compared to all other countries.[10] Education-wise Indian immigrants in America have been better equipped with 'human capital' to enter the higher echelons of the US job market than other immigrants.[11] In the 1980s, Indian immigrants continued to occupy high professional and scientific positions. A recent sample survey undertaken by the National Council of Applied Economic Research (NCAER 1993) also bears testimony to the qualitative component of Indian human capital: 91 per cent of the respondents in this survey (n = 503) had postgraduate professional education. Also, 96 per cent of the respondents had lived in the USA for over 10 years; and were in the upper income brackets compared to other immigrant nationals.

Less than half the number of Indian immigrants in the American group of NRI respondents in the NCAER sample survey were American citizens. This was perhaps due to the fact that an increasingly large number of Indian immigrants, that is, one-third or 33 per cent had naturalised themselves into American citizenship and thereby closed the option of permanent return to India, at least in principle (Khadria 1991). This apart, they also brought in large numbers of 'immediate relatives'. In addition, a large proportion of Indian students as well as workers of 'distinguished merit' and trainees coming to the US on temporary visas too have not returned to India on completion of their initial assignments. According to a recent trend projection by Khadria (1996), between one-third and one-fourth of such 'visiting' personnel actually became permanent

residents through visa conversions. These trends are in consonance with the fact that the 1990 US immigration law has opened the doors to the professionally qualified and occupationally skilled category of immigrants, prompting an American newspaper editorial to observe: 'We do not take just "huddled masses". We take the best the world can offer' (*USA Today* 1995). An estimate showing the projection of Indian scientific and professional personnel between 1990 and 2010 also corroborates a 60 per cent increase in all categories (see Khadria 1996).

In terms of the S&T areas, engineering, natural sciences, computing and medicine are the four areas on which some data are available for the 1966–86 period. According to the estimates of Gulati (1990), nearly 45,000 personnel were admitted as immigrants into the USA. Engineers accounted for 44 per cent; physicians and surgeons 30 per cent; followed by natural scientists (14 per cent) and computer specialists (2 per cent). There was a sudden decline in the outflow of doctors from 19 per cent in 1974 to 13 per cent in 1978 due mainly to restrictions imposed on this category by the US government, but it rose again by the mid-1980s to 17 per cent as Indians found ways of taking the requisite test (ECFMG) in neighbouring and other countries. No authentic estimates are available for the period after the mid-1980s. However, it may be pointed out that the exodus of computer specialists, particularly software engineers, surpassed the other categories including engineering personnel for the period following the late 1980s. The number of doctorate degrees awarded to Indian citizens in science and engineering in the USA from 1960 to 1985 are presented in Table 7. As can be seen from the table, 9,146 doctorates were awarded to Indian citizens, the maximum (45 per cent) being in engineering followed by life and physical sciences which accounted for about 20 per cent each between 1960 and 1985. It can be seen from Table 7 that 211 Indians were awarded doctoral degrees in engineering in 1985 in the USA. The corresponding figure for India during the same period was 175. One of the strong motivations to study in US institutions, as noted earlier, could have been the advanced professional level and the academic prestige attached to their degrees amongst the peer groups.

Apart from the large numbers, the notable feature of Indian migration to the USA has been the quality aspect. In other words, the USA is a country which, having created a demand pattern, has

TABLE 7
Indian Citizens Awarded Science and Engineering Doctorates in the USA from 1960 to 1985

Year	*Engg*	*Life Science*	*Phy Science*	*Earth, Atmos & Mari Science*	*Maths*	*Comp/ Inform-ation Science*	*Total*
1960–64	203	361	221	23	72	–	880
1965–69	525	551	404	34	114	–	1628
1970–74	1242	592	484	58	175	–	2551
1975–79	1039	307	424	44	94	14	1922
1980	184	45	91	2	14	3	339
1981	176	40	92	7	24	6	345
1982	160	34	94	6	19	12	325
1983	178	39	79	6	23	15	340
1984	194	55	102	7	32	16	406
1985	211	56	106	5	14	18	410
Total	4112	2080	2097	192	581	84	9146

Source: Gulati (1990).

been attracting the best talents from India. Taking the case of engineering, the study of IITs would be pertinent to explore the fact that the IITs accounted for 40 per cent of all engineering graduates who migrated to the US from India; and these are regarded as the best institutions in India. The 1986 Review Committee Report on IITs indicated that during 25 years the institutions produced 27,000 graduate engineers. Even though comprehensive statistics are difficult to obtain on the production and placements of IIT graduates, two studies by Sukhatme and Mahadevan (1987) and Ananth et al. (1989) on IIT Bombay and IIT Madras, respectively, are indicative of the larger problem. As Table 8 shows, the data on IIT Bombay for the mid-1980s reveal that approximately 37 per cent of undergraduates and 31 per cent of postgraduates went abroad after engineering studies and only a small percentage, that is, between 3 and 7 per cent returned to India. The case of IIT Madras is somewhat alarming. Since its inception in 1959, the proportion of its graduates emigrating abroad is 26 per cent. The extent of migration steadily increased from 20 per cent during 1968–72 to 35 per cent during 1983–87. Speciality-wise, migration varied from a minimum of 18.4 per cent in aerospace

TABLE 8
Brain Drain of IIT Bombay Graduates; Percentage of Graduating Students

Degree	*Go Abroad*	*Go Abroad and Return*	*Brain Drain*
BTech	37.51	6.71	30.8
MTech	16.65	3.25	13.4
PhD	14.23	4.43	9.8

Source: Sukhatme and Mahadevan (1987).

engineering to a maximum of 44.6 per cent in chemical engineering. Among the two batches of new technology related computer science graduates of 1986 and 1987, brain drain was as high as 58.5 per cent (see Table 9). As mentioned earlier, all the five IITs together produce between 1,000 and 1,300 graduate engineers every year and, according to various studies on IIT brain drain, it may be said that between 30 per cent and 40 per cent of these engineers find their way out of the country, mostly to the USA.

TABLE 9
Discipline-wise Migration from IIT Madras

Discipline	% *Graduates*	% *Abroad*	% *Migration*
Aerospace	07.2	05.1	18.4
Chemical	14.0	24.0	44.6
Civil	14.0	10.1	18.8
Comp. Science	00.8	01.8	58.5
Electrical	24.9	18.4	19.2
Mechanical	25.8	30.0	30.2
Metallurgy	11.4	10.6	24.2
Naval Architecture	02.7	00.0	00.0

Source: Ananth, Ganesh Babu and Natrajan (1989).

From the macro level perspective, another feature which determined the American demand for immigrant HQP was the rate of technological change, particularly in high technology areas and the associated new skill-based labour market demands. Once these were known to policy makers in the USA, the political economy of international economic relations came into play, so that satisfaction

of American labour market demand through brain drain from India (as from elsewhere) also became entangled with other issues of generation and monopolisation of scientific knowledge within the USA. The outward flow or brain drain of HQP need not, however, be seen *only* in terms of the legal and other economic and intellectual characteristics of the host country (so to say, the demand side), in this case the USA. From the 'supply' side of the spectrum, there are other factors which call for attention in the Indian context. Some of these are discussed in the following sections.

Outturn and Unemployment

Among the developing countries, India ranks fairly low in terms of its position of scientists and engineers per 10,000 labour force with the figure of 3.5 (1986) compared to South Korea 32.0 (1987); Mexico 7.6 (1984); Israel 139.3 (1984); and Egypt 14.6 (1986). Despite this dismal figure India has witnessed an oversupply of HQP from the 1960s but more profusely from 1970 as shown in Tables 3 and 10. For example, for the two important categories of graduates in engineering and technology, and postgraduates in science, these two tables reveal alarming figures. India, on an average, produced over 20,000 postgraduates in science per year in the 1980s and the cumulative records of unemployment for the corresponding years in the 1980s showed a figure over 28,000. Similarly, India produced over 20,000 engineering graduates and the same number remained unemployed in the 1980s, thereby indicating a very low rate of absorption. In terms of the average duration of waiting period in the previous decade also, postgraduates in general science were the worst affected, and engineers were not better placed either. The Indian industrialisation programme which received considerable emphasis from the Second Five-Year Plan onwards did not live up to the optimistic expectations. The Third National Conference of Scientists, Technologists and Educationists (hereafter Third S&T Conference) organised by the Committee on Science and Technology of the Cabinet Secretariat in 1970 drew attention to this failure as early as in 1970. The proceedings of this conference noted the mismatch between the specific needs and demands of the country for development which required technically trained manpower in considerable numbers. On the other hand, the proceedings pointed out to the large

TABLE 10
Unemployed S&T Personnel Registered in the Live Register of DGET

Category	*1971*	*1973*	*1975*	*1977*	*1979*	*1981*	*1983*	*1984*	*1985*
Graduate Science	99189	210716	237607	265656	286639	337190	379931	416623	430095
PG Science	10114	16036	19374	25529	25788	28003	38822	43500	7958
Graduate Agriculture	7325	8913	7958	9763	10841	13046	17027	18938	24437
PG Agriculture	682	959	887	1064	850	762	1252	1235	1489
Graduate Engineering	18646	22730	16978	19338	21387	19922	22593	26540	34791
PG Engineering	404	363	338	460	394	471	1232	504	732
Graduate Medicine	3848	5664	7301	8948	12923	15536	17607	20636	21800
PG Medicine	105	184	422	385	924	618	1068	844	1499
Total	140313	265565	290865	331143	359746	415548	479532	528820	522801

Source: Gujral (1987).

number of unemployed in the ranks of HQP. The figures of unemployment presented in Table 10 obviously reflect the under-utilisation of the HQP by Indian industry. During the early decades from 1950 to 1960s, the expanding university system and S&T agencies and laboratories absorbed a large number of the HQP. But as the expansion capacity of these institutions reached a saturation point in the 1970s compared to the 1960s, the problem of unemployment came into sharp focus. For instance, as some studies show, the S&T manpower in India doubled during 1969 and 1979 but the workforce in R&D activity increased only by 55 per cent (Gulati 1990: 452). The fact that Indian industry from the 1970s onwards failed to generate adequate demand for the HQP, poses the question whether we can characterise the problem of outflow of HQP in terms of brain drain. Here, brain drain should be understood in terms of an overflow of the idle capacity, if not export of excess of qualified human resources. Whilst the gap between the supply and demand of HQP continued to persist from the 1970s, some sociological problems inherent in the organisation of scientific research institutions have also contributed to the problem of brain drain.

Sociological Reasons

Some influential writers (Indiresan and Nigam 1993; Menon 1982; Rahman 1972; Rahman and Sharma 1974; Zaheer 1972) who held important positions in science agencies have in varying ways drawn attention to the lack of appropriate 'intellectual and professional climate' and work culture including reward allocation systems, hierarchy and bureaucracy in Indian research institutions. That these are persisting problems is no secret in Indian organisations. The Indian National Science Academy had organised a national workshop on 'Health of Science in India' in 1984. R.A. Mashelkar, head of the Council of Scientific and Industrial Research which employs 20,000 S&T and administrative personnel, mentioned at this important meeting the following sociological reasons which he believed were responsible for brain drain in the Indian context:

1. There is general lack of 'quality jobs' for talented scientists and, indeed, job satisfaction is an extraordinarily important factor.

2. Many scientists feel that there are limited opportunities for research in the areas of their specialisation. Lack of sophisticated equipment is a standard complaint. The substance of this complaint may vary from mere availability of the equipment to the lack of infrastructure support of a high order for its effective maintenance, which renders the facility ineffective.
3. Many scientists view the existing review system rather suspiciously. They do not see a correlation between the performance of a scientist and the rewards in terms of promotion, national recognition, etc.
4. A common complaint is that a scientist can spend only a limited amount of time on actual research due to high levels of teaching and administrative loads. An active scientist feels justifiably frustrated when he finds that he has to spend a disproportionately large amount of time on issues connected with the purchase of equipment, materials, etc.
5. A serious problem relates to the non-availability of contacts with the international community. The opportunities for international travel for a meaningful and vibrant dialogue with his counterparts abroad being limited, increasing amount of frustration creeps in.

In a revealing way, Mashelkar (1984) questioned the adequacy of material and economic reasons and underlined the professional factors as the important causes of brain drain in observing that 'the brains go where the brains are'. While Shiva and Bandopadhaya (1980) and Jairath (1984) questioned whether there is something like an Indian scientific community in the sociological sense of the term, in a different vein, a study on brain drain by Mahanti et al. (1995), based on 17 research groups in 12 scientific institutions, drew attention to the sociological problems inherent in the formation of a scientific community or specialist communities. A major finding of this study is

> . . . economic incentives is not the only motivation for researchers to leave their home countries. Appropriate intellectual climate conducive for research, wherein the presence of other researchers and groups in their specialization who provide a meaningful context for the research attention is seen as the most crucial feature for checking the process of brain drain (p. 109).

As pointed out further, a research group which had been institutionalised and which has achieved some degree of success can survive only for a brief period of time in the absence of other research groups and intellectual climate in the relevant discipline or speciality. There is no alternative other than promoting a community in a speciality with a viable size or a certain number of research groups depending on the contextual situation and demand pattern. The study in particular drew attention to the problems of intellectual leadership, system of rewards, pattern of communication and absence of 'invisible colleges' as being crucial factors in the formation of a viable number of 'research groups' in the development of a speciality and community which in turn check the process of brain drain to some extent.

In the case of the Indian Institutes of Technology, Indiresan and Nigam (1993: 356) virtually charged the Indian industry and society when they observed that 'in fact, an IIT engineer does not feel *wanted* in India, the way American universities make them feel wanted'. These authors (1993: 357) also draw attention to the related social problem which persists in Indian research institutions and which is responsible for brain drain. They cite the example of the Centre for the Development of Telematics (C-DoT) which attracted a couple of hundred bright non-resident Indian engineers back from the US. The objective of this Centre was to design the first 'state-of-the-art' electronic urban and rural exchange for telecommunications which entailed a somewhat 'paradigmatic' achievement for engineers in the mid-1980s. As is well known in Indian research circles, this advanced centre for telecommunications which was promoted and nurtured by Prime Minister Rajiv Gandhi with Sam Pitroda as chief of the 'Technology Missions' was embroiled in a 'political controversy' after the demise of Rajiv Gandhi. What appeared as a good case of brain gain initially, subsequently led to brain drain due to the spillover of political controversy which engulfed this centre.[12] As Indiresan and Nigam (1993) observe, 'unfortunately their work fell foul to the import lobby and certain vested interests and the program was tarred with a very black brush and severely constrained. As a consequence, most youngsters have left C-DoT and the country—this time to migrate mostly to Australia'.

Closely related to the sociological dimension of brain drain is the factor of '*internal brain drain*'—which refers to the increasing incidence of talented graduates and postgraduates in

science and engineering being lured into lucrative jobs in management and administration. So far no systematic data and analysis are available on the extent of loss incurred due to this factor but the problem has been brought into focus in the literature in recent times (see Gujral 1987; *The Hindu* 18 June 1996). But it may be assumed that approximately 15 per cent of all science and engineering personnel who enter the workforce occupy administrative positions; and approximately 45 per cent of engineering graduates opt for managerial and market-oriented positions as they offer 50 per cent higher salaries than conventional engineering jobs. As a scientist from India's premier scientific institution commented, 'it appears that even the best engineers will not be available to design new products for us, they would be managing the companies that produce them. This means that our best brains are being lost from science and technology to other professions' (*The Hindu* 18 June 1996).

Policy Discourse

The most striking feature of the period between the 1970s and 1980s has been the relative lack of policy attention and adequate space given to the problem of brain drain in the policy statements relating to science and technology in India. Among the policy discourses and documents related to science and technology during this phase: the Third S&T Conference; the first ever Science and Technology Plan of 1974; the Technology Policy Statement of 1983; and the annual sessions of the Indian Science Congress are important sources which point to the policy attention at the macro level. The annual Indian Science Congress sessions, which have played an historic role in the professionalisation of science in India since the early decades of the present century, have only paid 'lip sympathy' to the problem of brain drain in the 1970s and 1980s. Even the S&T policy discourse during this period did not pay attention to the problem it deserved in the face of stark realities of oversupply of the HQP, unemployment and exodus of trained human resources to foreign countries. In fact, a cursory examination of the policy documents reveals that brain drain did not at all figure as a problem issue. For instance, the 1983 Technology Policy Statement—which underlined the importance of attaining self-reliance in science and technology and gave a serious call to

strengthen indigenous technological base—completely overlooked the problem of brain drain in the face of dismal figures of unemployment of the HQP and brain drain of IIT engineering graduates.

Even education policy documents of the time did not provide for effectively devising any kind of mechanism to check the problem of brain drain. This was despite the fact that the Education Commission (1964–66) under the chairmanship of D.S. Kothari had, in chapter 16 of its report, referred to the problem of brain drain as 'of sufficient importance to merit a close and systematic study', although at the same time pointing out that not all who left the country were necessarily first-rate scientists, nor of critical importance to the country's requirements at that time. Unfortunately, the National Policy on Education 1968 based on this Commission's report and the subsequent resolution was to guide the contours of higher education system in India for at least two decades to come. At the time, the government perhaps took only the latter half of the Commission's observations on brain drain seriously, entirely overlooking the necessity of understanding the problem for time-bound policy intervention. Beginning in the mid-1980s, as Majumdar (1994, 1996) pointed out, the education policy became an arena of doing and undoing by frequent changes of government at the centre. The Congress government, after a year-long national debate on the document entitled 'Challenge of Education—A Policy Perspective', adopted the National Policy on Education (NPE) in 1986, but before its 'Programme of Action' could be made fully operational, the National Front government came into power in 1989. The new government, with its constituent parties having strong reservations about the NPE 1986's greater emphasis on new technology, modernisation and managerial efficiency, than on equity and distributive justice, reopened the debate. A national committee under Acharya Ramamurti was appointed in May 1990 to review the NPE 1986. The Ramamurti Committee's perspective paper and the final report of December 1990 entitled 'Towards an Enlightened and Humane Society' emphasised vocational education for the creation of skills of the kind needed by industry. Towards this end, the Committee restated the earlier document's argument for co-opting people in the industry, from craftsmen to factory engineers, as part-time teachers, and was, like the earlier document, silent on the issue of brain drain. It is another matter that by the time the Ramamurti Committee had tabled its report in December

1990, its sponsor, the National Front government, had itself fallen, making the recommendations ineffective for being incorporated into a new education policy that is yet to come.

Among the meso level science agencies, the CSIR continued to operate the Scientists' Pool Scheme and other institutional mechanisms to transfer technologies through non-resident Indian scientists. However, these schemes fell short of initial objectives with which they had been instituted. The other government science agency, apart from the CSIR, which focused attention on the problem of brain drain was the Department of Science and Technology which sponsored around seven studies in the different IITs, engineering colleges and a premier medical institution, that is, the All India Institute of Medical Sciences in New Delhi from the early 1980s (see Kalra et al. 1992). Unfortunately, these studies have yet to make an impact on the decision-making process in science and technology. For instance, the question of brain drain from the IITs did not get the attention it deserved in the 1986 Review Committee Report on the IITs. In the case of the Department of Telecommunications, the experience of Indian Telephone Industries losing substantial numbers of its highly qualified personnel to the private sector led to the formation of a Parliamentary Committee on Communications to examine the problem of brain drain from DOT. The Committee made a number of recommendations to improve the work culture but given the past experience the implementation may take a long time before the organisation loses its workforce.

The 1990s and Beyond: The Impact of Globalisation

The process of expanding the geo-economic influence abroad of national factors of production; the integration of national economies with that of the world systems of production and consumption; and the flow of information, human skills and technical knowledge across national borders are some of the main features of globalisation. Closely associated with the process of globalisation are the introduction of new economic reforms (structural adjustment programmes, liberalisation and privatisation) which in varying ways have facilitated the process of globalisation. The impact of globalisation, together with the new economic reforms, is manifested

both in negative and positive effects and directions depending on the strength and weaknesses of institutions and nations. Since the institution of science and technology is an important part of the geo-economic and other subsystems, the dimensions of globalisation influence it as much as they do to other parts and institutions. In this perspective, we are confronted with different aspects of 'gain' and 'drain' associated with the phenomenon of scientific migration. For example, Amartya Sen (1973, 1980) and other eminent scholars have time and again drawn our attention to the negative effects, namely, loss of critical skill (and with it the technology embodied in the human capital of the emigrant) and/or the associated subsidies invested in education.[13] India may have experienced such losses in the period of the 1970s and 1980s which, as discussed earlier, witnessed a high degree of brain drain which continues even in the 1990s.

The new economic reforms and the ongoing process of globalisation have, through direct foreign investment and overseas expansion of multinational enterprises, given rise to a new industrial and economic climate in recent years. While this climate has opened new promising avenues for the repatriation of skills in new technologies in software industry, education, biotechnology, micro electronics and telecommunications, there has been a corresponding increase in the demand for soft sciences such as commerce, computing and management sciences. The tremendous growth of new industries such as tourism, travel, hotel and catering, real estate, and fashion designing in a variety of sectors has placed increasing demands on the management sciences including marketing and finance. The new economic reforms introduced after 1991 have in varying ways accentuated the problem of internal brain drain. For instance, science (not referring to engineering) now has to compete with other rapidly growing occupations such as software computing fashion designing, hotel and tourism management, which are seen as offering better career prospects than science after high school education. There is, indeed, a general perception of students being motivated more towards commerce, management and computing rather than science subjects. However, engineering, medicine and legal professions continue to enjoy their prestigious positions.

As a result of these factors, if an increasing number of professionals opt to sell and market the products rather than be involved in their production, then there are likely to be more problems for the human resource policies. Over the decades, India has built up a

huge public sector which commands and controls the vital sectors of the economy in steel, railways, telecommunications, electronics, power, electrical industry, energy and offshore drilling, etc. As many of these enterprises are being 'privatised' and at the same time these sectors are being opened up for private (both domestic and multinational) competition, new problems have arisen for the HQP in these enterprises. As reported in the press, the 'creamy layer' in these enterprises has left the public sector to take up lucrative posts in the private sector. Initially, such trends were observed in telecommunications and electronics, but now even scientists and technologists working in the Defence Research and Development Organisation (DRDO) laboratories which are engaged in high technology areas such as radars, missiles and aircraft are leaving. It is reported that 131 scientists and engineers left the DRDO in 1994; 173 in 1995; and 144 in 1996. As the Defence Minister reported in the Parliament, 'while scientists/engineers in the DRDO have a challenging task, certain percentage of them have joined multinational companies for better compensation (attractive salary and perks)' (see *Times of India* 7 May 1997). So far, however, very little policy interventions have been made to systematically examine these problems relating to human resources.

There are some other studies which also draw attention to the positive sign bearing effects of brain drain (see Nayyar 1994; NCAER 1993). Such literature clearly reveals the 'gain' factor in brain drain—in terms of the contributions of the non-resident Indians (NRIs) to the economy. These contributions are mainly (*a*) financial resource flows in terms of monetary remittances and portfolio investments; (*b*) technological resource flows, mainly high-tech equipments and know-how through direct foreign investments in collaborative and joint ventures; and (*c*) human resource flows arising from skill transfer through exchange visit, home visit and home-coming of NRI scientists—the so-called 'reversal of brain drain' or return migration. One aspect of the new policies of liberalisation and globalisation has been the high hopes and expectations of gains from the geo-economic presence of India's scientific human capital well assimilated in the world labour market (see Chiswick 1978). But, even though no systematic empirical study is available, it has been hypothesised that the extent of financial gains accruing to India so far have not been much, except from the individual remittances (see Khadria 1996).

Of the various forms of gain, technology transfer through return migration of scientists and technologists of Indian origin from abroad or through short-term visit schemes assumes some importance in the Indian context. The CSIR has taken a lead in this and institutionalised the UNDP sponsored TOKTEN (Transfer of Knowledge through Expatriate Nationals) programme in the 1980s. This programme enables non-resident Indian (NRI) professionals to spend between four to eight weeks in Indian institutions. This scheme is mediated through the INRIST (Interface for NRI Scientists and Technologists) centre established under the CSIR in 1990 by the Indian government. It basically works as an interface between the NRIs abroad and the receiving organisations and industry in India that offer the visiting placements. In the absence of any systematic survey or study, it is difficult to reflect on its impact and effectiveness. This should not, however, be taken to mean that there are no promising examples of brain gain both as part of the globalisation process or independent of it. This latter aspect relates to the growth of strength in the professionalisation and improvement in the research climate in some disciplines which have a positive impact on checking brain drain and also in attracting the potential returnees. A recent study by Krishna (1996a) has shown that the professional growth of the areas of biotechnology and molecular biology during the last 15 years has led to more than a dozen research groups in various universities and national laboratories. Over one half of these groups were institutionalised as a result of the return of biologists which was evident in areas such as DNA fingerprinting at new R&D centres such as Astra established by a Swedish multinational at Bangalore; the Centre for Cellular and Molecular Biology, Hyderabad; the National Institute of Immunology, New Delhi; and Madurai Kamraj University, Madurai; Jawaharlal Nehru University, New Delhi.

The growth of computer software and biotechnology industry in some metropolitan cities such as Bangalore, Hyderabad, Baroda, Poona and New Delhi as a result of the return migration of engineers and biotechnologists, mostly from the USA, has been reported in the newspapers in recent years. As the Director of the National Research Development Corporation recently commented, 'the trend of reverse brain drain has started because of the economic liberalization . . . . We are trying to organize the high-tech companies to form a separate industry association. We expect the

number to increase from 100 to 200 companies in the next five years' (*The Times of India* 1 December 1996). Among the biotechnology companies which have mushroomed in the city of Bangalore are 'Shanta Biotech', 'Turbotech', and 'Polymide'. Another area which has developed as a result of the return migration of professionals and the inflow of capital is medicine which has led to the mushrooming of sophisticated clinics and hospitals in Mumbai, Chennai, Hyderabad and New Delhi. In Bangalore, there is a 200-member strong voluntary organisation of NRI professionals called RNRIA (returned NRIs association) of India. Though the membership in this organisation is dominated by doctors there are other professionals too.

From the globalisation perspective, the geo-economic presence of Indian scientific human capital in the USA has several possibilities of gain for India in a range of new technologies (such as information technologies, biotechnologies, and telecommunications) and frontier areas of science and technology (such as medicine and health, and material sciences). So far, no concrete government policies have attempted to tap this 'intellectual capital' through policies framed specifically on expatriates or even on return migration. Whatever little gains that have accrued to India, as seen briefly in the earlier examples, have taken place on their own momentum propelled by the new economic reforms and liberalisation. It is, however, questionable how far the benefits of these gains are going to be long-term, and how far will they trickle-down to benefit the Indian masses. Compared to the experiences of countries such as in Southeast Asia, it is a fact that the social and economic climate has not yet been firmly rooted in the Indian soil which will make the NRI scientists and technologists return to the country with capital and their wealth of knowledge. A closer scrutiny of the news of return migration from the USA in the media has another contrasting dimension of the limited 'promise' of liberalisation. There have been reports that many NRI engineers and scientists are being pushed out by continuous economic recession and job cuts in the US economy (see *Business World* 1994). Apart from this, there could be many compelling personal and domestic reasons for the return migration of scientists and technologists from abroad.

Although the NRI scientists and professionals have successfully carved a niche for themselves in the global intellectual labour market, there have been no significant trickle-down positive effects on the vital factors of human capital formation including the

scientific, technological and educational institutions. Further, the entry and establishment of new entrepreneurial firms and high tech companies, promising as they are at face value, have not yet been able to arrest the loss being inflicted by the flight of the HQP, their under-employment and unemployment. In all its ramifications, the 'gain' supposed to be accruing through globalisation or other institutional mechanisms and policies is likely to be neutralised by the gravity of the brain drain problem.

Concluding Remarks

The exploration of scientific migration in the context of brain drain and brain gain in India over the last few decades has thrown up several issues, some of which call for policy intervention. The first and the most important feature is that the emigration estimates, often reflecting quality indicators, show that India is a typical case with recurring brain drain problems, particularly since 1970. It is a typical case compared with the Newly Industrialising Countries (NICs) because despite very low scientist/technologist per population ratio and moderate economic growth rates of industrialisation, there is very high proportion of unemployment in the ranks of the HQP. Closely related to this is the 'nature' of brain drain in terms of the best, average or medicore and below average. Whatever subjective and objective means we use to assess the quality of emigrant scientists and technologists as suggested by various studies, India is certainly losing out the personnel who vary between the best and the above average.

The initial trend of brain gain experienced during the 1940s and 1960s was neutralised by the oversupply of the HQP and the rising trends in brain drain during the period of the 1970s and 1980s. Given the persistent status quo of the brain drain problem during the 1980s due to 'oversupply' and the limited HQP absorption capacity of the domestic sectors, and its interplay with international political economy factors on the demand side abroad, several new economic avenues created by the present phase of globalisation and liberalisation in such areas as telecommunications, biotechnology and information technology seem to have fallen short of making a perceptible impact. The increasing importance of information and high technology base across manufacturing and industrial sectors has generated a demand for new types of skills and a

dynamic institutional process to internalise this demand pattern. A dominant section of the Indian industry is simply not geared to such a dynamic pattern of demand. As a former member of the Telecom Commission commented,

> Department of Telecommunications has a large workforce trained in skills to maintain electromechanical and manual telephone exchanges, analogue transmission systems, and open wire lines. Their knowledge has to be enhanced for the digital environment. Simultaneously a shift has to be made towards modern techniques . . . (see *The Economic Times* 24 July 1995).

Moreover, even the dominant section of the educational and vocational system is not yet fully tuned to the changing needs. Thus, a range of skills generated while being out of tune with the new pattern of demand in the emerging industries, along with the existing mismatch between demand and supply is likely to swell the ranks of unemployment feeding into a form of 'brain drain'. There are dramatic changes in the pattern of demand in the industry as well. There is a greater demand for information and high technology based industries but not other sectors. Closely related to the impact of globalisation is the issue of internal brain drain discussed earlier in the paper. Globalisation and liberalisation have created 'two cultures' insofar as the financial and professional rewards are concerned between scientists and technologists working in the public and private sectors. Moreover, engineers with management and marketing degrees have relegated purely engineering personnel with lower salaries and rewards. Without appropriate policy intervention and correcting the imbalances created in these newly emerging sectors under globalisation, a different kind of 'internal drain' may emerge in the vital economic sector of public enterprises.

Despite high political legitimacy and support for the growth of scientific enterprise, and despite the continuing emigration of the HQP to foreign countries, neither the educational nor the science and technology policy regime has paid attention to the problem it deserves. The lack of appropriate institutional policy prescriptions on brain gain and drain is discernible even at the meso level science establishments and university structures. The CSIR is rather an exception to this charge but even here no systematic study has yet been undertaken to substantiate the effective functioning of

the Scientists' Pool Scheme and other programmes such as INRIST and TOKTEN institutionalised by the nodal science agency.

From the overall perspective of migration, no systematic indicators of quality are available with regard to the nature and type of brain drain and brain gain. Whatever limited empirical data and information on return migration are available raise a serious question whether the country has been able to attract the best of the talent from the Indian scientific diaspora or whether the mediocre brains find their way back home. Such a line of questioning emanates from two institutional sources. IIT Bombay data, which Indiresan and Nigam (1993) consider to be representative of the IIT system as a whole, indicated that the return migration figures were very low both for engineering undergraduates (6.7 per cent) and post-graduates (about 3.5 per cent). Considering IIT graduates to be among the best in the world, the rate of return migration does not appear to be impressive compared to the overall brain drain rate of about 30 per cent.

Further, the Scientists' Pool Scheme of the CSIR has been the main scheme for ensuring placements in various institutions for scientists and technologists returning to the country after higher training abroad. In the absence of any systematic study or a survey, there are some views about its working which are important. For instance, the head of the CSIR, Mashelkar, in 1984, called for a critical review of the Pool Scheme to improve its effectiveness. It was pointed out that the data on the placement of pool officers in the early 1980s indicated that less than 2 per cent of them were placed in industrial organisations. It is unlikely that this situation has changed in the 1990s. As Mashelkar argued in 1984, the issue is 'whether truly outstanding scientists have been benefited from this program or is it that the program has been able to draw the attention of only the "average" scientists, who had gone abroad as a result of a "diffused migration".' This is an important issue from the policy perspective. Assuming that India has been losing the HQP varying from the best to the above average, it would be worthwhile to enunciate policies which would be directed and targeted to bring back the best 10 to 20 per cent of the non-resident Indian scientists and technologists on a continuous rotational basis every year if not permanently. Closely connected to this is the idea of targeting the future or frontier areas of science and technology which are crucial for a global competitive edge. Decision makers in government and industry, and leaders of science

agencies will sooner or later have to evolve policies on brain gain to send a targeted size and types of HQP to industrially developed countries to draw from the international stock of knowledge through various institutional means. The Chinese and South Koreans are in a way following this route from the late 1980s in the USA by either establishing research centres or through their respective immigrant scientists who have formed associations like the Society of Chinese Bio-scientists in America. As the paper by Song (1997) shows, South Korea chalked out systematic S&T strategies from the 1970s which provide a number of lessons for other DCs. Further, a comparative case study in S&T policy perspectives and a pattern of technical education with a focus on human resource policies is called for between India and such East Asian countries. There are also small countries such as Colombia which are specifically tapping the international knowledge stocks through electronic networks from their non-resident scientific diaspora. Such efforts are important because the international division of scientific effort is so geared that developed countries are likely to continue dominating the 'frontiers' while developing countries like India will make attempts at 'catching up' in many areas at least in the coming decade or even beyond.

Similarly, it is necessary to pay greater attention to the way science and technology research is organised and the specialist communities are promoted. It is just not sufficient to institutionalise an area of research and provide some funding. There is need for a greater degree of professionalisation and promotion of basic knowledge in some crucial areas of research which will lead to a proliferation of research groups in universities and national laboratories. It is important to sustain the specialist communities in the sociological sense of the term. This relates to encouraging and strengthening journals, professional rewards, communication channels, academies, peer evaluation systems, and scientific mobility within the country, etc. It is extremely important to recognise that there are different modes of professionalisation in sciences and engineering fields which are oriented towards different types of networks and clientele. In the changing scenario of research systems which are geared towards market forces, 'excellence' and 'reputations' may have different connotations for different professional groups in different locations.

Finally, there is the question as to what will constitute the crucial areas, from the macro point of view, of the country gaining

from scientific migration, whether as brain drain or brain gain. Temporary and ad hoc benefits like remittances, imported sophisticated equipments and even rotational 'home visits' by the NRI scientists and technologists settled abroad cannot be a long-term solution to the inherent loss of human capital taking place continuously through brain drain (Khadria 1996).

This paper is not a comprehensive exercise by any means. In terms of the data and information and the coverage of scientific and technical fields of research including different types of institutions covered, it is a limited exploratory exercise. Given the magnitude of the problem and its embeddedness in the quantitative and qualitative aspects from a variety of social science perspectives, the paper calls for more in-depth case studies on different aspects of brain drain and brain gain. Studies sponsored by the Department of Science and Technology on the IITs and the All India Institute of Medical Sciences could be taken as the starting point for such further and advanced research.

NOTES

1. These overlapping phases should not however be taken as fine analytical distinctions as they are constructs reflecting the broad discourses and trends. As argued later, India remained a case of brain drain despite these different trends and possibilities over a period of time.
2. In contrast, 'science for policy' perspective refers to the phase wherein the scientific and technological system feeds into or appropriately legitimises the policy objectives. In other words, the politico-economic expectations in supporting large science and technology projects are well understood by the scientific establishment which is manifested in the steering of science and technology research in specific directions.
3. The terms of reference for the Committee were:

    1. To assess the requirements for different grades of scientific and technical manpower taking a comprehensive view over a period of the next ten years of the needs of government (civil and defence), of teaching and research, and of industry, agriculture, transport, medicine and other fields dependent on the use of scientific and technical manpower.
    2. To make recommendations regarding the action to be taken during the next five years to meet the requirements, with particular reference to:

        (*i*) the immediate improvement and expansion of facilities for scientific and technical training in Indian universities and special institutions;
        (*ii*) training overseas in scientific and technical subjects;
        (*iii*) the promotion and development of scientific and technical research;
        (*iv*) the utilisation of scientific and technical manpower; and

(*v*) the maintenance of a Register of Scientific and Technical Personnel to facilitate their utilisation to the best advantage.

4. The address of Dr Humayun Kabir (see *Minerva*, 26, 1963–64, p. 251). The register of scientists abroad was maintained by the Council of Scientific and Industrial Research (CSIR). This is referred to later.
5. For instance, the Scientific Policy Resolution of 1958 which was passed by the Indian Parliament in varying ways legitimised the policy for science. The problem of brain drain did not figure in this resolution and, on the other hand, this important document argued for the expansion of the scientific and technical manpower base. This being the very early stage of India's development, a cursory examination of the three major review committee reports on the Council of Scientific and Industrial Research which discussed various problems of industrial research and training did not consider the problem of brain drain as a major issue in the context of industrial research and industrialisation process. Journals such as *Economic and Political Weekly* and *Minerva* published various articles on science and society in the 1960s. For example, see Parthasarathi (1969).
6. Thanks are due to Professor M.G.K. Menon for providing the names of the four scientists without which the group referred to by Professor Yash Pal would have remained anonymous.
7. As the former head of the manpower division of the CSIR which administered the Pool Scheme observed, the recruitment to the scheme was not restricted to persons who applied to it. The scheme was such that the personnel registered in the Indians Abroad Section of the National Register of Scientific and Technical Personnel are automatically considered for the selection in the Pool provided they have no regular employment in India (see Gujral 1987).
8. In varying ways this was a sequel to the American emphasis on space research at NASA in competition with the 'Sputnik' programme of the USSR in the 1950s and 1960s. Subsequently, the post-oil crisis recession of the early 1970s gave a new impetus to R&D in the US, particularly the energy saving technologies with outcomes like the silicon chip, the optical fibre, and the semiconductors that were to usher in the so-called microelectronics revolution. American expenditure on defence R&D, growth needs of its technologically based economy, and of academics in response to the upsurge in expenditure on tertiary education thus propelled the demand factor into the forefront of international migration dynamics (see Khadria 1991, 1992).
9. For the 1970–79 period, India was fourth in Asia after the Philippines, South Korea and China. Mexico was at the top and Cuba was at the third position respectively. For 1993, Indian immigration figured around 35,000.
10. Of the immigrants from India during the 1975–80 period, 36 per cent were in professional, executive and managerial occupations (Khadria 1990). This share was the highest among all developing countries. This proportion increased to 50 per cent in 1983. Correspondingly, the average earnings of Indian immigrants were also amongst the highest, rising further in the late 1980s.
11. The US Census of 1980 showed that as many as 89 per cent of Indian born aged 25 years and above had at least high school education and as many as 66 per cent had a college degree. These figures were far above those for all immigrants

(the figures being 53 per cent and 16 per cent respectively) and the total US population (the figures being 67 per cent and 16 per cent respectively).

12. Notwithstanding political and other problems due to the liberalisation of the Indian economy, C-DOT achieved some major milestones in demonstrating the digital exchanges, particularly in the rural areas. By highlighting the problems generated by political interference in the functioning of R&D organisations, we wish to subscribe to the constructive mode of criticism which, we believe, is necessary for healthy functioning of scientific institutions.
13. This is despite the fact, as Bhagwati asserted in 1984, that 'one cannot begin to analyse international . . . migration unless one first understands the immigration control system pertinent to any given parametric situation' (Bhagwati 1984).

REFERENCES

AHMED, I. et al. (1994), 'Perspectives of the Scientists' Pool Scheme in Relation to Brain Drain', *Journal of Scientific and Industrial Research*, 53(2) (March), pp. 173–89.

ANANTH, M.S., K. GANESH BABU and R. NATARAJAN (1989), *Data Base for Brain-Drain: Institution Based Study, IIT Madras*. Madras: IIT.

BHAGWATI, J.N. (1984), 'Incentives and Disincentives: International Migration', *Weltwirtschaftliches Archives: Review of Works in Economics*, 120(4), pp. 678–701.

BLAUG, M., P.R.G. LAYARD and M. WOODHALL (1969), *The Causes of Graduate Unemployment in India*. London: Allen and Unwin.

Business World (1994), 'The Reverse Brain Drain—India's Prodigal Children are Returning in the Thousands to a Lukewarm Welcome', Trend Report (18–31 May), pp. 76–83.

CHISWICK, BARRY R. (1978), 'The Effects of Americanization on the Earnings of Foreign-born Men', *Journal of Political Economy*, 86, pp. 897–921.

GOVERNMENT OF INDIA (1966), *Education and National Development, Report of the Education Commission (1964–66)*. New Delhi: Government of India.

——— (1986), *National Policy on Education 1986*. New Delhi: Government of India.

——— (1990a), *Towards an Enlightened and Humane Society—A Perspective Paper*. Ramamurti Committee on National Policy of Education. New Delhi: Government of India.

——— (1990b), *Final Report*. Ramamurti Committee on National Policy on Education. New Delhi: Government of India.

——— (1992), *National Policy on Education 1986—Revised*. New Delhi: Government of India.

GUJRAL, S.P. (1987), 'Role of CSIR in Manpower Development', in *40 Years of Research—A CSIR Overview*. New Delhi: CSIR.

GULATI, R.R. (1990), 'India's Brain Drain to the US', *Current Science*, 59(4), pp. 196–202.

INDIRESAN, P.V. and N.C. NIGAM (1993), 'The Indian Institutes of Technology: Excellence in Peril', in Suma Chitnis and Philip G. Altach, eds, *Higher Education Reform in India—Experience and Perspectives*. New Delhi: Sage.

JAIRATH, V.K. (1984), 'In Search of Roots—The Indian Scientific Community', *Contributions to Indian Sociology* (n.s.), 18(1).

JHA, C.S. (1989a), 'Engineering Manpower Training—A Quest for Excellence', in P.V. Indiresan, V.N. Arora and M.L. Gulrajani, eds, *Development Through Technology—A Symposium on Nehru's Vision*. New Delhi: Indian Institute of Technology Delhi.

——— (1989b), 'A Dream and the Reality—The Story of IIT Delhi', in P.V. Indiresan, V.N. Arora and M.L. Gulrajani, eds, *Development Through Technology—A Symposium on Nehru's Vision*. New Delhi: Indian Institute of Technology Delhi.

KALRA, V., BRIAN D'MONTE, K. RAMACHANDRAN and K.R. SUNDARAM (1992), *Pilot Study to Evaluate the Phenomenon of Brain Drain amongst the Graduates of All India Institute of Medical Sciences*. Report Sponsored by the Department of Science and Technology, New Delhi.

KHADRIA, B. (1990), 'Migration of Human Capital to United States', *Economic and Political Weekly* (11 August), pp. 1784–95.

——— (1991), 'Contemporary Indian Immigration to the United States—Is the Brain Drain Over?', *Revue Europeene Des Migrations Internationales* (Poitiers), 7(1), pp. 65–96.

——— (1992), 'Some Methodological Issues in the Study of International Migration of Skilled Manpower (Brain Drain) from Developing Countries', in V.N. Kothari, ed., *Issues in Human Capital Theory and Human Resource Development Policy*. Bombay: Himalaya Publishing House.

——— (1993), 'Science, Technology and Human Capital', in Tapas Majumdar, ed., *Nature, Man and the Indian Economy*. New Delhi: OUP.

——— (1996), 'Return of Human Capital—The Second Generation Effects of Brain Drain', *Times Fellowship (1992) Report*. New Delhi: Times Fellowships Council.

KRISHNA, V.V. (1993a), 'Science Policies to Innovation Strategies: "Local" Networking and Coping with Internationalism in the Developing Country Context', *Knowledge and Policy*, 6(3–4), pp. 134–57.

——— (1993b), *S.S. Bhatnagar on Science, Technology and Development, 1938–54*. New Delhi: Wiley Eastern Ltd.

——— (1996a), 'Brain Drain, Brain Gain and Scientific Communities: Indian Experience in the Field of Biotechnology'. Paper presented at the International Symposium organised jointly by National University, Colombia and ORSTOM, Paris, on Scientific Migrations, Bogotá, Colombia, 23–26 June.

——— (1996b), 'Science, Technology and Policy Changes in India', *Science, Technology & Society*, 1(1), pp. 129–44.

MAHANTI, S., V.V. KRISHNA, E. HARIBABU, VINOD K. JAIRATH and APARNA BASU (1995), *Scientific Communities and Brain Drain—A Sociological Study*. New Delhi: Gyan Publishing House and NISTADS.

MAJUMDAR, T. (1994), 'India: Government and Higher Education', in G. Neave and Frans A. van Vught, eds, *Government and Higher Education Relationships across Three Continents—The Winds of Changes*. The Netherlands: Pergamon.

MAJUMDAR, T. (1996), 'India', in M. Woodhall, ed., *Higher Education in Asia: The Development of Higher Education in Nine Countries 1960–90*. The Netherlands: Pergamon.

MASHELKAR, R.A. (1984), 'Brain Drain: Causes, Consequences and Remedies', in *Workshop on Health of Science in India*, Indian National Science Academy, New Delhi.

MENON, M.G.K. (1982), 'Basic Research as an Integral Component of a Self-reliant Base of Science and Technology: Its Role, Relevance, Support, Areas of Thrust', *Journal of Scientific and Industrial Research*, 41 (February), pp. 55–82.

NAYYAR, D. (1994), *Migration, Remittances and Capital Flows—The Indian Experience*. Delhi: OUP.

NCAER (1993), Study of Investment Preferences of Expatriates from India. Unpublished report sponsored by Citibank, Bombay. New Delhi: NCAER.

PANIKAR, J.T. (1985), *International Cooperation in Higher Education in Science and Technology—Perspectives for the 90s*. New Delhi: Oxford & IBH Publishing Co.

PARTHASARATHI, A. (1969), 'Sociology of Science in Developing Countries—The Indian Experience', *Economic and Political Weekly*, 4(2) (August), pp. 1277–80.

PRASAD, K.V.E. (1979), 'Education and Unemployment of Professional Manpower in India', *Economic and Political Weekly*, 19 May.

RAHMAN, A. (1972), *Trimurti: Science, Technology and Society—A Collection of Essays*. New Delhi: People's Publishing House.

RAHMAN, A. and K.D. SHARMA (1974), *Science Policy Studies*. Bombay: Somaiya Publishers.

SEN, A. (1973), 'Brain Drain: Causes and Effects', in B.R. Williams, ed., *Science and Technology in Economic Growth*. Edinburgh: Macmillan.

——— (1980), 'Labour and Technology', in J. Cody, H. Hughes and D. Wall, eds, *Policies for Industrial Progress in Developing Countries*. Oxford: OUP.

SHIVA, V. and J. BANDOPADHYAYA (1980), 'The Large and Fragile Community of Scientists in India', *Minerva*, 4, pp. 466–75.

SMILLIN, LOUIS D. (1989), 'The Past, Present and Future of the Indian Institutes of Technology', in P.V. Indiresan, V.N. Arora and M.L. Gulrajani, eds, *Development through Technology—A Symposium on Nehru's Vision*. New Delhi: Indian Institute of Technology Delhi.

SONG, HAHZOONG (1997) 'From Brain Drain to Reverse Brain Drain: Three Decades of Korea Experience', *Science, Technology & Society*, 2(2).

SUKHATME, S.P. and I. MAHADEVAN (1987), *Pilot Study on Magnitude and Nature of the Brain-Drain of Graduates of the Indian Institute of Technology, Bombay*. Bombay: Indian Institute of Technology.

UDGAONKER, B.M. (1993), 'Scientific Research: Autonomous Research Institutions and Universities', in Suma Chitnis and Philip G. Altach, eds, *Higher Education Reform in India—Experience and Perspectives*. New Delhi: Sage.

USA Today (1995), 'The New Immigrants: A Changing Nation may Now Close the Door', Special Report by Maria Puente (Special Issues 30 June; 3 July; and 5 July).

ZAHEER, H. (1972), 'Science and Technology in Underdeveloped Countries', in Baliga Committee, ed., *Science and Society—Essays in Honour of Dr A.V. Baliga*. Bombay: Lalvani Publishing House.

Reversing the Brain Drain: The Case for Utilising South Africa's Unique Intellectual Diaspora

DAVID E. KAPLAN

Introduction

FOR OVER THREE decades South Africa has witnessed large-scale immigration and emigration of skilled professional and technical personnel. In an earlier paper (Kaplan 1996a) the official data recording this inflow and outflow and its major determinants were analysed. Since then, new evidence has come to light which raises considerable doubt about the validity and usefulness of the official data on immigration and emigration. Moreover, a proposal to develop a network for the South African 'intellectual diaspora', has been made and, in support of this proposal, preliminary data have been collected which provide some insight into the character and size of this diaspora.

In the first part of this paper a brief description of South Africa's capacities in relation to science and technology is presented. A historical sketch is followed by a consideration of inputs and outputs and the human resource dimension. South Africa's predominance, particularly in terms of scientific and technological outputs, among African countries is stressed. At the same time, South Africa has notable deficiencies in terms of human resources for S&T.

David E. Kaplan is Associate Professor, Science and Technology Policy Research Center, University of Cape Town, Private Bag, Rondebosch 7700, Cape Town, South Africa.

Science, Technology & Society 2 : 2 (1997)
SAGE PUBLICATIONS NEW DELHI/THOUSAND OAKS/LONDON

The next part provides a brief outline of 'scientific migration' to and from South Africa, according to the official South African data. A major qualification is that the data referred to here relate not to the migration of 'scientists', but rather to the category of 'professional, semi-professional and technical occupations'. Immigration and emigration figures are available for this category, but not for the more narrow grouping of 'scientists'.[1] Unless designated otherwise, the discussion in this paper therefore relates to this broader occupational category, rather than to 'scientists' more narrowly conceived. The evidence suggesting that this official data should be treated with considerable scepticism is also briefly discussed.

In the third part a preliminary assessment of some of the qualitative and quantitative dimensions of South Africa's intellectual diaspora is presented. It is suggested that there is a strong prima facie case for mobilising South African trained professionals and technical personnel through the creation of a network and there is a strong likelihood of success.

A series of major new policy directions in the area of S&T strongly reinforce the case for a network project. Some of these reasons are briefly discussed here.

South Africa's Science and Technology Capacities

Although earlier attempts were made to establish research capacity in South Africa, these efforts were fragmentary and primarily dedicated to supporting only the mining industry.[2] The CSIR, founded in 1945, South Africa's first and largest science council, was conceived of as a national research organisation, almost identical in character and objectives to similarly named institutions created at the same time elsewhere in the British Commonwealth.[3] By the mid-1980s, the CSIR was responsible for 13 per cent of all research undertaken on the continent of Africa.[4] The CSIR incorporated national laboratories for all the basic sciences and the organisation was principally science driven.

After the Second World War, scientific research was encouraged in the South African university system as well. As in the case of other Anglo-Saxon universities, the racially segregated 'white' universities were strongly disciplinary based with a research culture which laid emphasis on scientific publications. Though scientific

output in the universities was high, yet very little of this found its way into any commercial application. A survey of over 200 significant South African innovations concluded: 'There was strong evidence of a failure to commercialise significant university-led inventive abilities' (Philips 1990: 32).

Beginning in 1987, the CSIR underwent a major restructuring process. Increasingly, the focus shifted to applied research and under the pressure of a new formula for funding from government, to far greater market orientation. The CSIR now receives less than 50 per cent of its funding from the government—giving it one of the highest ratios of contract income to government funding, by comparison with similar institutions internationally (Garett and Clark 1992).

In terms of S&T inputs, South Africa's expenditure on R&D in 1993–94 amounted to nearly R2.6 billion (approximately $0.65 billion at the then exchange rate), accounting for around 0.75 per cent of GDP (DACST 1996a: 48).[5] South Africa's expenditure on R&D was only 0.22 per cent of the world total. Nevertheless, South Africa accounted for about 60 per cent of all R&D expenditures on the continent of Africa.[6] In the *World Competitiveness Report* of 1995, South Africa ranked 28th out of 48 countries in its S&T related strengths, much higher than its overall competitiveness ranking of 42nd.[7] However, it is important to note that a considerable, although declining share of the resources devoted to R&D are 'mission-oriented', particularly for atomic energy and defence.[8]

In terms of S&T outputs, South Africa's share of publications in the Science Citation Index (SCI) peaked in 1988 (0.6 per cent) but has subsequently declined quite sharply to 0.48 per cent in 1994 (FRD 1996: 133). In terms of the ISI's National Science Indicators, the number of publications has remained constant after 1987—approximately 3,300 per year (Pouris 1996: 268). A recent assessment of both the number of publications and citations revealed that South African science was 'anaemic' (Mitton 1995: 1). In terms of the Social Science Citation Index (SSCI), South Africa's share of world output rose from 0.25 per cent in the early 1980s to around 0.37 per cent in 1993, declining sharply to 0.3 per cent in 1994 (FRD 1996: 133).

In terms of scientific fields, measured by both publication count and by the number of citations, only a few areas are advancing significantly.[9] These include astrophysics and the agricultural

sciences (plant and animal sciences). The most important discipline in the 1970s and early 1980s, clinical medicine, has seen a drastic retreat with a decline in the absolute number of papers. In terms of the number of publications by main disciplinary fields, between 1981–85 and 1990–94, the number of publications in social sciences and humanities increased by 42 per cent; traditional sciences (physics, chemistry and material sciences) 15.2 per cent; land and primary sector sciences (agriculture, ecology, geology and plant and animal sciences) by 14.7 per cent; technology (engineering, mathematics, computer science and astronomy) by 7.5 per cent; multidisciplinary sciences by 6.5 per cent; and in life sciences (biology, clinical medicine, immunology, microbiology, molecular biology, pharmacy and neurology) they declined by 21.5 per cent.

Overall, South Africa's share of world publications in both the SCI and SSCI has shown a declining trend. Nevertheless, as Table 1 shows, South Africa's publications in the SSCI and the SCI are far higher than for any other African country.

In terms of patent activity, in the 1990s, South Africa's performance was below that in scientific publications. In 1994, South Africa's share of patents granted in the US was 0.2 per cent (FRD 1996: 145). If the share of patents in the US Patent Office is a proxy for technological output and the share of publications in the SCI is a proxy for scientific output, South Africa's performance was far better in the latter than in the former, with a ratio of 1:2.4. Nevertheless, in terms of patents granted in the US, as well as patents granted to local residents in the domestic market, South Africa was far ahead of any other country in Africa—far in excess of Egypt, for example, whose publications in the SCI were some two-thirds that of South Africa. In 1992–93, South African residents secured 3.25 patents per 100,000 population, ranking between Canada and Ireland, with Egypt only securing 0.04. In the 1990s, Egypt generally secured less than half a dozen patents per annum in the US (FRD 1996: 143).

In terms of human resource development, the performance of South Africa's S&T system has been poor. South Africa fares comparatively poorly in terms of total R&D personnel as proportion of the labour force.[10] While South Africa accounted for 60 per cent of all R&D expenditure in Africa, it has only 28 per cent of the continent's scientists and engineers (FRD 1996: 118). In 1992, the entire science and engineering (S&E) workforce numbered a

TABLE 1
South Africa and Africa Publications: Number of Articles in the SCI and SSCI

Country	*1993*		*1994*	
	SSCI	*SCI*	*SSCI*	*SCI*
Southern Africa				
Angola	2	8	2	11
Botswana	18	40	27	42
Lesotho	11	12	6	10
Madagascar	1	9	0	13
Malawi	24	72	19	88
Mauritius	2	13	1	22
Mozambique	9	16	9	15
Namibia	4	27	9	39
South Africa	470	3766	380	3798
Reunion	1	32	4	30
Swaziland	16	30	21	32
Zambia	18	74	8	71
Zimbabwe	40	236	34	226
Rest of Africa				
Algeria	5	234	2	274
Egypt	64	1943	43	2143
Ghana	19	94	37	114
Kenya	51	592	61	525
Morocco	10	412	4	452
Nigeria	127	890	111	745
Tunisia	10	289	7	340

Source: FRD (1996 Table 5–4).

little under 209,000 (FRD 1996: 79).[11] Systematic racial discrimination and poor science and maths education in schools have been the major factors limiting the supply of qualified S&T personnel. High vacancy rates for S&T personnel (greater than the vacancy rates for all other professionals and significantly higher than for all formal sector employment) are another indication of the need to expand the supply of S&T personnel.

Over the last few years in particular, this shortage was exacerbated by emigration. While the restructuring of S&T education may, in the longer term, increase the supply of S&T graduates, there are serious obstacles to this process which can, in any case, only yield results in the longer term. A more immediate solution to these problems could be through the operations of a brain gain policy. These two issues will be discussed in the following.

South Africa's Migration Patterns

The official data reveal that between 1947 and 1995, South Africa enjoyed a net gain of immigrants over emigrants for 40 of the 48 years. The same picture was essentially true for the professional and semi-professional categories. By contrast, over the last decade, during the years 1986, 1987, 1994 and 1995 there was a net loss for all occupations and for the professional and semi-professional categories. A net loss for 1996, larger than the net loss for 1995, appears to be very likely.[12]

In Figures 1 and 2 we can see the immigration and emigration figures for (*a*) all occupations, and (*b*) the professional and semi-professional categories, for the 1985–95 period. It is clear that the movement of all occupations and of the professional and semi-professional categories track each other very closely, suggesting that there are very similar explanatory underlying factors. The pattern is clearly one where generally official inflows are positive, except following major political crises, when emigration increases rapidly and there is an outflow. Thus, substantial official outflows followed Sharpeville (1961); the period of nationwide unrest following Soweto in 1976; the declaration of a state of emergency (1985); and the period leading to the change in government to one of national unity (1993). However, while the official data are probably useful in revealing overall trends in immigration and emigration, they are certainly highly misleading. In particular, they grossly understate the true extent of emigration.

This understatement is obvious when South African data are compared with that of other countries. The official South African data record that for the period 1984–93, there were 28,965 emigrants who went to the UK, while 33,640 immigrants arrived from the UK—leading to an overall net gain of 4,675 for South Africa. For the same period, the UK data give the total number of immigrants from South Africa as 100,700 and the emigrants to South Africa as 52,600, that is, leading to an overall net loss of over 50,000 for South Africa.[13] The UK emigration figures are over three times the South African figures, while the South Africa immigration data are also understated, by a little over one half. With respect to Australia, the data discrepancy is also large. Thus, the South

FIGURE 1
Total Immigration and Emigration: All Occupations

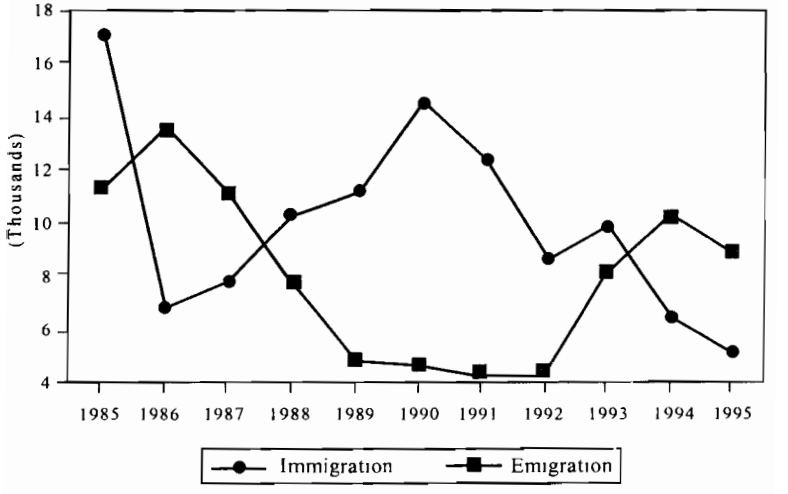
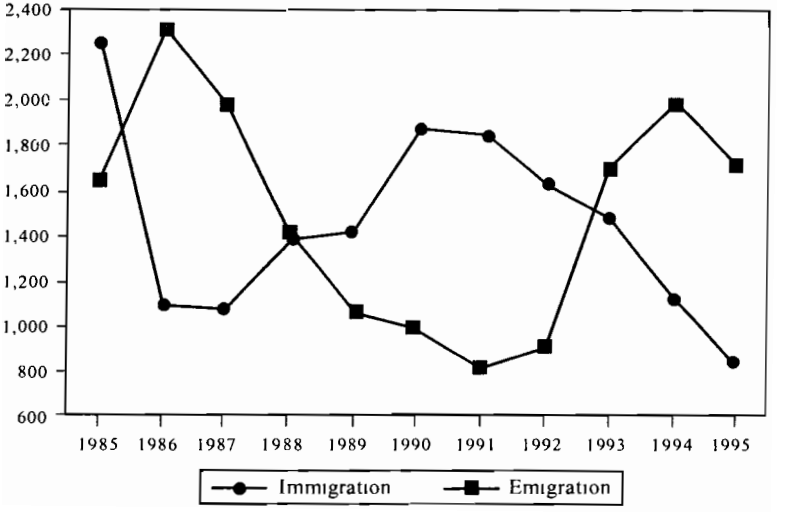


FIGURE 2
Immigration and Emigration: Professional, Semi-Professional and Technical



African data show that 1,330 South Africans emigrated to Australia in the year ending 30 June 1995. According to the Australian data, the number of South African immigrants was 2,792. For the year ending 30 June 1996 the figures were 1,855 and 3,190.[14]

People leaving South Africa are not required to state whether they are leaving South Africa permanently and it is evident that, for a number of reasons, many people prefer to state that they are leaving only as tourists. In the 1975–94 period the number of South Africans who declared that they were leaving the country as tourists exceeded the number returning by over 511,000 persons, that is, more than 10,000 persons per annum.[15] Many of them, it can be assumed, effectively emigrated.

High levels of emigration seem set to continue. The *World Competitiveness Report* for 1995 ranked the incentives for well-educated people to stay employed in South Africa as only 2.16 on a scale of 0–10, that is, below Brazil, Mexico and India.[16] There has been some immigration, particularly from the region. However, this has provoked considerable disquiet and has been declining considerably. Indeed, recently more skilled and professional personnel have left South Africa for the region, than have immigrated from the region.[17] In addition, an immigration policy is in force which includes stringent selection criteria for prospective immigrants, a policy which is highly questionable and is being increasingly challenged (Kaplan and Lewis 1997).

Therefore, the prospects of reversing the outflow of professional and skilled persons, in the near future, appear bleak. In the context of significant shortages of professional, semi-professional and technical occupations, which will intensify if South Africa realises its targeted growth rate of 6 per cent per annum by the year 2000,[18] alternative ways of rapidly supplementing the local S&T workforce will have to be evolved. One significant way would be to utilise the skills and talents of South Africa's intellectual diaspora in order to take advantage of the large-scale emigration of skilled persons that has occurred over a number of years, and particularly over the last two decades.

South Africa's Intellectual Diaspora

As the preceding discussion has shown, large numbers of professional, semi-professional and technically skilled South Africans,

certainly much larger numbers than the official data indicate, have emigrated, particularly since the Soweto uprisings of 1976. However, while South Africans frequently speculate about the dimensions of this intellectual diaspora, no systemic studies have been conducted and there is no available data on its quantitative or its qualitative characteristics.

One characteristic is nevertheless evident. The intellectual diaspora is overwhelmingly white. In 1985, 142,007 out of a total university student population of 215,786 were white, that is, approximately two-thirds (FRD 1996: 207).[19] Not only the predominance of white graduates accounted for the racial characteristic of the diaspora, but also the fact that white graduates had easier access to the industrialised countries. This was due to the fact that many of them possessed or could immediately claim entry rights, particularly to the UK, since they had family and other social networks abroad, and also because most of them had English as a their mother tongue.

Another characteristic, but one more difficult to specify precisely or to quantitatively substantiate, is that the political disposition of many of those in South Africa's intellectual diaspora is likely to be of a 'liberal' persuasion. The term 'liberal' here is used loosely to denote an opposition to the previous apartheid regime and the likelihood of broad support or, at least sympathy for the 'new' South Africa. Political disposition is important if the intellectual diaspora is to be mobilised in support of local developments. As noted earlier, the large-scale emigration from South Africa, and the emigration of professional and skilled personnel in particular, followed major political crises—Sharpeville (1961), Soweto (1976) and the 'Rubicon' speech and the declaration of a state of emergency (1985). Many of these emigrants were, in very general terms, opposed to the government policy at the time. There are indications that those who have migrated from South Africa more recently have been guided less by political and more by pragmatic motivations.[20] Those who have left since the assumption of power of the new government of National Unity (1994), are less likely to be liberal and more likely to be unsympathetic to the new government. Nevertheless, there is a possibility that many in the intellectual diaspora will have a broad sympathy for the new dispensation and some, notably those who left or were forced to leave because of their opposition to apartheid, will be strongly committed to supporting the new dispensation.

A number of South Africans living abroad whose opinions have been sought on the desirability of forming a network whereby they might make a contribution to local development have all responded very enthusiastically. Since 1994, South African graduates resident abroad have made major financial contributions to their alma mater and there has been a noticeable increase in South African academics resident abroad who have been visiting South African academic institutions. Though by no means definitive, all indications are that there is a broad sympathy among significant sections of the intellectual diaspora that could potentially be mobilised.

As a first attempt to gauge some of the other dimensions of the intellectual diaspora, data were collected from the alumni associations of five major South African universities. The university alumni associations have the task of maintaining contact with the graduates, wherever they are resident. All publish a regular magazine covering news about the university and other items of interest, which is sent to all the graduates who are contactable. Frequent reunions are also planned and appeals made for monies for university projects. The alumni associations are an important source of data and, to some extent, operate as the hubs of a weak but quasi-network.

The five universities from which data were obtained were Cape Town, Witwatersrand, Natal, Rhodes, and Stellenbosch. The first four universities are English-speaking historically white universities (HWU). Stellenbosch is an Afrikaans-speaking HWU. Data were not available from any of the historically black universities (HBUs),[21] but the number of their graduates resident abroad is, as outlined earlier, likely to be quite limited. Neither were any data obtained from other tertiary education institutions, although these largely produce technicians and only a few professionals or scientists. Nevertheless, this is a skewed sample and the data given in the following should be assessed in this light.

One further qualification. The data presented here include not only former South African residents and graduates now living abroad, but also graduates from other countries who were enrolled in South African universities. However, this is not likely to be more than 10 per cent of the total and these graduates could also be included within the network. Nevertheless, further analysis of the alumni data lists should make it possible to distinguish only former residents of South Africa.

The data for the number of graduates by principal country for the five universities are listed in Table 2. A number of characteristics are evident.

1. *The size of the intellectual diaspora is very large.* A total of 21,485 graduates from these five South African universities live abroad and their addresses are known. Moreover, it is clear that the overall number of South African graduates resident abroad is far higher than this figure. First, there are many graduates residing abroad, but who are not currently contactable—4,187 from Rhodes and Cape Town universities alone.[22] Second, in some cases, graduates resident abroad use a local home address such as their family home. Third, this figure excludes other universities and tertiary institutions. It is likely that the intellectual diaspora is well in excess of 50,000, and it is probable that with a little more effort in acquiring address lists, over 30,000 will be easily contactable.
2. *The intellectual diaspora is spatially highly concentrated.* Over 63 per cent of contactable graduates from the five universities are concentrated in six countries—Australia, New Zealand, Canada, Israel, the UK and the USA, with large concentrations in the UK and the USA. Only in the case of Rhodes less than 50 per cent of its graduates resident abroad are living in these six countries, this is probably due to the fact that a higher proportion of Rhodes graduates are from elsewhere in the region, primarily Zimbabwe. There are also significant concentrations of South African graduates elsewhere in Africa, particularly in the southern African region. Other sizeable concentrations are in Germany and Holland. Geographical concentration will clearly facilitate the operations and the management of a network.
3. *The intellectual diaspora has a high number of highly skilled graduates.* While detailed and comprehensive statistics are not yet available, an indication of the quality of graduates is the high number of students who obtained a doctoral degree, the highest degree conferred by the university. In Table 3 profiles of the doctoral graduates from each of the ten faculties of the University of Cape Town are presented. Of the 379 students who obtained a doctoral degree, 28 per cent of the university's contactable doctoral students are living abroad.

TABLE 2

South African Graduates Abroad—Contactable

	Australia	*New Zealand*	*Canada*	*Israel*	*United Kingdom*	*United States*	*Total Contactable*	*Six Countries as a % of Total*
Natal	680	175	277	na	1010	451	4057	64
Wits	860	153	444	261	926	1198	4728	81
Rhodes	392	84	155	na	701	203	3339	46
UCT*	766	206	434	121	1488	849	8818	59**
Stellenbosch	38	31	88	5	112	87	543	67
Total	2736	649	1398	387	4237	2788	21485	63

Notes: * UCT data for individual countries only for graduates in the period 1975–95. Total contactable figures are for all years.

** Percentage of total contactable graduates for six countries for the period 1975–95 only.

Source: University Alumni Offices, personal correspondence.

TABLE 3
UCT PhD Graduates Abroad by Faculty of Graduation

	Arts	*Commerce*	*Education*	*Engineering*	*Fine Arts*	*Law*	*Medicine*	*Music*	*Science*	*Social Science & Humanities*	*Total*
Not Contactable	40	2	5	38	1	0	77	0	132	13	308
Contactable	160	23	15	144	11	1	345	0	565	53	1317
Total	200	25	20	182	12	1	422	0	697	66	1625
					Contactable Alumni						
No. Local	129	16	11	108	11	1	198	0	419	45	938
No. Overseas	31	7	4	36	0	0	147	0	146	8	379
Total	160	23	15	144	11	1	345	0	565	53	1317
Overseas as % of Total	19	30	27	25	0	0	43	0	26	15	29

Source: UCT Alumni Office, personal correspondence.

By comparison, of all the contactable UCT graduates who passed out during the last twenty years, some 14.6 per cent are known to be living abroad and of those who graduated during the last ten years 10.6 per cent are living abroad. Thus, the percentage of doctoral students abroad is nearly twice as high as the percentage of all graduates resident abroad. Therefore, indications are that the intellectual diaspora is, at least in terms of the degree awarded, more highly skilled than those who remain in South Africa. It should also be noted that the percentage of contactable doctoral graduates living abroad is particularly high in medicine (43 per cent), commerce (30 per cent), education 27 (per cent), science (26 per cent) and engineering (25 per cent)—these areas are most likely to make a contribution to local development and are characterised by considerable scarcities of skills and, therefore, there is an urgent need to supplement local skills and capacities in these areas.

Since the alumni records list the faculty of graduation as well as the area of residence, it is possible to derive the broad disciplinary breakdown by location. For example, Table 4 lists contactable and non-contactable graduates of the University of Cape Town, who graduated from the faculties of engineering, medicine and science over the last ten and the last twenty years respectively and who are now resident in the USA.

TABLE 4
No. of UCT Graduates Resident in the USA for the Past Ten and Twenty Years from the Engineering, Medicine and Science Faculties

Faculty	*Residents for Past 20 Years*		*Resident for Past 10 Years*	
	Contactable	*Not Contactable*	*Contactable*	*Not Contactable*
Engineering	57	25	16	8
Medicine	210	57	65	17
Science	139	67	43	26
Total	406	149	124	51

Source: UCT Alumni Office, personal correspondence.

The alumni records reveal a large and highly skilled intellectual diaspora. This diaspora is locationally concentrated, primarily in a few English-speaking industrialised countries, but also in some of the surrounding countries. Moreover, indications are that the

principal broad disciplinary fields are those which have the highest potential to make a significant contribution to local economic development.

The alumni records do not reveal the totality of South African graduates resident abroad, but those who have maintained some contact with their alma mater in South Africa and are on their university's mailing list, are far more likely to be among those who would respond to the appeal of a network which is designed to allow graduates resident abroad to play some role in local development. The alumni records, therefore, provide both a significant database from which further information can be sought and the base upon which a far more elaborate network can be built.

Conclusion: The Brain Gain Option in the Current Policy Context

Before the present government came to power, there was no ministry or agency which had overall charge of the entire South African S&T system (Kaplan 1996b). Under the direction of the new Department of Arts, Culture, Science and Technology (DACST) three major new policy initiatives have been made. A White Paper has recently been published (DACST 1996c); a national audit of S&T capacities is underway as is a technology foresight exercise. Exploiting South Africa's intellectual diaspora could, in a number of ways, complement these policy initiatives. The following are illustrative and not exhaustive.

The audit exercise will be particularly critical in that it will allow for the identification of areas of local strengths and weaknesses. A project to exploit South Africa's intellectual diaspora will need to match local needs with identified capacities existent within the network. Thus, the audit process will focus on projects based on utilising the network.

The technology foresight exercise aims at identifying the trajectories of those technologies which will have particular significance for South Africa. Since South Africa is a minor player only with a few researchers located at the technology frontier, the skills of South Africans resident abroad, a number of whom are located at the technology frontier, could prove invaluable.

The White Paper clearly states that S&T, organised around the concept of the national innovation system, will be given a major fillip and proposes some new concrete policies. One major proposal

is in regard to the funding of Science and Technology (SET) institutions. The White Paper proposes 'To develop and apply a system of performance measurement by introducing a formal system of peer review, stakeholder input and efficiency auditing into government SET institutions' (DACST 1996c: 31). Thus, all SET institutions will be periodically reviewed. One criterion of assessment will be the scientific quality of the outputs.

> The knowledge required to perform this part of the review is of an expert nature and government officials, whose skills are usually at a policy or an administrative level, would not be able to do full justice to the process. A team consisting of appropriate peers selected from similar SETIs in other countries, augmented by local experts, would provide a better mechanism (DACST 1996c: 32).

South Africans resident abroad with a knowledge of the operations of SETIs located elsewhere, but who, unlike the typical foreign expert, also have an understanding of the South African situation and a real commitment to support local development, could perform a critical function in ongoing peer review exercises. A formal network will help identify South Africans who could play this role.

The network could also be used in a number of ways. For example, the network and a detailed database will make it possible for local researchers to identify potential research collaborators; for local academics to identify South Africans resident abroad who are willing to take local South African graduates into their laboratories or classrooms; for local academics to identify South Africans resident abroad who are active in their sphere of interest and who visit South Africa for other reasons and to involve them in local teaching activities. Finally, there are many potential applications for collaboration in the industrial sphere. For example, local firms might access support for a new technology development where this is not available locally. The fact that South Africa has a relatively sophisticated S&T and industrial system, makes it more likely that South Africans resident abroad who make use of the network will also gain. In the longer term, a well-functioning network will prosper, not on sympathy or goodwill, but only if it can secure mutual benefit for all participating parties.

In South Africa today increasing policy emphasis is on manufacturing as opposed to the extractive industries of mining and agriculture. Within manufacturing, the emphasis in industrial policy is on supporting the production of more high value added items and export orientation is also strongly encouraged. All this is sure to increase the technology/innovation intensity of manufacturing industry in particular and of the economy in general, thus increasing the demand for skilled and technically trained persons. However, deficiencies in the education system, particularly in relation to science and technology education, will severely constrain supply, at least in the short to medium term (FRD 1996: ch. 1). Moreover, as discussed earlier, the indications are that the current high rates of emigration of skilled persons is likely to continue. Making use of the skills of South Africans resident abroad, would therefore accord with the direction of industrial policy and could potentially make a contribution to bridging the gap between the demand and supply for skilled and professional personnel.

A project, formally entitled, A Brain Gain Strategy for South Africa, has been proposed as consonant with the new policy directions. The project has been proposed by ORSTOM and the Science and Technology Policy Research Center (STPRC) located at the University of Cape Town. A formal presentation has been made to the government and to a number of S&T policy analysts. Some financial support has already been pledged to the project and the government has formally extended its support through the DACST. Provided the rest of the required financial support can be secured, the project will officially get underway in the second part of 1997.

Overall, South Africa is 'blessed' with an intellectual diaspora of great promise. At the same time, a number of significant developments within the field of a very active S&T policy and industrial policy provide a uniquely positive context for the development of a policy of brain gain through the construction of a network. The South African experiment will certainly be worth watching.

NOTES

1. The major sub-categories here are—engineers and related technologists; medical practitioners, specialists and dentists; education and related occupations; accountants and related occupations; others. Engineers would generally be

included in 'scientific' migration studies, hence the data relating to this specific sub-category are isolated and presented here. The other sub-categories would include but would be wider than that of 'scientists' conventionally understood. The data for the entire category—professional, semi-professional and technical occupations are a measure of overall brain drain/gain.

2. The definitive history of science in South Africa remains to be written. Brown (1977) and Ambrose Brown (1978) are probably the best attempts. But, they are dated. For a bibliography, see Plug (1990). There are a number of histories of particular domains of science, for example, for medicine see Brink (1988).
3. For a history of the CSIR see Basson (1996) and Kingwill (1990).
4. Garbers (1989), quoted in Lutjeharms and Thomson (1993: 9).
5. This may be an underestimation. There are some problems with recent survey data. In the previous survey, undertaken two years earlier, it was estimated that South Africa allocated R2.8 billion (approximately US $0.8 billion) to all types of R&D, accounting for fractionally more than 1 per cent of GDP (DNE 1993: 9).
6. Foundation for Research Development, Directorate for Science and Technology Policy (FRD 1996: 118).
7. *World Competitiveness Report* (IMD 1995).
8. For some estimates, see Kaplan (1996b: 50) and DACST (1996b: 36).
9. This information is based on Pouris (1996: 269–70).
10. The *World Competitiveness Report* (1995) ranked South Africa 34th out of 48 countries in this respect, while South Africa ranked 28th for S&T in toto.
11. The 1993 October Household Survey gave a total S&E workforce of a little under 220,000 (FRD 1996: 333). These figures are inclusive and include technicians and nurses. The number of scientists and engineers, more narrowly defined, is approximately 85,000. This comprises 16,513 engineers, 28,873 natural scientists, 34,455 health scientists (doctors, dentists and pharmacists), and 21,695 academic staff (FRD 1996: 296–97). UNESCO estimated the number of scientists and engineers in South Africa in 1992 as 62,168. Scientists include natural scientists and natural science technologists, and engineers include professional engineers and engineering technologists. UNESCO, *Statistical Year Book* (1995) cited in FRD (1996: 99). The number of S&T personnel engaged in R&D (excluding technicians and supporting staff) was 18,596 in 1993–94 (DACST 1996a: 89).
12. Between January and August 1966, there was a net loss of 3,930 (compared to 2,744 for the same period in 1995). In the professional and semi-professional categories, there was a net loss of 949 (compared to 923 for the same period in 1995). The major factor has been a 20 per cent increase in emigration (Central Statistical Services, Tourism and Migration, January–August 1996).
13. UK, Office on National Statistics (1995).
14. *Financial Mail* (25 October 1996: 24).
15. Robyn Arnold, Directorate for S&T Policy, Foundation for Research Development, personal communication.
16. Quoted in FRD (1996: 96–97).
17. For details, see Kaplan (1996a: 9–10).
18. As envisaged in terms of the government's macro-economic strategy entitled Growth, Employment and Redistribution (GEAR).

19. By 1993, there were 153,223 white university students out of a total student enrolment of 332,897, that is, 46 per cent.
20. A leading sociologist viewing the growing brain drain as the new government was about to come into office identified the three previous brain drain periods which were precipitated by political events in the following words: 'We are about to enter a fourth phase . . . but this one, unlike the previous three, is not driven by moral abhorrence of apartheid. It constitutes rather a pragmatic, reactive approach to the situation.' 'Uncertainty Provokes Fourth Brain Drain', *Weekly Mail*, 11 (17 March 1994).
21. Requests for data were sent to all twenty-one universities. Only seven responded, and only five provided useable data.
22. Alumni Offices, personal correspondence.

REFERENCES

AMBROSE BROWN, J. (1978), *South African Science*. Cape Town: Macdonald Heritage Library.

BASSON, N. (1996), *Passages to Progress—The CSIR's Journey of Change, 1945–1995*. Johannesburg: Jonathan Ball.

BRINK, A.J., ed. (1988), *South African Medical Research. Twenty Years of Growth*. Pinetown: Owen Burgess Publishers.

BROWN, A.C. (1977), *A History of Scientific Endeavour in South Africa. A Collection of Essays Published on the Occasion of the Centenary of the Royal Society of South Africa*. Wynberg, Cape: Rustica Press.

CENTRAL STATISTICAL SERVICES (CSS) (various years), *Tourism and Migration*. Pretoria: CSS.

DEPARTMENT OF ARTS, CULTURE, SCIENCE AND TECHNOLOGY (DACST) (1996a), *Resources for Research and Development, 1993/94*. Pretoria: Government Printer.

——— (1996b), *Preparing for the 21st Century. White Paper on Science and Technology*. Mimeo.

——— (1996c), *Preparing for the 21st Century. White Paper on Science and Technology*. September. Pretoria: DACST.

DEPARTMENT OF NATIONAL EDUCATION (DNE) (1993), *Resources for R&D, 1991/92*. Pretoria: Government Printer.

Financial Mail, 'Exodus as Rainbow Nation's Iridescence Fades', 25 October 1996.

FOUNDATION FOR RESEARCH DEVELOPMENT, DIRECTORATE FOR SCIENCE AND TECHNOLOGY POLICY (1996), *South African Science and Technology Indicators*. Pretoria: FRD.

GARBERS, C. (1989), 'Die Afrika-dilemma: Is daar hoop?', *Scientiae* (September), pp. 6–7.

GARRETT, G.G. and J.B. CLARK (1992), 'Science and Technology in Transformation in South Africa', *Transformation*, 18–19.

IMD (1995), *World Competitiveness Report*. Geneva: World Economic Forum.

KAPLAN, D.E. (1996a), 'Migrations of the Professional, Semi-Professional and Technical Occupations in South Africa: Past Patterns, Current Trends and Policy'. Paper presented at the symposium on 'International Scientific Migrations Today. New Problematic', Santafe De Bogota, 24–27 June.

KAPLAN, D.E. (1996b), 'Science and Technology in a Democratic South Africa: What has the New Government Inherited and What are the Major Policy Challenges?', in M. Barrère, ed., *Sciences et Développement*. Les Sciences Hors D'Occident au XX Siècle. Vol. 5. Paris: ORSTOM.

KAPLAN, D.E. and D. LEWIS (1997), 'Skills Shortage, Results of Voodoo Economics', *Business Day*, 19 February.

KINGWILL, D.G. (1990), *The CSIR. The First 40 Years*. Pretoria: Scientia Press/ CSIR.

LUTJEHARMS, J.R.E. and J.A. THOMSON (1993), 'Commercialising the CSIR and the Death of Science', *South African Journal of Science*, 89, pp. 8–14.

MITTON, S. (1995), 'South African Science Anaemic: Serious Action Surely Advisable', *Science Watch*, 3 March.

PHILIPS, B. (1990), 'Innovations in South Africa: A Basis for Technological Policy Guidelines'. *Science and Public Policy*, 17(1) (February).

PLUG, C. (1990). 'Publications on the History of South African Science. Annotated Bibliography to the End of 1987'. Pretoria: University of South Africa (UNISA).

POURIS, A. (1996), 'The Writing on the Wall of South African Science: A Scientometric Assessment', *South African Journal of Science*, 92 (June).

UNITED KINGDOM, OFFICE ON NATIONAL STATISTICS (1995), *International Migration. United Kingdom, England and Wales*. Series MN No. 21. London: The Stationery Office.

UNESCO (1995), *Statistical Year Book*. Paris: UNESCO.

Mobility of Russian R&D Personnel in the 1990s: Magnitude and Consequences

G. KITOVA and T. KOUZNETSOVA

Introduction

MARKET REFORMS IN the early 1990s took place in Russia under conditions of social and economic crisis. The depth of this crisis turned out to be unequal within different sectors of the national economy, different regions, and different spheres of activity. The main feature of R&D development during this period was the unprecedented reduction of scale: thus the number of researchers and technicians was almost halved during 1990–95. The intensity of national reduction in R&D personnel during this period and the uncontrolled character of this process explain to a considerable extent the increasing interest in the problems of scientific personnel mobility,[1] in its scale and factor assessment.

This paper presents the results of a study conducted during 1993–95 at the Analytical Center on Science and Industrial Policy.[2]

Dynamics of the National R&D Personnel: Indicators and Opinions

Stable post-war increase in the number of people engaged in Russian science started to slacken by the 1980s, and decreased in

Galina Kitova is senior scientist at the Analytical Center on Science and Industrial Policy (ACSIP), 8A Pereulok Obukha, Moscow 103064, Russian Federation.
Tatyana Kouznetsova is Deputy Director, Analytical Center on Science and Industrial Policy (ACSIP), 8A Pereulok Obukha, Moscow 103064, Russian Federation.

Science, Technology & Society 2 : 2 (1997)
SAGE PUBLICATIONS NEW DELHI/THOUSAND OAKS/LONDON

absolute terms by 1990. In 1990 the national R&D personnel decreased by 12 per cent, in 1991 by another 14 per cent, in 1992 by almost 10 per cent and in 1993 by 15 per cent.[3]

In 1994–95 the national annual rate of reduction of R&D personnel slackened to 7.5–8 per cent. By 1994 those who wished and could had left R&D. The protracted character of social and economic crisis favoured the slackening of the outflow. As the differences in economic situations between sectors and organisations smoothened down, chances to obtain a new, highly remunerated job became slimmer for employees, formerly engaged in R&D.[4] As the crisis developed and extended, the tension on the labour market rose: the gap between the demand and supply of labour force increased. In these conditions outflow from the sphere of R&D was restrained by the threat of unemployment.

The reduction of R&D personnel varied greatly between different categories. This led to some shifts in R&D personnel structure and highlighted the negative trends which are seen in Russian science. Thus, the extraordinary decrease in the number of people in applied research reflected the depth of crisis in these sectors of Russian science. According to the estimates of R&D organisation managers, by 1994 the intensity and structure of the national R&D personnel reduction had already become a factor restraining the conduct of experiments. By the age structure, the national R&D personnel was redistributed between two groups: 31–40 and over 50, to the advantage of the latter group. This indicates not only the aging of the Russian science workers, but also some more dangerous processes. Russian science is losing people who are at the peak of their intellectual and creative potential. They hold skills, knowledge and experience for the future generation of scientists. This allows one to speak about the breach in the scientific personnel circulation mechanism in Russia.

The Russian 'experiment'—the sharp reduction in the national R&D personnel within a short period of time—was accompanied by lively discussions on its desirability, limits and possible consequences. Opinions and estimates of researchers differed significantly. Thus, OECD experts estimated the size of Russian R&D as redundant (OECD 1994) and the national R&D personnel reduction as insufficient. The opinion of the national science community was not so simple.

Most of the Russian experts emphasised that the decrease in the national R&D personnel may have disastrous consequences for Russian science. In some cases not only quantitative parameters of the process were subjected to criticism, but also its uncontrolled character. National experts insisted that the state should set the scale, structure and mechanism of R&D reduction in accordance with the goals of national development. Those who contended that this reform of science 'from the top' could lead to some serious scientific and social losses found themselves in a minority.

Positions that the Russian government had taken in this discussion can be assessed only indirectly through isolated statements of officials. If we consider the dynamics of the state expenditure on science as accumulative and a sufficiently objective indicator of the government attitude towards R&D, then the sharp drop of science in the hierarchy of national priorities is evident. However, in spite of this general 'background', the position of the government looked inconsequential. In 1992 and to some extent in 1993, Russian reformers depended on the rapid and sufficiently smooth self-adaptation of science to the new market conditions. In 1993 officials agreed with the assessment of the OECD experts on the necessity for the sharp scaling down of Russian science.[5] However, according to them, the implementation of the corresponding programme, 'from the top' was doomed to failure, because of the number of social and political factors, including positions of the scientific community. At the same time, in 1993–94 the government was forced to recognise the critical state of national science and adopt a number of measures to secure the most valuable part of it.

The fact that during the 1990s state expenditure on science was declining several times faster than the number of people engaged in science appears to be highly significant for the evaluation of the national R&D personnel dynamics. Thus, if the number of researchers and technicians declined by 40 per cent in 1991–95 (the number of the national R&D personnel by 33 per cent), the federal budget appropriations on R&D at 1991 constant prices witnessed an almost sixtold decline. As 90–95 per cent of the R&D budget was provided by the state, this resulted in deterioration of the R&D both in terms of its environment and the emergence of constraints on the manner in which research and development is conducted. Russian science did not succeed in adapting to the sharp, prolonged decline of financial resources. In these conditions the national R&D personnel reduction should be considered as

insufficient, that is, incongruous with the dynamics of science funding. This gives reason to assume that even a larger scale but controlled reduction of the national R&D personnel would have had much less painful and destructive effects for Russian science than the uncontrolled outflow that was seen in the 1990s.

The Russian R&D Personnel Mobility: An Overview

Up to the end of the 1980s the main feature of the national R&D personnel dynamics in Russia was the inflow of university graduates and postgraduates. The outflow included those who had retired, left to take care of a child, and had left for other reasons. Steady state dynamics of these parameters and the irrelevant contribution that inter-branch movement of R&D workers made to it, explain to a considerable extent the fact that researchers had almost no interest in the problems of scientific personnel mobility. Attention was focused on the problems in 1992–93, when a sharp decline in the national R&D personnel had made obvious the influence of this process on the scale, structure and dynamics of the national R&D resources.

The first wave of studies on R&D personnel mobility in Russia dealt with the problem of emigration of Russian scientists abroad.[6] In these studies different approaches to the estimation of the scale of brain drain were used; the 'emigratory' attitude of different categories of scientists and students was examined; major problems of Russian scientists' work abroad were investigated; consequences of brain drain for Russian science, its schools, and the development of science in recipient countries were evaluated, etc.[7] In comparison with other countries, problems concerning the Russian scientific diaspora[8] have not been examined in depth. Instead, researchers' efforts are concentrated on the evaluation of the magnitude of brain drain. The specificity of the research on Russian brain drain is explained to a considerable extent by the absence of reliable data on the number and structure (for example, by fields of science) of emigrant scientists, the new place of settlement and employment details.

Not meaning to underplay the significance of the consequences of brain drain for science in Russia and abroad, it can be said that the attention focused on this problem was not in line with the scale

of this problem in Russia. Scholars studying R&D personnel mobility in Russia should concentrate their efforts on the so-called internal part of this process, that is, the inter-branch and territorial movement of national R&D personnel within the country. The state of research in the field of R&D personnel mobility in Russia is characterised by a large number of works, devoted to the different aspects of this problem. Because of differences in the objectives of these works and the variety of approaches and methods used, the results are hardly comparable and, in some cases, may even be contradictory. Along with incompleteness of data this can be explained by the predictable trends in mobility and the absence of effective regulatory measures. In our opinion, the emerging decline of interest in the scientific personnel mobility problems is inadmissible. The unique Russian 'experiment' carries on and the effect of its development aggravates itself.

The R&D Personnel Mobility: Objectives

This study aims to evaluate the parameters of the scientific personnel mobility in the 1990s and to evolve methods for its comprehensive analysis in Russia. Its main features are as follows:

1. Focusing on the internal part of the phenomenon of scientific personnel mobility. This not only reveals the relation between the internal and external scientific personnel mobility that occurred in Russia, but also aims to attract the attention of researchers, the scientific community as a whole and the government to the internal brain drain which is leading to a sharp decline in the number of Russian scientists.
2. Research on the scientific personnel mobility at the level of the country, separate regions and organisations of R&D. Such zooming overcomes a number of restrictions inherent in many works in this area and provides not only an overall picture of its development, but also the specific features it manifests in separate regions of the country in R&D organisations.
3. An attempt to integrate the official data, characterising the scientific personnel mobility in Russia, with the results of sample surveys. Thus, in this research all kinds of mobility of

R&D personnel are considered; both official data and results of surveys are used; methods that take into the account the specific features of Russia are applied throughout.

These research objectives were dictated, to a considerable extent, by the access to information. Initially, the problem of scientific personnel mobility was examined using the official Russian statistics. Continuous surveys of personnel mobility in 1992–93 conducted by the Russian Federation State Committee for Statistics (GOSCOMSTAT) in R&D organisations, was the only source of direct information on the mobility of R&D personnel. Analysis of the survey results permitted an evaluation of the quantitative indicators of mobility, in particular the number who had entered and those who had left R&D organisations; their structural characteristics (sex, age, categories of scientific personnel); main inflow channels of those engaged in R&D and directions of their outflow. The incompleteness of official statistics and the absence of reliable information on the development of these processes after 1993 led to the adoption of sample surveys to study the phenomenon.

The sample included 15 regions of the Russian Federation,[9] where over one-third of the national R&D resources are concentrated. If we consider the fact that Moscow's share of the national R&D resources is 38 per cent (between 36 per cent to 40 per cent according to different resources) and that science in the capital differs a lot from that in other regions, it can be said that the survey covered over 60 per cent of 'non-metropolitan science'.[10] The fact that the sampled indicators for Russia as a whole coincided with those for regions may confirm the representativeness of the results obtained.

The survey of the R&D personnel mobility in the regions was conducted by sending out questionnaires to the heads of regional bodies. The questionnaire, specially designed for this purpose, comprised 30 questions, grouped into six categories. Over one-third of the questions were directly related to the mobility of R&D personnel. Inclusion of such categories as 'General Characteristics of the Regional R&D Sphere', 'National Science Policy and its Consequences for the Region', and 'International R&D Cooperation of the Region' in the questionnaire made it possible to identify the main factors which determine the specific nature of the scientific personnel mobility in each region. When analysing the results of

this survey, opinions and evaluations of the heads of the regional bodies were studied along with the objective data on the state of the R&D in the regions. A sample survey of personnel mobility in R&D organisations was also conducted as part of the study. The sample consisted of 60 R&D organisations located in six regions,[11] two of which (Moscow and St Petersburg) were chosen to illustrate the situation in the metropolis, while the remaining four represented the periphery. Participating institutions belonged to different sectors of science and were engaged in R&D in ten fields of science.[12] The survey techniques used included acquisition and analysis of statistical data on the personnel movement in R&D organisations; questionnaire and interviews for the heads of organisations; questionnaire for the heads of regional R&D offices, where the participating organisations are located.[13]

Main Results

Summary Characteristics of the R&D Personnel Mobility

The fact that the number who left R&D far exceeds those who entered R&D is the main characteristic of the scientific personnel mobility in Russia. During 1992, according to official data, 226,000 people left R&D (approximately 40 per cent of the national R&D personnel by the beginning of the year) while at the same time 80,000 were recruited. In 1993 the national R&D personnel outflow reached 41 per cent of its number (approximately 204,000 people) by the beginning of the year as inflow exceeded 90,000 people. The ratio between outflow and inflow was 2.8:1 in 1992 and 2.3:1 in 1993. These data not only confirm the hypothesis that the national R&D personnel scale and structure in the 1990s and their dynamics were determined by mobility indicators, but also signal the main direction: the outflow of employees from R&D.

Outflow of Employees from Russian Science

The distribution of personnel who left R&D institutions in Russia in 1992–93 is uneven according to different categories of scientific and technical personnel. The outflow of researchers working in applied science and development was way above the average: they

accounted for 35 per cent of the total number who left, while other researchers accounted for 15 per cent of the outflow. Two categories—technicians and supporting staff—accounted for almost 30 per cent of the total outflow. The number of executives (directors of institutes, heads of labs) declined more slowly in comparison with others.

In accordance with Russian labour legislation, a worker can be dismissed for several reasons: due to his own wishes; reorganisation and staff reduction; transfer to another organisation; termination of a contract or agreement, retirement and others.[14] Over half of those who left the R&D organisations were dismissed at their own request. This was often seen in the case of the supporting staff.

The analysis of the structural parameters of the outflow led to the following conclusions. First, the outflow of R&D personnel was quite spontaneous and beyond the purposeful regulating influence of the state. Parameters of the outflow were determined by factors external to R&D (for example, due to changing relations of remuneration rates in science and other branches of the economy). Thus, the outstanding level of outflow of the supporting staff and technicians was, to a considerable extent, explained by the greater employment opportunities available outside R&D.

Second, the proportion of staff dismissed because of reorganisation and staff reduction considerably declined during 1992–93. This shows that no fundamental organisational reforms took place in the R&D sphere during this period.

Third, regulation of the outflow process on the level of R&D organisations was restrained by economic reasons. Thus, according to the valid legislation, when personnel dismissal takes place because of staff reduction, an organisation established by the law should financially compensate those being dismissed. Besides that, the use of this regulating instrument led to a decline of the share of financial resources from the state budget allotted to organisations.

Inflow of Personnel to Russian Science

The decline in the proportion of researchers and the increase in supporting staff in the inflow in 1992–93 should be related to considerable shifts in the structure of this process. According to Russian labour legislation, those taken on for employment have traditionally been subdivided into those who were employed by an

organisation itself and those who were transferred from other organisations, graduated from universities, assigned by the Employment Service and others (for example, after military service). Most of those who entered the R&D organisations were employed by the organisation itself (between 56 to 73 per cent of the total inflow).

The relative reduction in the university graduate inflow was an indicator of the negative processes taking place in Russian R&D. Those who had been employed by the Employment Service were insignificant and their proportion increased from 1.4 to 2.3 per cent in 1992–93. Most of those employed by the Employment Service belonged to the supporting staff. Discrepancies between the parameters of the inflow into R&D and the parameters of their outflow led to changes in the personnel structure. The share of executives has significantly increased (by 2.5 per cent within two years). This indicates that the reduction of R&D personnel was not followed by organisational reforms in R&D institutions (for example, reduction in the number of institutions or departments). Consequently, an increased number of departments do not have 'the critical mass' of workers necessary for research at their disposal. Current mobility affects the age structure of the national R&D personnel, not only in terms of personnel aging, but also in terms of an emergent gap between the different generations of scientists.

Regularities and tendencies revealed during the survey of scientific personnel movement, conducted by the State Committee for Statistics, were confirmed by the data from sample surveys. Along with this, surveys conducted in the regions of Russia and in the R&D organisations allow us to broaden the notions of this process development, discover its peculiarities, evaluate its consequences and to substantiate possible future scenarios.

R&D Personnel Mobility in Russian Regions

In the opinion of the majority heads of regional science bodies questioned (70 per cent), the decline in the national R&D personnel had an adverse impact on the science sector of a region and contributed to its crisis. At the same time, this process had practically no influence on the social and economic conditions of a region. This is explained by the insignificant share of science in the

economic sector of most regions (including those represented in the sample).[15]

The survey of the R&D personnel mobility in regions led to correction of the notions about the 'destruction' of the industrial sector of science and the relative prosperity of the academic sector as well as university science as suggested by the official data.[16] The highest rate of personnel outflow was observed in the industrial sector of the regions surveyed. However, in the main regional centres of academic science (Nizhniy Novgorod, Novosibirsk, Sverdlovsk regions, Krasnoyarsk territory) the academic sector was affected first. It can be assumed that the academic sector's relative prosperity is due largely to the dynamics of the sector in the metropolitan region. The overwhelming contribution of the metropolitan region to the academic sector as a whole can be explained by its over concentration in this region.

Negative trends in the age structure of the personnel at the national level were confirmed by the sample survey conducted in several regions. Two age groups—30–40 years and under 30 years dominated the outflow.

While the rate of reduction of higher qualified personnel (doctors and candidates of science) at the national level was far below the corresponding figures for other personnel categories[17] in several regions (Samara and Novosibirsk regions), it contributed significantly to the general outflow. This can be explained by the inter-regional variations in the rate and depth of market reforms in the Russian economy. Commercial sector development in Moscow was much stronger than in other regions. Thus, opportunities for alternative employment for higher qualified scientific personnel are far more limited in the provinces. The absence of additional sources of income under conditions of low labour remuneration, prevalent in science in the 1990s, forced doctors and candidates of science working in the periphery to quit R&D and seek employment in other spheres of activity. The outflow of highly qualified personnel from science in these regions, where their share was insignificant, revealed an increasing gap between metropolitan and provincial science.

Problems of employment for departing personnel are central to the evaluation of the national R&D personnel reduction process in the 1990s and its consequences. Some comments on the data obtained from the survey on further employment of those who left

R&D organisations are in order. First, analysis of regional labour markets showed that it is much more difficult for those who left R&D organisations to get new jobs than for those who left other sectors of the national economy. In 1993–94, only 18 per cent of those who applied to the 'Science and Scientific Service' branch of the Federal Employment Service were given a post.[18] Corresponding figures for the 'Industry' branch and the 'Transport and Communication' branch were 28 and 38 per cent respectively. Second, the intensity of science intra-branch mobility was, on the whole, lower than that in other sectors of the national economy. Over the past several years, the Federal Employment Service managed to 'return' to science no more than 15–17 per cent of those who applied. Third, the inter-regional variations in the employment parameters for those who left science were determined either by the scale of a region's economy, the scale of R&D sector or the rate of development of the commercial sector in a region. The situation in Sverdlovsk region was contrary to the opinion that the large bulk of those who left the R&D sphere were 'devoured' by the non-state sector of the economy. In this region, those who left the R&D sphere were evenly distributed in all outflow directions: non-state sector of the economy (and non-state organisations of the R&D sphere), state organisations in other sectors of the national economy, regional authorities. In this specific case a definite role was played by the particularly considerable size of industry and science complexes and market reforms.

The lack of official data on scientific personnel migration makes it impossible to distinguish between the 'territorial' part of mobility and the 'inter-branch' part. Our attempt to correlate these two parts within a region is quite promising.

Preliminary analysis of the general migration situation in the regional sample[19] revealed a specific status in Tiumen and Saratov regions and Stavropol territory. While the first of these regions was characterised by considerable population outflow, the other two were characterised by the number of refugees and forced migrants officially registered on their territories (real inflow of migrants into these two regions considerably exceeded official evaluations of the inflow).

According to the survey results, the share of R&D personnel in the flow of migrants, entering and leaving the region, was insignificant. It is obvious that the share of R&D personnel in the flow of

migrants influences the mobility parameters of the R&D personnel of the region only in the case of employment in organisations in this sphere. However, such employment is unlikely if we take into account the reasons mentioned earlier. For all this, the role of scientists' migration in the R&D personnel dynamics for Russian regions and the parameters of its mobility was insignificant. Some exceptions are worthy of attention in the light of this regularity.

First, Tiumen region is an example of the new assimilation territory with a considerably large (for the regions of this group!) R&D sphere. The scientific sector of the region is geared to just one branch. Mass population outflow (including scientists) in the 1990s became the decisive factor for the development of the new assimilation territories. The consequences of the scientific personnel migration may be irreversible for the R&D sphere of such regions.

Second, for higher qualified scientist migrants, particularly for doctors of science, the probability of employment in the R&D sphere of the recipient regions was estimated to be considerably higher than for others. This leads one to conclude that scientists' migration in Russia has more influence on the mobility parameters of higher qualified personnel than for those in the R&D sphere as a whole.

Third, in regions characterised by limited R&D resources and insignificant number of higher qualified personnel, when doctors of science get a job in the R&D sphere, this leads to the high relative indices of their number. This demonstrates that scientists' migration has a greater impact on the mobility parameters of personnel with higher qualifications than for R&D personnel as a whole.

Thus, scientific personnel mobility trends, revealed on the national level, are reproduced in the Russian regions as well. Along with this, the development of this process in regions was characterised by a number of specific features related to the scientific community size and structure, the overall economic situation and the intensity of market changes, as well as the state of the regional labour market. The analysis of regional features of scientific personnel mobility indicates that the development of this process in metropoles (Moscow and St Petersburg) is different from that in the provinces, which encompass nearly every other region in the country. The metropolitan factor emerged more clearly in the personnel mobility survey of the scientific and technical organisations.

Mobility of Personnel in R&D Organisations

The differences between R&D mobility parameters in the metropoles and in the provinces can be explained by the historical role of Moscow and St Petersburg in the country's economic and political development. Thus, the size of Moscow's scientific complex, which greatly outranks that of any other region (including St Petersburg), increased the possibility of intra-branch mobility of R&D personnel. The proximity of R&D organisations to the federal government bodies also led to certain advantages for these two regions. The consequences of the wide involvement of these regions in international R&D collaboration were dual: it created the preconditions for the stabilisation of R&D employment, though it increased the chances of migrating abroad (including contract-based work). Rapid development of market infrastructure of the economy and a great demand for highly qualified labour, and permanent on-going reorganisation of state agencies which employed part of the highly qualified personnel contributed to an outflow of R&D personnel from these regions.

The combined influence of these and some other factors was manifested in the differences in R&D personnel mobility parameters in Moscow and St Petersburg from the average. If in Russia as a whole the dynamics of R&D personnel were characterised by a sharp decrease in the institutions surveyed (especially in 1992–93), in a number of academic institutions in Moscow the personnel increased in number. The total coefficient of mobility (ratio of the total number of incoming and outgoing from the organisation to the total number of employed at the beginning of the period) reached 25 per cent in 1993–94 in Moscow. It did not exceed 19 per cent in the provinces.[20] The number who left institutions in Moscow exceeded 3–3.5 times the number who entered. For the provincial institutions, this ratio was more than 4. These and other results of the survey indicate the relatively high contribution of the in-branch component to the parameters of scientific personnel mobility in Moscow. As noted earlier, if possibilities of 'in-science mobility' in Moscow were determined by the size of the scientific complex, then its intensity was due to a difference in how certain institutions 'felt'. Gradual smoothening of the differences (mainly through a decrease in the number of 'wealthy' organisations) led to a considerable decline in the intensity of in-branch mobility in Moscow science.

Supporting staff and technicians were the most mobile groups of personnel of the surveyed institutions. This was largely due to the objective dependence of inflow of these categories on their outflow. As a matter of fact in 1992–93 the scope of outflow of these categories threatened not only the implementation of R&D, but also the very existence of a number of institutions (supporting their infrastructure in particular). An excess inflow of these categories in the 1990s was supposed to be a forced process for the R&D sphere (the minimum needed compensation of outflow). According to the managers of the institutions covered in the survey, skills and experience of the newly recruited personnel, as a rule, were of greater value than those who left.

The low level of researcher mobility in the 1990s could be explained by the intention of a number of institutions to survive under crisis conditions by keeping those scientific personnel who are difficult to replace. It was clearly reflected in the policy of directors of the leading industrial R&D institutions. According to them, in 1993–94 this was decided 'just in case', in the hope of emerging demand for research and development. They also noted that the exceeding outflow of technicians and support personnel from science in 1994 obstructed the execution of tests and experiments. The negative consequences of this are also related to a decrease in qualifications of the national R&D personnel.

As noted earlier, low mobility of R&D managers led to just a nominal existence of a number of R&D organisations/departments by 1994. And the necessity of structural change of the organisations in this case was obvious, although it was rarely implemented.

The age characteristics of personnel mobility in the surveyed organisations generally coincided with the average and reflected an on-going aging of the national R&D personnel as well as a steady 'washing away' of specialists of the middle, most active age and expanding 'gap' between the younger and the older groups of scientists. Certain differences between the metropolis and the provinces were also observed. Thus, the process of aging of scientific personnel in the provinces was restrained by the inflow of young specialists: almost one-third of those recently hired in the provinces were younger than 25 (whereas in Moscow and St Petersburg they represented less than a quarter). The proportion of this category in the outflow was 4.5 per cent in the provinces

and nearly 8 per cent in the metropolis. This could be explained by the fact that in Moscow and St Petersburg university graduates could find highly paid jobs outside the sphere of R&D. In the major regions employment opportunities for graduates are limited.

Some specific features of R&D personnel mobility in different scientific areas revealed by the survey are also linked to regional labour markets. The inter-field variation of mobility parameters in the metropolis was insignificant, but in the provinces the medical institutions stood out. The general mobility coefficient reached 50 per cent in medical institutions (60 per cent for the highly skilled personnel). For the provinces this could be explained by wide employment opportunities for health scientists and medical doctors in insurance medicine and in paid, private medical services. Thus, people employed in scientific organisations with a medical profile could find highly paid jobs outside the R&D sector that requires their knowledge, skills, and experience. Mobility intensity in physics, mathematics and engineering in the provinces was much less than the average.

A considerable dependence of R&D mobility parameters not on difficult conditions prevalent in certain institutions but on restrictions of the local labour market appeared at first sight the paradoxical result of the survey. In many cases people employed by scientific institutions remained there not because they wanted to but because they had no other alternative. Even a slight revival of the economy of the regions and therefore in the availability of attractive opportunities could be a stimulus for a new wave of outflow from science.

At least, salaries in the R&D sphere should be aligned with the average for the national economy and conditions for modernisation of scientific facilities should be created so as to prevent further outflow of the national R&D personnel. In the current scenario, these problems can be solved only through the state budget. The minimum increase in the state budget allocation needed to solve these problems would be rather low according to our estimations. Yet, implementation of this seems highly unlikely. Despite sharp decline in R&D personnel in Russia over the past years, this process is far from over. An on-going monitoring of R&D personnel mobility is justified.

Migration of Scientific Personnel in Russia: Approaches to Evaluation[21]

In the absence of coherent and reliable data on scientific personnel migration in Russia, there is a need to design an approach for evaluating the scope of this process. In order to single out this category from the overall flow of migrating population, it was hypothesised that the ratio between migrating R&D personnel and the overall migrating population is the same as the ratio between R&D personnel and the population at large. This baseline analysis was enhanced and adjusted to comply with the results of expert evaluations.

The three commonly distinguished flows of migrating population are due not only to the difference in the share of scientific personnel, but also to a peculiar influence of these flows on the R&D personnel dynamics. Migration flow within the regions of Russia is largely rooted in the transfer of population between the cities and the countryside. If scientists move from the city to the countryside, it means that they cease to be involved in R&D. As for the reverse flow (from the countryside to the cities) one can hardly find any. Thus, migration within regions results in a decline in the national R&D personnel. According to estimates, the contribution of migration within regions to the decline in R&D personnel in 1992–93 was nearly 3 per cent. It is evident that the dynamics of this index in the near future will depend on the socio-economic environment and the structure of migration flows within regions.

At first sight inter-regional migration should lead to a redistribution of scientific personnel among regions, although the shape of this redistribution is determined by the geography and structure of inter-regional flows. During the past few years these flows have been shaped mainly by the outflow of population from the new assimilated regions, and this flow does not include R&D personnel. At the same time in the context of recession in science and decrease in R&D personnel, inter-regional migration leads to personnel reduction as well. In fact, an outflow of R&D personnel as part of inter-regional migration leads to a decline in R&D personnel of a region. However, as a rule, the inflow of R&D specialists in a region does not automatically lead to their employment in R&D. Inter-regional migration accounts for 5–7 per cent of the total reduction in the national R&D personnel, according to our estimates.

There are other aspects which are relevant for evaluating the scope of inter-republican migration influence on the dynamics of the national R&D personnel. First, the high level of explicit and latent unemployment in Russian science has restricted the influence of R&D personnel influx from the republics of the former Soviet Union (despite its considerable scope) on the number of people engaged in Russian science. Only a few of the migrating scientists have been able to secure a job in Russian R&D (mainly people with high qualifications). Second, the mass of population leaving Russia in the total flow of inter-republican migration consists mainly of people who emigrate from the newly developed regions in Russia to the republics of the former Soviet Union. The level of education and the skill of the migrants affirm that there is a slight outflow of R&D personnel.

According to our estimates, in Russia the highest 'losses' of R&D personnel caused by the movement of population within the borders of the former Soviet Union took place in 1992–93, accounting for almost 2.5 per cent of the total decline in the number of people working in Russian science.

Thus, despite some simplification while the approach was applied with regard to actual data and a certain subjectivity, it can be said that nearly 10 per cent of the total decline in the national R&D personnel in the 1990s was due to migration through the territory.[22]

The Main Trends and Scope of Russian Scientists' Emigration

Emigration of scientists in the search for better conditions of life and work has become a widespread feature of Russian life. Problems of migration of scientists are usually associated with a generally unfavourable state of science. Outflow of specialists and scientists is often seen as affecting the national interests as well as military, economic, and technological security of the country. Some experts assessed the costs of the corresponding losses for the nation's economy as a result of emigration in terms of billions of roubles, and the 'reproduction' costs of specialists exceeded the total volume of foreign investments including all kinds of foreign support.

Concern voiced by the world community about the problem of emigration of Russian scientists was explained mainly by forecasts

(early 1990s) on the considerable rise in emigrant flow and emigration of specialists from the military sphere to countries with unstable political regimes. According to the State Committee for Statistics of Russia, more than 20 per cent of those who left Russia in 1993 for permanent residence abroad had higher educational qualifications (GOSKOMSTAT 1994). The share of scientific personnel in the total number of emigrants was, however, not very high: for most of the countries it did not exceed 1 per cent. But certain countries would be way ahead of the 20 per cent level in 'brain gaining' if this category of emigrants was expanded to include university teachers, engineers and technical personnel, managers of enterprises, and students. This reveals a sufficiently high 'quality' of Russian emigration.

If the major flows of total emigration were bound for Germany, Israel, the USA and Greece (mainly due to ethnic migration), the USA and Israel were the main destination countries for emigrants with higher education. The most 'intellectual' flows were to Austria (60 per cent), France (52 per cent), the USA (48 per cent), and Canada (40 per cent). The most 'scientific' flows were to Austria (6.0 per cent), Canada (6.4 per cent), and the USA (2.4 per cent). University teachers, engineers, managers of enterprises, and students largely emigrated to the USA and Austria. Scientific personnel emigrated mainly from the central region (Moscow and Moscow region), the northwestern region (St Petersburg), and the Western Siberian region (Novosibirsk and Tomsk regions). University teachers, engineers and technical personnel, and students emigrated mainly from the central and the Western Siberian regions (Omsk, Tomsk, and Novosibirsk regions).

Scientists' decision to leave the country is determined by a combination of 'general' factors (economic and political instability, uncertainty about the future, decline in living standards, low social status of science, insufficient demand for the results of scientific activity, lack of prospects) and 'specific professional' factors (uninteresting job, poor work conditions, willingness to integrate and belong to the international scientific community). If, in 1989–91, the major motives for emigration were socio-political instability and low demand for the results of scientific activity, later living standards were the main motive for emigration. Emigration seems more likely or even easier than migration within Russia in the search of a worthy and highly remunerated job.

The main factors inducing scientists to leave the country coincided with the reasons for the outflow of R&D personnel. At the same time there are factors restraining emigration. Among them are 'immigration capacity' of the Western countries; job uncertainty; differences in qualification standards; language barriers; etc. Expanding contacts, increasing flow of information about conditions of work and life in foreign countries, and the attitude of foreign countries to emigrating scientists, make it possible to weigh all the prospects of finding a job abroad and to make a substantiated decision about emigration.

Surveys of R&D institutions in Moscow[23] which have a considerable emigration potential showed that managers had a restrained attitude towards the emigration process. Emphasising the significance of this problem for Russia (that is, preserving scientific schools) and the deleterious effects on certain fields of research because of the emigration of some scientists, they highlight some important facts:

> Departure of scientists for permanent residence abroad is largely because of 'family reasons', and not professional problems.
> New openings for self-fulfilment of scientists in Russia appear.
> Internal migration and 'depletion' of the scientific activity through insufficient state support of science, privatisation, and some other processes in R&D in Russia have caused much more harm.

One of the important trends revealed by the surveys is that the preference for working positions abroad is based on work contracts of emigrants. Sociological surveys reveal that the range of contract-based migration of Russian scientists (probation, work in foreign scientific centres on long-term contracts) exceeds direct emigration three to fivefold, and sometimes it is the first stage of emigration.[24]

Foreign foundations are considerable sources of financing for institutions and individual scientists. According to the survey of scientists in academic institutions, more than half of the scientists are involved in work based on individual and group contracts and grants with foreign countries. Young specialists show a strong preference for contract-based work.[25]

Expectations of Russian scientists about contract-based work abroad are analysed in Table 1. A higher level of self-dependence

TABLE 1
Expectations from Potential and Actual Work at Foreign Scientific Organisations
(% of Respondents, Evaluated Potential and Actual Benefits at 4 and 5 on a 5-Point Scale)*

Better chance to realise all professional skills	87 (75)
Working with competent colleagues	74 (58)
Working under highly skilled supervisors	38 (46)
Friendly psychological climate	70 (74)
Salary matching qualification	78 (60)
Direct scientific contacts with specialists	76 (80)
Adequate facilities	90 (90)
Access to necessary scientific information	89 (84)
Chance to contribute to science	78 (74)
Work on problems vital for renaissance of Russia	40 (31)
Professional development	71 (67)

Note: * Evaluation of actual benefits are in parentheses.

and increasing likelihood of receiving grants abroad and in Russia, which in the near future may become one of the leading motives of contract-based emigration of Russian scientists are considerable additions to the motives listed here. This is due to an understanding of the importance of integration into the international science community. Well-known names, references, status of the institution for which one works, projects in which one is involved, participation in international scientific meetings, as well as other factors determine not only the current material and professional capabilities of a person, but also his or her future professional career in general.

Giving preference to contract-based work in many cases scientists stake on their professional career because only a few scientists go on to work in science abroad. The majority of scientists interviewed from academic institutions preferred to work in Russia rather than emigrate. Nearly 80 per cent of the respondents claimed that they did not intend to combine their work in R&D institutions with commercial activities; 90 per cent pretended that they were not willing to leave science for business; 64.0 per cent did not wish to leave science (and 21.4 per cent said that they were not likely to leave).[26]

These estimates are rather surprising for anyone who is aware of the Russian reality. The opinion of directors of the state scientific centres permits an interpretation of the results.[27] Many of them

noted that 2–3 years ago working abroad was undoubtedly the most advantageous alternative. Today new opportunities leading to high profits have emerged in R&D, despite the on-going crisis in science and the continuing attractiveness of contract-based work.

Quantitative assessment of external migration and its contribution to the R&D personnel reduction is a difficult task. The official statistics do not give the whole picture of the extent of scientists' emigration.[28]

According to official data, 492 scientists left Russia for permanent residence abroad in 1993, 302 in 1994, and 290 in 1995.[29] Assuming that apart from teaching all the university teachers who left the country were involved in research and development (which is rather doubtful), the number of R&D personnel who emigrated abroad in 1994 is estimated at 500, and in 1995 they numbered less than 500. As a result the contribution of emigration to the decline in the number of specialists involved in R&D was estimated to be 1–1.5 per cent of the total decrease.

Taking into account the rather stable ratio between direct and contract emigration, the overall number of scientists who emigrated in 1994–95 was around 2,500 persons per year.[30] Thus, the contribution of the external 'brain gain' (direct and contract-based emigration) to the total decline in R&D personnel in Russia is somewhere between 3.5 and 4.5 per cent. Considerable variations between regions, R&D institutions and scientific areas do exist. Brain drain estimates, analysis of indirect information, and the results of the survey of scientists' emigration intentions show a slight stabilisation of the process. Meanwhile, there is no place here for unwarranted optimism since Russia will not be able to catch up with world living standards and hence some scientists (especially the younger ones) capable of selling their skills abroad would still strive to emigrate.

Emigration or long-term work of Russian scientists abroad has not assumed the form of scientific exchange. It retains all the features of one-way brain drain. This is a problem inherent to developing countries and countries with economies undergoing a transformation. Scientists' reports from foreign scientific missions, and some indirect data obtained during the research, support the idea that international contacts in many cases are leading to the 'pumping out' of intellectual skills and knowledge to the benefit of foreign institutions and of science in the countries paying for

Russian scientists' work and life. Under these circumstances claims that by working abroad Russian scientists enrich the world science can be accepted only to a limited extent.[31]

State Regulation of R&D Personnel Mobility

Almost all measures of the state science policy adopted in Russia in the 1990s influenced (or were supposed to influence) the dynamics of the national R&D personnel. Indeed, the creation of budget and non-budget foundations for R&D support,[32] the development of new forms of organisations in R&D, support of the top priority scientific and technical fields in the form of federal programmes, programmes directed toward stimulating innovation activity[33] and other activity were aimed at overall R&D support, resolution of the problem of implementation of the research results in the national economy, and preservation of R&D personnel. The realisation of this activity slowed down the outflow of personnel from the R&D sector. For instance, the creation of state research centres, which was aimed at boosting the outstanding scientific schools, was an example of such programmes. The dynamics of the centres' personnel indicate that the problem of outflow was not so critical for the centres as it was for other organisations, though it did exist.

Almost all policy measures had a rather ambiguous impact on the dynamics of scientific personnel. The programme of support for scientific centres, for example, generally aimed to encourage centres to keep personnel. At the same time it should not be denied that the expanding international contacts of the centres (some of them entered the world market only after gaining the status of centre) created the preconditions for personnel outflow abroad.

There is also some uncertainty regarding the impact of secondary employment. Under conditions where there is a growing gap between the salaries in science and in other spheres of the national economy, directors of R&D organisations had to provide their staff with extra work in order to check the outflow. As a result some institutions in fact lost their staff, though formally they had the same number of employed people. It should be added that there is only a small number of supplementary employment where

scientists can use their specialised knowledge acquired through training. Today in Russia business is the main sphere of supplementary employment for scientists. As a result R&D personnel in effect rapidly lose their qualifications which is equivalent to moving out of science.

The outflow of R&D personnel in Russia in the 1990s revealed the necessity of evolving specific measures to preserve the most valuable part of it, as well as to employ the released R&D specialists in other sectors of the national economy. The most ambitious among these programmes was an inter-departmental programme on the regulation of migration of R&D personnel (it was implemented in 1994). It stipulated the creation of favourable organisational, legal, social and economic conditions of labour and life of scientists. The main features of this programme are as follows:

1. Legal regulation for hiring specialists by domestic and foreign organisations and companies. This criterion is fulfilled only partially. Recommendations on the application of a contract-based hiring system of R&D personnel and provision for intellectual property rights in agreement with international collaboration and contracts between domestic and foreign organisations.[34]
2. Protection of the state's interests (technology transfer safeguards); compensation for the damage caused by partial loss of R&D personnel; participating in international conventions and signing bilateral agreements with countries which have the highest emigration of people from Russia. The necessary normative documents are being prepared by the Security Council, commissions and committees on science–technical and military–technical policy, committee on patents and trademarks, commission for security provision of intellectual property, State Committee for science and technical policy, other ministries, and are being adopted by the Russian government.
3. Developing a system of training and refresher courses. Developing a credit system for students for obtaining higher education in Russia and abroad.
4. Expanding business links with countrymen and creating conditions for the re-emigration of scientists. It is the most

declarative point of the programme. The likelihood of scientists' return depends directly on the prospects of stabilisation of the situation in Russia.

5. Enlisting the world scientific community to contribute to the resolution of issues of primary importance for the development of Russia and establishing international institutions in Russia.

In addition, the government adopted resolutions to financially support scientists (state scholarships for outstanding scientists and talented young scientists of Russia, additional payments for degree and academic ranks). The partial emergence of legal foundations of regulation of R&D personnel mobility implies recognition of this process as an objective fact. This should not, however, be considered as a final solution of the problem of R&D personnel outflow. The roots of the process have not been eliminated. In general, low efficiency of activity in controlling R&D personnel dynamics can be explained either by underfinancing (or sometimes total absence of it) or the overall economic situation (there is no solvent demand for R&D products).

A brief analysis of the state policies with respect to the preservation of R&D personnel shows that all of them have a technical nature and are aimed at lessening the damage caused by the impact of any of the external (for R&D) factors. Moreover, some state decisions indirectly affecting science had a greater influence on employment in this sphere than did direct regulations.

Considerable aggravation of the overall R&D situation at the end of 1995 (caused by the gap between the obligations on R&D and their fulfilment[35]) has once again put on the agenda the question of the major restructuring of Russian science involving a reduction in the number of scientific institutions. Unlike in 1991–92, however, when the idea was proclaimed from the 'top' and had not been applied due to a number of reasons, in 1996, the institutions themselves accepted the necessity of restructuring.[36] Thus, if the government capitalises on the current situation and undertakes all the responsibility for drastic transformations in R&D in 1997, there would be an additional reduction in the national R&D personnel. The scope, structure and criteria of this reduction should be determined by the government. There is a need for supplementary studies in order to determine the limits of possible

administrative reduction of Russian science (including R&D personnel) and to estimate its consequences.

NOTES

1. Mobility here is understood either as an inter-branch movement of personnel, engaged in R&D or as migration over the territory.
2. Part of these results were presented at the symposium on International Scientific Migration Today, Bogotá, Colombia, June 1996.
3. See, for example, GOSKOMSTAT's reports for R&D for various years and CSRS (1996). It should, however, be mentioned that one could find different data on Russian R&D personnel decrease in the 1990s. It is partly due to the following reasons: (*a*) during the 1990s GOSKOMSTAT revised its own R&D data for previous years several times; (*b*) new R&D indicators appeared in Russian statistics in the 1990s; and (*c*) national R&D statistics methodology has been changing considerably in the 1990s.
4. The outflow from the sphere of R&D to the commercial sector was limited by its overconcentration in the largest cities of the country (Moscow and St Petersburg), and by the saturation of the labour force demand (especially for the highly qualified) by 1994.
5. Negative perception of this report by the Russian scientific community explains, to a considerable extent, the fact that the government endeavoured not to parade its consent with conclusions and recommendations of the Western experts.
6. Legal emigration opportunities appeared only in 1992, when certain emigration rules and restrictions, valid in the former USSR, were abolished.
7. See, for example, RAS Institute of the Employment Problems (1993); Ikonnikov (1993); Raikova (1995).
8. For example, Nina Toren's research on Russian scientists diaspora in Israel (1994, 1996).
9. The survey was conducted in Nizhniy Novgorod, Saratov, Tomsk, Tula, Kalugha, Pskov, Tiumen, Sverdlovsk, Vologda, Samara, Novosibirsk and Orenburg regions; in Stavropol and Krasnoyarsk territories; and in St Petersburg.
10. This method—excluding the metropolitan region—is frequently applied to country investigations dedicated to the analysis of the R&D sphere distribution over the territory. See, for example, Inhaber (1977).
11. The survey of personnel mobility in R&D organisations was conducted in Moscow and St Petersburg, Nizhniy Novgorod, Tomsk, Saratov regions and in Stavropol Territory.
12. Physics and mathematics, chemistry, biology, geology and mineralogy, engineering, agricultural sciences and veterinary science, geography and oceanology, medicine and pharmacology. Organisations which have conducted R&D in more than one of the nine selected scientific disciplines formed the tenth group.
13. Selected methods determined the set of instruments used for the survey: forms for collection of statistical data on those who had been employed in or dismissed

from the institutions surveyed, worked out evaluation methods of the research and information structure of the personnel departments of these institutions; questionnaire for the heads of institutions; questionnaire for the heads of the regional science bodies.

14. Reasons for dismissal are recorded in a special document on labour activity (work-card), and in the documents of personnel departments.
15. Moscow is the only exception: at the beginning of the 1990s science accounted for up to 20 per cent of employed people in the economy of the city.
16. Traditional distribution of R&D organisations between academic, industrial, firm and university sectors is understood under the sector structure of Russian science.
17. Moreover, the number of the doctors of science in the country increased by almost 16 per cent during 1990–95.
18. It is estimated that 20–50 per cent of those who lost their jobs report to the Employment Service. Those who left R&D report to the Service far less than those who quit other sectors of the national economy.
19. Based on the Federal Migration Service data on the main migration flows of population in Russia in the 1990s.
20. For Russian science this indicator did not exceed 10 per cent in the 1980s.
21. Migration means movement through a territory. In accordance with practice, intra-regional (movement within the territory of a certain region), inter-regional (movement between regions) and inter-republican (movement of population between Russia and republics of the former Soviet Union) migrations are distinguished in Russia.
22. Migration includes here the three types of migration defined in note 21.
23. Concerning this survey see Kitova et al. (1995).
24. The authors were involved in these surveys which were conducted by the Analytical Center on Science and Industrial Policy in 1993–94 as part of the research project 'International Cooperation as an Instrument of R&D Organizations Support (Sociological Aspect)'. Similar estimates for this ratio were given by the experts of the Russian Ministry of Science and Technology Policy.
25. See note 22.
26. Based on the results of the surveys mentioned in note 22.
27. Based on the survey of R&D institutions in Moscow. See note 21.
28. Official statistics consider only departure for permanent residence abroad. Those engaged in the scientific sphere have been singled out only since 1992.
29. See GOSKOMSTAT bulletins for the corresponding years.
30. Based on official data and the author's own unpublished work.
31. Opinions on the one-way direction of brain drain in Russia are widespread in the Russian scientific community. Most of the directors of R&D institutes interviewed described Russian brain drain as a one-way stream. This issue has been discussed at two all-Russia seminars 'Russian Science: State and Problems of Development', Novosibirsk, September 1996, and Obninsk, February 1997. Views expressed at these two seminars largely support the authors' stand on brain drain in Russia being a one-way process.
32. The Foundation for Basic Research, the Humanitarian Scientific Foundation, the Foundation for Technological Development, the Foundation for Small-Sized Enterprises of Scientific Sphere Support, and some other foundations were created in Russia in the 1990s. Foundations support certain research

directions, scientific bodies, individual scientists, providing financing on a competitive base. Foreign foundations and international organisations also extend support to Russian scientists.

33. The framework of arrangements for improving innovation activity in Russia involved in particular the stimulation of foreign investments as well as the creation of scientific parks, business centres, small innovation-oriented enterprises, etc.
34. Only a number of scientific organisations use contractual forms of hiring. The problem of hiring is examined by different non-state intermediary companies which have access to special information on Russian specialists. Specialised labour exchanges and other forms of hiring are not working efficiently.
35. The 'gap' between the state financial liabilities on R&D (fixed in the state budget) and their fulfilment has turned out to be a tradition in the 1990s. In 1995 science received 60 per cent of all funds earmarked in the budget. By September 1996 this parameter had not exceeded 30 per cent. The increase in the 'gap' was in line with the cut in the real volume of the state assignments for science.
36. It is significant that the Russian Academy of Sciences (RAS) having reported against any kind of reorganisation of Russian science in the 1990s, has allayed its stand in 1996, and already recognised the necessity of looking for approaches and means for it.

REFERENCES

CSRS (1995), *Russian Science and Technology at a Glance: 1995*. Moscow: Data Book/CSRS.

GOSKOMSTAT (1994), 'Size and Migration of the Russian Federation Population in 1993', *RF State Committee on Statistics Bulletin*. Moscow: Computer Centre of the GOSKOMSTAT.

IKONNIKOV, O.A. (1993), *Scientific Personnel Emigration from Russia: Today and Tomorrow*. Moscow: Kompas.

INHABER, H. (1977), 'Changes in Centralization of Science', *Research Policy*, 6(2).

KITOVA, G.A., T.E. KOUZNETSOVA and B.V. KOUZNETSOV (1995), 'R&D Personnel Mobility in Russia: Scale, Pattern, and Implications', *Studies on Russian Economic Development*, 6(5).

OECD (1994), *Science, Technology and Innovation Policies in the Federation of Russia. Evaluation Report*. Paris: OECD.

RAIKOVA, D.D. (1995), 'Scientists in a Critical Situation', *Vestik Academii*, 65(8) (August).

RAS INSTITUTE OF THE EMPLOYMENT PROBLEMS (1993), *'Brain Drain': Potential, Problems, Prospects*. Issue II. Moscow: Russian Academy of Sciences.

TOREN, N. (1994), 'Professional-support and Intellectual-influence Networks of Russian Immigrant Scientists in Israel', *Social Studies of Science*, 24, pp. 725–43.

——— (1996), 'Integration of Immigrants in Science, Medicine and Engineering and the Structure of Collegial Networks in Israel', *Science and Public Policy*, 23(6), pp. 361–67.

*The Impact of Jewish Refugee Chemists from Nazi Germany on Chemistry in Palestine/Israel**

UTE DEICHMANN

THE EXPULSION OF the Jewish and politically undesirable scientists began shortly after the takeover of the National Socialists in January 1933. One of the main goals of National Socialist policy was the 'purging' of the entire civil service and public sector of Jews and those with left leanings. Since all general and technical universities in Germany were (and still are) state institutions, the laws and decrees concerning the civil service applied to professors and lecturers at universities. The first and most important of these was the Law for the Restoration of the German Civil Service, passed on 7 April 1933. As a consequence, all Jewish (non-'Aryan') and a few outspoken liberal or left wing university teachers were dismissed. This was followed by dismissals from the Kaiser Wilhelm Institutes. Non-'Aryans' were defined as all persons with at least one Jewish grandparent, irrespective of their religion. Exemptions from the law for Jewish front line soldiers of the First World War were abolished as soon as Nuremberg laws were implemented in September 1935.

Different sciences were affected to varying degrees by the anti-Semitic National Socialist laws. Due to higher participation of

* This work was supported by grants Mu 575/8-1 and -2 of the Deutsche Forschungsgemeinschaft to Benno Müller-Hill.

Ute Deichmann is at Institute fuer Genetik, Universitaet zu Koeln, Weyertal 121, D-50931, Koeln, Germany.

Science, Technology & Society 2 : 2 (1997)
SAGE PUBLICATIONS NEW DELHI/THOUSAND OAKS/LONDON

Jews, chemistry and physics were far more affected than biology. This essay concerns academic chemists and not chemists in industry. The definition of chemists used here refers to 'habilitated'[1] university teachers in Germany and Austria who worked at the institutes of organic, inorganic, physical chemistry, as well as biochemical departments in the medical faculty, and doctoral researchers at Kaiser Wilhelm Institutes. Between 1933 and 1938, 139 (25.5 per cent) chemists and biochemists of a total of 544 were expelled from their positions and 109 of them emigrated. At least 85 per cent of those expelled were Jews (according to the Nazi's definition) or married to a Jew. In biology 13 per cent were dismissed and 10 per cent emigrated.[2] Due to the use of different criteria, data on the dismissal and emigration in physics vary between 15.5 per cent and 25 per cent.[3]

The majority of the refugees (60 per cent) first emigrated to various countries in Western Europe, particularly the UK (31 per cent). However, by the end of the 1930s, they had to emigrate a second time as they had been given only temporary positions in the UK, and many European countries were occupied by the Germans. The US had the highest number of emigrés in chemistry (35 per cent), followed by the UK (18 per cent), Switzerland (7 per cent), Palestine (5 per cent), Turkey (4 per cent), Sweden (3 per cent) and Brazil (2 per cent). Only about 50 per cent of all refugee chemists received a tenured position at a university or a post in industry.

Palestine was the country in which chemistry benefited most by the exodus of chemists from Germany, despite the fact that only a small percentage of the dismissed German chemists emigrated there. Chaim Weizmann, himself a chemist and as a Zionist leader largely involved in bringing scientists to Palestine, did not succeed in convincing the most illustrious German Jewish scientists, Einstein, Haber and Willstaetter and the respected younger scientists Fritz London and Otto Stern to emigrate to Palestine. As Michael Chayut has pointed out, fundamental research in Palestine was too new to attract Jewish academics who became refugees after 1933.[4] Thus Einstein, who was involved in founding the Hebrew University, which was established in 1925 as a research university, later expressed doubts about high quality physical research being conducted there. He also rejected the American collegiate model that Judah Leon Magnes, Chancellor of the Hebrew University wished

to introduce instead of the German academic research system, advocated by Einstein. Weizmann, too, became dissatisfied with the situation at the Hebrew University and founded an institute devoted to applied research in Rehovot which later became the Weizmann Institute of Science in 1949. Until 1940 only three academic physical scientists had settled permanently in Palestine: theoretical physicist Racah from Italy who was appointed Professor at the Hebrew University, and two chemists from Germany, Ladislaus Farkas and Ernst David Bergmann who along with Racah were to become the most influential scientists in Palestine/Israel. Physical chemist Adalbert Farkas, like his brother Ladislaus Farkas, an immigrant from Germany, left Palestine in 1934 and moved to the US, where he was given a post in industry. An unknown number of refugee Jewish medical scientists and physicians emigrated to Palestine. Among the medical biochemists were Ernst Wertheimer who was Associate Professor at the University of Halle, until his dismissal in 1934, he became co-founder of the Hadassah Schools of Medicine and Pharmacy of the Hebrew University of Jerusalem. Yeshayahu Leibowitz was appointed a medical biochemist at the Hebrew University. After completing his studies in chemistry and philosophy at the University of Berlin (PhD in 1924) he studied medicine at the Universities of Cologne and Heidelberg. Following the anti-Semitism wave he had to complete his MD at the University of Basle in 1934. Leibowitz's main contributions were, however, in philosophy and political theory. Felix Bergmann, brother of Ernst David Bergmann, had studied chemistry as well as medicine at the University of Berlin. He left for Palestine immediately after completing his examinations in November 1933 and later became head of the School of Pharmacy of the Hebrew University. Many younger immigrants from Germany later became academic chemists and biochemists. Due to the German occupation of Eastern European countries and the policy of extermination, a large number of scientists from these countries emigrated to Palestine during the Hitler era, and the new European refugee chemists, among them many Hungarians, made up the great majority of the staff, at least at the Hebrew University during the first decades after the Second World War.[5]

What follows is a description and brief analysis of the influence of Ladislaus Farkas and Ernst David Bergmann on chemistry in Israel.

Ladislaus Farkas who had been one of Fritz Haber's assistants, established a Department of Physical Chemistry in Palestine/Israel, first at the Daniel-Sieff (later Weizmann) Institute in Rehovot and then at the Hebrew University of Jerusalem. After his dismissal in 1933, he went to England, where he received a temporary position at Cambridge University. In September 1934 when he met Weizmann, to whom Haber had recommended Farkas as Director of the Department of Physical Chemistry at the Sieff Institute, Farkas did not have an alternative offer. In addition, he was attracted by the challenge of creating a new department. Zionism did not influence Farkas' decision to move to Palestine. In 1935, Farkas became Director of the Department of Physical Chemistry at the Hebrew University, founded by him, and at the same time carried out research at the Daniel-Sieff Institute.

Until the war, Farkas continued and extended basic physical chemical research. Together with his brother Adalbert, who became his senior assistant, he continued research on the orthopara conversion of hydrogen, which he had started under the supervision of Karl-Friedrich Bonhoeffer at the Kaiser Wilhelm Institute for Physical Chemistry under Fritz Haber. They pursued research on the chemistry of heavy hydrogen and para-hydrogen and their applications for elucidating chemical problems, photochemistry of solutions, and catalysis of hydrogenation reactions. Investigating the hydrogenation of ethylene, acetylene and benzene, and polymerisation reactions of ethylene and butylene, the Farkas brothers also worked on the mechanism of the catalytic activation of hydrogen. They proposed the dissociation of hydrogen on the surface of a catalyst.[6]

During the Second World War Ladislaus Farkas was appointed Scientific Secretary of the Science Advisory Commission to the Palestine War Supply Research. Most of his research projects after 1939 were directed to applied research, and many of his students were supported by grants from industry. At the time a rapid process of industrialisation took place in Palestine, in which refugees from Germany and other European countries played an important role. Due to the increasing enrolment of refugee students, the number of students at the Hebrew University rose from 171 in 1932–33 to 1,041 in 1939–40.[7] Farkas established relations with the major economic enterprises at the time, the citrus industry and Palestine Potash Ltd situated in the Dead Sea. He envisioned the

future industrial use of potash, bromine and magnesium, found in compounds in the Dead Sea, and was involved in the planning of large-scale potash production.[8]

After the war, Farkas' plans to resume basic research met with considerable resistance from the university administration, when he asked for re-investment in the laboratory. He wanted to pursue research on isotope and tracer chemistry for which he needed new equipment, and a long argument between Farkas and the administration followed. The Senator did not want to invest more money in research and teaching, arguing that the department had received considerable sums during the war.[9] These developments led Farkas to write to Weizmann that he doubted the possibility of doing scientific work in the future at the Hebrew University, unless funds for research and instruction were granted soon. 'Otherwise, it is to be feared that all the efforts of the last 20 years will be wasted and our university will sink to a level even below that of other small universities in the Middle East.'[10] Finally a compromise was reached.

When war broke out in Jerusalem in 1947, and the Arabs assumed control of the Mount Scopus Campus, the Department of Physical Chemistry (as other departments) had to be relocated in the city. In December 1948, Farkas left for the US in order to purchase scientific equipment for his institute. Unfortunately, the plane crashed soon after taking off from Rome and Farkas was killed. He was just 44 years of age. Farkas' impact on physical chemistry and its practical applications in Israel lasted until long after his death, as Dr S. Wald from OECD pointed out:

> Until today, one notices the impact which one single man who was a leader in the application of science, has had in Israel: Prof. Farkas, professor of physical chemistry at the Hebrew University . . . . Furthermore, an impressive number of industrial-technological developments are due to him, his pupils and now in turn to their pupils. Such individuals are rare everywhere.[11]

As these words indicate, a large number of professors in chemistry at the Hebrew University and other Israeli universities were Farkas' students or students of his students. His successor Gabriel Stein completed his MSc under Farkas, and PhD under Joseph Weiss in England, who was one of Haber's assistants in

Berlin. Joshua Jortner and Raphael Levine, two of Stein's students, became influential physical chemists in Israel.

What Farkas did for physical chemistry in Palestine/Israel, Ernst David Bergmann did for organic chemistry at the Daniel-Sieff Institute and the Hebrew University. Bergmann not only influenced research and teaching to an extent unequalled at the time, but he also played an important role in Israeli science policy, working with Chaim Weizmann and later Ben Gurion. Bergmann began his research on polycyclic aromatics, under the supervision of Wilhelm Schlenk at the University of Berlin. In 1928, he became Privatdozent (lecturer) in Berlin. In 1932, he co-authored a textbook: *Wilhelm Schlenk, Ausführliches Lehrbuch der organischen Chemie.* Schlenk, who was a friend of Haber, had to leave his position in Berlin for political reasons and was transferred to Tuebingen. He was reproached by the NSDAP officials for having remained alien to the (Nazi) movement and for maintaining his links with Jews.[12] The book reveals, however, that Schlenk was ready to compromise with the Nazis and to claim the intellectual contributions of his Jewish colleague as his own in order to safeguard his reputation as a textbook author. In 1939, the second edition of the book appeared with Schlenk as the sole author. (This is one of many examples of non-acknowledgement or stealing of Jewish intellectual property during the Nazi era, the most prominent one being the publication of Heinrich Heine's poems by an 'unknown' author). Schlenk informed Bergmann about his decision to omit his name before the book was printed. Bergmann's strong protests did not change his decision; he argued that if Bergmann's name appeared in the book, it would not be published at all.[13] According to Felix Bergmann, Ernst's brother, 95 per cent of the material appearing in the book had been written by Ernst David Bergmann.[14]

The Bergmanns belonged to a German Zionist family; their father was a rabbi in Berlin. When Ernst David Bergmann was dismissed in April 1933, Carl Neuberg recommended him to Chaim Weizmann who was on the lookout for a director for the new Daniel-Sieff Institute in Rehovot.[15] Bergmann went to London, and a long relationship and friendship developed between the two chemists. For several months, they organised co-workers and equipment for the institute. In January 1934, Bergmann arrived in Palestine, and the Daniel-Sieff Institute was established under his directorship. He remained Director of this institute and in 1949

was appointed Scientific Director of the Weizmann Institute, a post he held till 1951. From 1939, he worked on war related research projects for the Ministry of Supply in England and also for the military in the US. After the founding of the state of Israel in 1948, Bergmann was asked by Prime Minister Ben Gurion to accept the position of Scientific Director and Coordinator of scientific work of the war ministry, a position which he held ever since. For personal reasons he left the Weizmann Institute in 1951 and joined the Hebrew University as Professor of Organic Chemistry. His wife Chani Bergmann recalls,

> Bergmann had worked 18 years, from 1933 till 1951, with Weizmann, and then another 18 years together with David Ben Gurion, in a partnership which greatly influenced Israel's development. He became a personal advisor to Ben Gurion and Shimon Peres, and a scientific advisor to the Minister of Defence under Ben Gurion. He dreamt together with Ben Gurion of greening the desert, improving the scientific educational system, developing a militarily self-reliant and strong Israel. He planned the nuclear research programmes with Shimon Peres as well as the Dimona facilities.[16]

People who have known Bergmann recall his fundamental knowledge, his energy and talent for organisation.[17] Chaim Gilon, Professor of Organic Chemistry at the Hebrew University, who had been in close scientific contact with Bergmann for two years, characterises him as a teacher and scientist:

> He was a chemist with a fundamental knowledge in all fields of chemistry, which he taught in nine parallel lectures at the Hebrew University. They included: terpene chemistry, alkaloid chemistry, resonance phenomena in organic chemistry, fluorinated compounds, organic chemical biosynthesis of natural products, organo metallic chemistry. His lectures were brilliant. He was a very ambitious and a very capable man. Having an excellent memory, he could tell every student who asked him about organic syntheses the page number of the pertinent volume of a journal or book which contained the answer. In his research he was very innovative. His main fields of research were the following: 1. He investigated reactions of metals with aromatic compounds (this

was the continuation of his work with Schlenk); 2. He was interested in nature products, especially in connection to medicine (he isolated these substances in order to modify them chemically and test their action); 3. He applied physical methods in organic chemistry (for example dipole moment, UV calculations and quantum mechanics); 4. He did a lot of research in fluorine chemistry. He had the courage to enter new scientific areas, for example he went into nuclear physics and from there to nuclear medicine. He always saw the application side of science. Coming from a German origin, he never spent a wasted minute, and he embarked on many activities apart from his research. Thus he became scientific adviser to Ben Gurion, and it is due to Bergmann's influence that science in Israel became highly respected and by that gained much more support financially than before. If Bergmann had concentrated his forces, he would presumably have achieved more in his own research.[18]

Joseph Klein, Professor of Organic Chemistry at the Hebrew University, recalls, 'He was a good teacher for students who wanted to learn. His lectures were well prepared, but not interrupted by nice stories. He worked hard until the last day of his life.'[19]

Bergmann transferred from Germany to Israel not only his fields of research (which he subsequently augmented and diversified) but also attitudes typical of German scientists at the time, such as punctuality and high demands on himself and his students. But, as Chaim Gilon recalls, some of his attitudes underwent a change following his emigration. Thus, he was able to combine organisation with Israeli improvisation, and though he did not establish close ties with his students, he treated them in a friendly way. Science excited him throughout his life. Bergmann's energetic dedication not only to science, teaching and science policy, but also to practical and military applications, reminds one of Fritz Haber. In terms of methods and aims of their war contributions, there are, however, decisive differences. Haber supported the war and prolonged it, by developing internationally banned chemical weapons which served entirely the nationalistic ambitions of a would-be super power. Bergmann placed himself at the disposal of a country which had become the homeland for many of those expelled by

this ambitious super power, possibly even of Haber himself had he not died in 1934, and whose existence was threatened.

The German–Jewish refugee scientists and scholars contributed greatly to the rise of Palestine's and later Israel's universities as leaders in the Middle East and to their achieving international standards within a short time. In his foreword to the Hebrew University's semi-jubilee volume of 1950, Albert Einstein emphasised the importance of universities and of science for the development of Israel. But, at the same time, he warned against attitudes, such as a narrow utilitarian spirit, undue nationalism, purely formalistic observance of religious doctrines and provincialism, that may endanger the possible beneficial influence of science on the development of any country:

> I can well envisage the University becoming increasingly important not only for the new state of Israel but also for the Jews throughout the world. But if it is indeed to become so then its spirit must keep pace with the greatness of the task. In other words, our highest ideal must be the acquisition and diffusion of knowledge. Only then can we create those permanent conditions in which practical achievements can also flourish and bring benefits to the country. A narrow, utilitarian spirit is as dangerous as is one which places undue emphasis on nationalism or on the purely formalistic observance of religious doctrines. We must also beware of the provincialism which so often accompanies self-glorification.[20]

Einstein ends by expressing the hope that the university 'will become a factor in Israel in strengthening the spirit of mutual understanding among men, which comes with selfless striving after truth.'

The tremendous influence that Ladislaus Farkas and Ernst David Bergmann had on chemistry in Palestine/Israel when they were still very young can be related in considerable part to their scientific eminence and personalities. But it is also due to the fact that Palestine's/Israel's political leaders considered science a decisive basis for the intellectual and economic development of the country and provided the necessary freedom and support.

NOTES

1. The Habilitation is an academic degree beyond the doctorate which allows the holder to teach at a university.
2. Regarding chemistry, see unpublished data by the author. His study on the impact of the expulsion of Jewish chemists included 544 chemists and biochemists who were university teachers at all German and Austrian universities or researchers at KWIs. Regarding biology, see Deichmann (1996: 15ff).
3. Beyerchen (1977); Fischer (1988: 83–104).
4. Chayut (1994: 237–63).
5. Information given by Saul Patai, Department of Chemistry, the Hebrew University, 22 December 1994. A number of European scientists came to Palestine before 1933. Among them was Andor Fodor, who came to Palestine in 1923 and was appointed Professor of Biochemistry at the Hebrew University of Jerusalem. He was the first Professor of Science in Palestine/Israel.
6. Adalbert Farkas and Ladislaus Farkas (1937: 827–37; 1937: 837–44).
7. See Chayut (1994).
8. Information obtained from Leorah Kroyanker, the daughter of Ladislaus Farkas, Jerusalem, 1 December 1994.
9. Chayut (1994).
10. *Ibid.*
11. Wald (1992).
12. Berlin Document Center, Berlin, Germany, File Wilhelm Schlenk.
13. Correspondence between Bergmann and Schlenk in the Weizmann Archives, Rehovot, Israel.
14. Personal communication, 27 December 1994.
15. Personal information given by Felix Bergmann, 27 December 1994.
16. Personal communication, 17 December 1994.
17. See, for example, Ginsburg (1963: 323–50). The article also contains a list of publications by E.D. Bergmann.
18. Personal communication, 14 and 27 December 1994.
19. Personal communication, 23 November 1994.
20. From the Foreword to *The Hebrew University of Jerusalem, 1925–1950* (1950).

REFERENCES

BEYERCHEN, ALAN (1977), *Scientists under Hitler*. New Haven and London: Yale University Press.

CHAYUT, MICHAEL (1994), 'From Berlin to Jerusalem: Ladislaus Farkas and the Founding of Physical Chemistry in Israel', *Historical Studies in the Physical and Biological Sciences*, 24.

DEICHMANN, UTE (1996), *Biologists under Hitler*. Cambridge: Harvard University Press.

FARKAS, ADALBERT and LADISLAUS FARKAS (1937), 'The Catalytic Interaction of Heavy Hydrogen and Benzene on Platinum', *Faraday Soc.*, 33.

FARKAS, ADALBERT and LADISLAUS FARKAS (1937), 'The Mechanism of Hydrogenation Reactions and the Formation of Stereochemical Isomers', *Faraday Soc.*, 33.

FISCHER, KLAUS (1988), 'Der quantitative Beitrag der nach 1933 emigrieaten Naturwissenschaftler zur deutschsprachigen Physikalischen Forschung', *Berichte zur Wissenschaftsgeschichte*, 11.

'Foreword', *The Hebrew University of Jerusalem 1925–1950*. Silver Jubilee volume, 1950. Jerusalem: Goldberg's Press.

GINSBURG, DAVID (1963), 'Ernst David Bergmann', *Israel Journal of Chemistry*, 1.

WALD, S. (1992), *OECD, An Exploratory Study. Industry, Science, University in Israel*. Jerusalem: National Council for Research and Development.

VINEETA HOON, *Living on the Move: Bhotiyas of the Kumaon Himalaya*. New Delhi: Sage Publications, 1996, 256 pp. Rs 345.

Market economy coupled with the spirit of capitalism has transformed the world into a giant panopticon which leaves people with no other choice but to follow the mainstream market trend. Societies and people who have not been able to do so are variously designated as marginal, indigenous, tribals with the express purpose of bringing them into the mainstream. This involves active intervention of the government and other allied agencies involved in policy matters concerning the development of the area. Development in this context somehow always denotes better use of technology. What has to be kept in mind is that better technology means that which has power to provide better utility which in turn is defined in terms of consumption levels. The fact that all this has led to a deterioration of the environment, depletion of natural resources and even degradation of social values has never made us question our development strategy. But, what is more disturbing is the belligerence with which this strategy is thrust on the so-called marginals without making any effort to understand their needs and their methods to tackle their social and economic needs. Vineeta Hoon's work is important because it forces the reader to see the world from the other end of the panopticon.

Based on the author's fieldwork experiences among the Bhotiyas during 1985–87 which was later updated, the book shows how the Bhotiyas are culturally and technologically very organised people who, despite the widely accepted view, are very efficient users of energy resources, without posing any threat to the environment. Through time-space and energy utilisation analysis the author shows how pastoral nomadism and transhumance are actually appropriate technological mechanisms which are effective in a marginal environment.

Science, Technology & Society 2 : 2 (1997)
SAGE PUBLICATIONS NEW DELHI/THOUSAND OAKS/LONDON

The Bhotiyas of Kumaon live in the highest reaches of Kumaon Himalayas, and eke out a living in these harsh and hostile terrains through agriculture, pastoralism and trade based on transhumance and nomadism. The author's initial experiences in tracing them was quite difficult to say the least as she notes in the beginning. The main objective of the study is to demonstrate how the fundamental needs of the people are fulfilled through their interaction with nature while maintaining the delicate environmental balance and how they cope with outside interferences. She lived with several families in each of the Bhotiya valleys; the main methodological tools used were interviews, participant observation and questionnaires. Interestingly, the main problem in data collection was from the government officials.

The altitude of the region and the consequent climatic and ecological particularities of the zone have given rise to a specialised kind of resource use. The Bhotiya pattern of resource use has components of both transhumance and pastoral nomadism. This has affected the difference of social organisation between the nomads and shepherds. In this area various types of subsistence strategies are evident. These people do not live in isolation and during their stay in the winter villages and during the periods of migration they share resources with other ethnic groups. In recent history the infiltration of outside forces has led to changes in the traditional lifestyle of the Bhotiyas. Since this area lies on the border between India and Tibet, the deployment of armed forces and the closure of the border from the Tibetan side has affected the nomads who traditionally engaged in trade with Tibet. The development programmes of the government is another factor. These programmes are designed for a sedentary population and do not include sufficient provisions for transhumance and nomadic populations.

Hoon uses the time-space model to analyse the Bhotiya lifestyle. Transhumance and nomadism involve the regulation of space and time. Time or changing season defines the criterion for selecting space utilisation. The annual migration cycle, involving the repetitive use of the same space has given them a strong sense of place in terms of resource use. The Bhotiyas categorise space at three levels, according to the author. The first order of space is the perception of total space in terms of their transhuman and nomadic migration from winter to summer spaces. The second order of time

space regions is the winter and summer spaces. These spaces are the pastures or villages and are regarded as essential resources. Since these places have been traditionally utilised over centuries their cultural existence and identity is closely linked with these spaces. The third order of space for shepherds are campsites, pasture and pasture boundaries within which they have to operate. They also have an elaborate classification of activities according to space. The time space routine is, however, subject to various constraints both inherent and exogenous.

In the next section the author discusses the perception of time. Time is not merely an inert flow but is an active dimension of social life. Here, the traditional distinction between Western and non-Western conception becomes somewhat problematic to maintain. At one level the Bhotiya conception of time, similar to many traditional societies, is cyclical and at another level they demonstrate a full understanding of clocks and calendars. This apparent dichotomy results in Western concepts of time being used in dealings with government and other outside agencies and their own conceptions in day-to-day affairs. The time analysis offers a valuable cross-cultural view of life. It also shows how those people have been able to reconcile the two conceptions of time in their time budgeting which guides their various activities. However, the perception of time as cyclical is changing. The penetration by the cash economy is generally leading to widespread changes: reciprocal labour is now equated in terms of hourly or daily wage. Consequently, there is intergenerational disparity in values and lifestyle.

The analysis of the energy basis of the Bhotiya economy shows how despite the common perception of policy makers that transhuman practice and pastoralism are less efficient ways of energy utilisation, these methods are effectively used by the Bhotiyas to conserve the energy quality or available work. Through an innovative use of the thermodynamic laws within the systems boundaries, the author shows how at all the three subsystem levels, that is, production, consumption and storage, the Bhotiyas compare favourably with any other part of the world. The three subsystems are located at different altitudes and are usually fairly separated from one another. The time space cycles that these people use help in the regeneration of these subsystems.

The best part of this work is not just that it is able to portray the cultural and economic activities of the Bhotiyas in a new light but

also that it is able to locate the Bhotiya world-view within which all of it is enmeshed.

Department of Sociology **Amit Prasad**
Delhi School of Economics
Delhi University
Delhi

BIBEK DEBROY, *Beyond the Uruguay Round: The Indian Perspective on GATT*. New Delhi: Sage Publications, 1996, 228 pp. Rs 325 (hb), Rs 195 (pb).

One of the problems in discussions of the GATT/WTO or the whole question of the new globalism which is being set in place in various countries through the implementation of neo-liberal policies, is the apparent 'self-evident' nature, the very 'given-ness' of the 'new world order'. It is in this 'given-ness', reinforced by the collapse of the socialist bloc, that lies its greatest strength. It is almost as if this, the power of capital, is the sole timeless, eternal truth representing the 'natural order of things'. A new version of social Darwinism as it were underlies this renaissance of laissez-faire—the thesis that not only posits the eternal struggle for survival as the law of nature and society alike, but also celebrates its evolutionary logic where the fittest alone can survive. This assumption also underlies the philosophy of history where the fittest—those endowed with the most 'advanced' technology and 'Scientific/Rational' outlook—alone are sanctioned by history to survive and inhabit the earth. Needless to say, some versions of the Marxist philosophy of history do as well certify and celebrate the victor, for the victor can only be a victor if he (always masculine) is ordained by history to be so.

In these 'radical' versions of this eventually fatalist philosophy of history, it is not only customary to claim that capital was the necessary agent of progress and history's 'onward march', but also that the downfall of socialism was *because it tried to skip stages*: the ultimate essentialist logic. Socialism failed because capitalism was bypassed!

This is where it becomes almost impossible to distinguish between a radical of the above and a hard core ideologue of globalisation,

such as Bibek Debroy. If one were to extend the above logic to the field of contemporary North–South relations, what would it amount to? Would it not amount to saying that the 'backward' South, the lands of technological backwardness, ignorance, superstitions, unreason and of underdeveloped markets, needs to now quickly catch up and become modern? Would it not extend to saying that the people whose livelihoods are at stake in this process and who are often protesting, the traditional fisherfolk, for example, are only working to keep the country backward, thinking just of their self-interests?

Yet, it is precisely the given-ness of the logic of capital that makes everything look like a timeless truth. Add to this, certain other assumptions that characterise Debroy's world and you have the perfect Bank/IMF picture of the world. Imagine that the world is a conflict free place, or at any rate, conflicts if any, are accidental and take place between individuals. Or, else they may simply be outcomes of irrational choices. Imagine all this and you have the world of people like Debroy. While explaining why he needed to write the book, he explains that the myths that were propagated during the build up to the signing of the agreement at Marrakesh in 1994, '*Suppressio veri, suggestio falsi* was quite common, especially when one was pandering to the heart and not to the brain'. Sure enough, it does not strike Debroy that the heart and the mind in question did not belong to the same body and they were, therefore, in any case two (or many) different entities to reckon with. Of course, when the traditional fisherfolk lose their livelihood, they are likely to respond with their hearts and not with their minds.

To be fair with Debroy, however, he is talking of the intellectuals who were opposing the GATT agreement rather than the people who were affected. But then what recourse do such intellectuals have when they want to raise issues of justice and equity, which are surely emotive issues and may often stand in direct conflict with the arbitration rendered by that ultimate 'rational allocator'—the market. The mind here belongs to the cold, impersonal, rational calculator that is the market, and the heart to living human beings pushed into raising emotive issues of justice and equity.

Debroy agrees that the GATT accord is a *fait accompli* (p. 14). At least in the sense that, even though Article XV allows the possibility of opting out, there are tremendous costs that may be involved in withdrawing. Yet, he does agree that North–South

relations are characterised by structural (?) inequities, that heavy external borrowings for countries like India led to reverse flows and that efforts to forge a common South position were never strong enough after the non-aligned movement went out of steam (p. 18). But that really does not bother the author. It is just as well. After all, the givens can never be questioned! For in the final analysis, his benign world is inhabited by just two kinds of people—producers (who may further be divided into 'efficient' and 'inefficient') and consumers and in the transactions among them there are trade-offs. If the South did not manage to put together a solid position and negotiate with the North, then they were just bad bargainers.

It is with such a world-view that the author goes about discussing the myths propagated by the opponents of the accord. Consider, for example, his response to the 'loss of sovereignty' argument.

> This is indeed true, but such a loss of sovereignty logically follows the moment one agrees to the disciplines of multilateral trade agreements . . . (T)he loss of sovereignty is not a phenomenon that characterizes India alone. The Americans, the French or the Japanese have lost their sovereignty *just as much as the Indians have* (pp. 27–28).

This is truly remarkable for it displays the perfect naiveté if not outright blindness towards the structural features that characterise the North–South relations in particular and power relations in general. The fact that the big five or seven control everything from the major part of productive investments to global trade, from financing of global institutions to the United Nations, leaves little scope for asserting that the loss of sovereignty suffered by them is in the same degree as that suffered by the countries of the South.

However, the volume under review is what can best be defined as a strategic, rather than a principled theoretical defence of the General Agreement on Tariffs and Trade (GATT) treaty and its successor, the World Trade Organisation (WTO), by someone who is a known believer in the free market doctrine. Bibek Debroy's is a well known name among those who have been trying to follow the changes initiated in the Indian economy generally, and in India's international trade especially since 1991. He has contributed to various financial papers and has also served as a consultant to the Ministry of Finance during this period.

The volume is more in the nature of a handbook on the GATT agreement and examines in detail its various provisions. Since the volume is supposed to provide an Indian perspective on the GATT/ WTO, it deals at length with questions of market access, and sectoral issues like textiles, agriculture, services and intellectual property rights, both in relation to patenting of life-forms as well as pharmaceuticals. It is a handbook that reproduces all the major sections and clauses of the agreement along with explanatory comments in a manner that can be accessible to the lay reader. The need for such a book by an expert on the issue can hardly be overstated.

Centre for the Study of Developing Societies **Aditya Nigam**
29 Rajpur Road
Delhi

ASHISH KOTHARI, NEENA SINGH and SALONI SURI, eds, *People and Protected Areas: Towards Participatory Conservation in India.* New Delhi: Sage Publications, 1996, 276 pp. Rs 350 (hb), Rs 195 (pb).

Since 1978, the creation of National Parks for the preservation of wildlife have led to the displacement of people residing in these areas. The loss of livelihood incurred by these people has often led to the critique that these parks have served the interests of an elitist class. On the other hand, those defending these parks have emphasised the importance of protecting endangered species. The essays in this volume avoid these extreme positions and make an important contribution to the debate. While recognising the need to preserve the animal and plant life of the region, it also emphasises the desirability of restoration of the legitimate rights of the 'indigenous communities'. It promotes the view that the conservation of biodiversity of the wildlife sanctuaries in India can be best met through the joint participatory management by the people and the state. To this end, it is argued that the exclusion of people from these sanctuaries is not legitimate and only precipitates the conflict between the state and the people. In this sense, the majority of the

essays in this volume attempt to apply the principles of joint forest management to the Protected Areas for wild life conservation.

In the introduction to the volume the editors provide a brief sketch of the entire debate and lay down the foundation of the broad argument. In the main, they make a case for the inclusion of people in the management of these areas. They argue that local 'indigenous people' have always lived in the forests and maintained its biodiversity. Since they have the requisite knowledge, skills and will to preserve these resources they should be involved in the management of these areas. However, they are aware that several practical and theoretical questions regarding the nature of these systems remain unanswered. The pertinent questions raised by them concern the following issues:

> What are the institutional forms of joint management of protected areas? Of particular significance amongst these is the need to determine the benefit sharing arrangements between the people and the state and the specific roles that each will play.
> How are the current laws to be changed or what are the alternative provisions if such a system were to be established?
> What are the terms of the partnership between the state and the communities?
> What attitudinal problems are likely to arise when changes are made to the current system of conservation and how can these problems be resolved?

The essays in this book attempt to answer these questions by starting with the assumption that the people living in the vicinity of these sanctuaries have always lived in harmony with their environment which includes the flora and fauna of the area. In this sense, the traditional patterns of settlement and resource use maintained an ecological balance that was disturbed by official policy. All the contributors are unanimous in their acceptance of this precept. However, the differences lie in the extent to which this belief is accepted uncritically. For example, S.C. Dey, Chhatrapati Singh and M.N. Murty emphasise the legal and institutional difficulties in the practical implications of the Joint Management of Protected Areas. In contrast, other essays show instances of joint management and local community involvement in increasing the productivity of forests. G. Raju, Kusum Karnik and Bharat J. Pathak

uncritically accept the option of community management of protected areas.

A striking feature of the book is its focus on the joint management of tree cover rather than wildlife protection. Therefore, a large part of the discussion is on increasing the productivity of NTFP or controlled grazing and access to forests. There is hardly any exploration of the ways in which the conflict between tigers, lions and other animals may threaten the life and property of humans. Though some papers in the volume explicitly talk about the creation of core and buffer zones in the protected areas, questions regarding the management of these zones remain to be elucidated. Till such time, the protestations of the ecological balance between plant, animal and human life remain a romantic dream.

The second major drawback of the book is its failure to examine whether community based forest management is a viable alternative to the centralised control of protected areas. Even though authors like Dey and Singh seem to be uncomfortable with the idea of community based management, they do not express the need for new institutional innovations which would lead to decentralised control of forests. Thus, even though the focus of the book is on institutional and legal innovations in the management of protected areas it fails to examine the issues connected with the relationship of joint management with the rest—the wider political economy. As a result, the book does not answer the crucial question of whether community based forest management is a viable alternative to centralised state management of forests or not. This volume does not prove the viability of community based management, it merely assumes that this form of management is desirable. Herein lies the romanticism of its authors.

Research Fellow **Archana Prasad**
Indian Institute of Public Administration
New Delhi

ORSTOM
L'Institut français de recherche scientifique pour le développement en coopération (French Scientific Research Institute for Development in Cooperation)

Président du Conseil d' Administration	**Philippe Lazar**
Director General	**Jean Nemo**
1996 Budget	**FF 1.1 Billion**

ORSTOM is a state-owned public research agency under the joint authority of the French research and overseas development ministries. For 50 years now, it has been conducting research in intertropical environments—research that has earned international recognition. ORSTOM employs 2500 research personnel including 600 from the countries of the South. Presently, there are 27 research units grouped under five multidisciplinary departments. There are 54 establishments including five centres in France (at Bondy, Brest, Montpellier, Orleans and Paris) and the rest in French overseas departments and territories (at French Guyana, Martinique, Reunion Island, New Caledonia and French Polynesia).

. . . for development
To development actors and Southern partners, ORSTOM offers programs and findings on tropical environments, their resources and the knowledge about societies. It also offers its consultancy and diagnosis capabilities to French, foreign and international organisations, whether governmental or independent.

. . . in cooperation
Through collaboration with other scientific institutes in France, Europe and the developing countries, ORSTOM is actively involved in international research programs in the intertropical zone. The scientific and technical decisions governing this research are taken jointly with our French and foreign partners. ORSTOM also helps to empower and strengthen the scientific capacities of the South, through research training and specific assistance.

The major research topics for the period 1996–2000 are:

- **Conditions for development, forms of development**
- **Dynamics of the major oceanic, aquatic and terrestrial ecosystems**
- **Utilisation of natural resources**
- **Towns and development**
- **Health and development**

Of Interest to STS: Science, Technology and Development Program (STD) is a part of the Society, Urbanisation and Development (SUD) Department which has a core group of 5 full-time researchers. STD has been involved in research relating to sociology of the scientific communities, science indicators, economics of technical change and innovation and international scientific migrations in the developing countries during the last decade.

For further information – contact: 213, rue La Fayette, 75480 Paris cedex 10, France.
Tel: 33 1 48 03 77 77; Fax: 33 1 48 03 08 29; Web:http//WWW.orstom.fr

Book Notes

Gender Working Group, *Missing Links—Gender Equity in Science and Technology for Development*. Ottawa: United Nations Commission on Science and Technology for Development, IDRC, 1995, 371 pp. Price not mentioned.

Women, especially women in the developing world, occupy few positions of power within the realm of science and technology. Yet, women's experience of science and technology frequently differs from that of men—and often in less positive ways. Gender differences in this field have real consequences for the quality of women's lives and for sustainable human development. They reflect issues of justice, equal access to knowledge, and equal opportunities to shape that knowledge.

Why do boys surge ahead in primary school science education while girls fall behind, a gender difference that continues at higher education levels? This question is one among many posed and examined in *Missing Links*. Gender specialists from around the world examine topics ranging from indigenous knowledge, health and information to education, literacy and small business. They provide valuable insight into the failure of science and technology to answer women's needs and the lack of women's power in this critical domain. Their analysis along with the recommendations of the Gender Working Group of the UN Commission on Science and Technology for Development, shows that the missing link will be forged only through greater gender equity in science and technology for development.

Science, Technology & Society 2 : 2 (1997)
SAGE PUBLICATIONS NEW DELHI/THOUSAND OAKS/LONDON

NAGESH KUMAR and N.S. SIDDHARTHAN, *Technology, Market Structure and Internationalization—Issues and Policies for Developing Countries*. London: Routledge and The United Nations University, 1997, 175 pp. Price not mentioned.

The technological capacity of nations is increasingly seen as a crucial influence on their international competitiveness and growth prospects. Yet, technology has not received adequate attention in the development policy of many developing countries.

This volume discusses the domestic and external factors that impinge upon the process of technological capability building in developing countries and draws policy implications. Specifically, it examines the interaction between technological effort in developing countries and factors such as:

Trends of globalisation, emergence of new technologies and stronger patent regimes.
Market structure, firm size and performance.
Affiliation with multinational enterprises and technology imports.
International trade.

Crucially, the authors redress the balance in the current literature by providing a developing country perspective on the economic analysis of technology and considerations affecting policies. Providing fresh insights, this volume will be of interest to researchers in development economics as well as to those involved in policy formulation in developing countries.

SHANTI GEORGE, *Third World Professionals and Development Education in Europe—Personal Narratives, Global Conversations*. New Delhi: Sage Publications, 1997, 328 pp. Rs 395.

Every year, thousands of students and professionals from the Third World travel to the West to study the why and how of development. However, there have been few attempts to assess

whether the First World is an appropriate place to study Third World problems or to find out what happens to these students once they complete their studies. The Institute of Development Studies, The Hague, commissioned a study to explore a cross-section of its students in Asia, Africa and Latin America. The result is a broad study of international development education as lived, experienced and reflected upon. Based on extensive interviews, the author concludes that development education involves not merely formal academic study, but also a multi-layered experience which encompasses learning from daily life and from society at large. This process requires individuals to overcome major cultural and political barriers in order to appreciate other realities. The book provides insights into development issues that its protagonists gained from living for a period in a First World country, and from 'global conversations' that compared and connected the experience of classmates from across the world. This volume will be of interest to students and scholars in development studies in the social and human sciences.

PRANAV N. DESAI, *Science, Technology and International Cooperation*. New Delhi: Har-Anand, 1997, 192 pp. Rs 350.

The study provides an analysis of the functioning of the UN system for the last 50 years. In the context of socio-economic and resource situation of the developing countries, an analysis of resource allocation in different sectors of the major specialised agencies, such as UNESCO and FAO, has been undertaken with a focus on their priorities and programmes coherence. The implications of this for the development process have been discussed in the light of new developments such as UNCED, and GATT Agreement.

This book will be of interest to students of international affairs, science policy studies and development economics, administrators and decision makers.

JAMES H. COLLIER with DAVID M. TOOMEY, eds, *Scientific and Technical Communication, Theory, Practice and Policy*. Thousand Oaks: Sage Publications, 1997, 415 pp. Price not mentioned.

Scientific and Technical Communication is a major textbook that presents a new focus area in communication studies. It integrates multidisciplinary perspectives on the relations among rhetoric, science, technology and public policy making to the process and product of technical communication. The volume is inspired by science and technology studies (STS), a field emerging from the history, sociology and philosophy of science and technology, which also has roots in economics, political theory and rhetoric.

Reformulating the issues raised by STS within the context of technical communication, the volume is divided into two parts. Part one provides a summary, critique, and alternative to recent theoretical perspectives developed in the rhetoric of science and the sociology of scientific knowledge. The second part applies these critical alternatives to the traditional practices of scientific and technical communication and shows how these new practices can be applied to communication that is vital in the formulation of national and local S&T policy.

This introductory textbook will offer students and professionals in the areas of scientific and technical communication, rhetoric and media studies broad-based and applicable knowledge.

MARIA INES BASTOS and CHARLES COOPER, eds, *Politics of Technology in Latin America*. London and New York: Routledge, 1995, 258 pp. Price not mentioned.

This edited collection examines the political conditions affecting science and technology capability building in Latin America.

In a comparative discussion centring on Argentina, Brazil and Mexico, the contributions examine the capacity of Latin American governments for building national systems which support innovation in industry. They examine how state capacities for the design and

implementation of science and technology policies have evolved, and how political factors, such as military rule and authoritarianism, have shaped such capabilities and the pattern of development. The influence of international factors on policy changes is also examined.

In looking ahead to the future economic and social development in Latin America, the contributors find that selective but active state intervention in favour of technological change will be needed to ensure the implementation of realistic technology policies.

National Institute of Science, Technology and Development Studies

Dr. K.S. Krishnan Road
New Delhi 110 012 (INDIA)

Phones: 5714064, 5743227; **Telex:** 031–77182;
Telefax: 011–5754640; **E-mail:** nistads @ sirnetd. ernet. in

NISTADS is a research institute of the ***Council of Scientific and Industrial Research***. It specialises in analysing issues of science and technology and their interface with society within a broad spectrum of economic, social, historical and cultural perspectives—variously termed as science policy studies, science and technology studies, or science of science.

NISTADS provides consultancy services and undertakes sponsored studies in the above areas for national agencies, central and state government departments, industries, etc.; and international organisations like World Bank, UNESCO, WAITRO, IDRC and American Institute of Physics.

MAJOR RESEARCH AREAS

The research projects undertaken at NISTADS are essentially multidisciplinary and carried out by teams drawn from the Institute's scientific staff (about 55) having qualifications and experience in diverse disciplines of natural sciences, engineering, mathematics, statistics, and disciplines of social sciences, management, etc. Research programmes, and likewise the Institute's expertise, are built around the following major themes: **(a) Technology assessment and forecasting; (b) Resource planning and utilisation for regional development; (c) Application of S&T in rural areas; (d) Sociology of science; (e) Women and science and technology; (f) History and philosophy of science; (g) Science and technology indicators; (h) Research and training on R&D management; (i) Information systems and databases for S&T; and (j) Science communication.**

PUBLICATIONS

NISTADS' research outputs are brought out in the form of ***Books, published research papers, Reports, Proceedings, Working Papers, etc.*** Cumulative ***'List of Publications (1979–94)', Annual and subject lists*** can be supplied on request.

Current Literature on Science of Science: The monthly journal includes abstracts of papers (from about 250 international journals), digests of reports, book reviews and statistics in areas related to science policy studies. ***Annual subscription***: Rs. 150 (in India); £33 or $62 in developing countries; and £48 or **$90 elsewhere.**

Abstracts

Migration of Scientists and the Building of a Laboratory in Argentina

Pablo Kreimer

French

A partir du cas d'un laboratoire de biologie moléculaire à Buenos Aires, le but de cet article est de montrer comment différents types de migrations scientifiques ont contribué à la genèse de ce laboratoire. La présentation de l'étude de cas est précédée d'une brève introduction historique sur la communauté scientifique argentine, son contexte politico-institutionnel, et les différents périodes de migrations successives ayant affecté le pays. Une typologic proposant trois cas "idéaux" principaux est également proposée pour mieux comprendre les logiques migratoires des scientifiques et leurs conséquences.

Spanish

El propósito de este articulo es el de mostrar cómo, en el caso particular de un laboratorio de biología molecular de Buenos Aires, se articularon diferentes tipos de migraciones científicas, de modo de dar origen a la *constitución misma* de dicho laboratorio. Para ello, realizamos una breve descripción del backround histórico de la comunidad científica en argentina, de su contexto politico-institucional, y de los sucesivos períodes migratorios que se han ido produciendo en el pais. Antes de presentar el estudio de caso, proponemos tres "tipos ideales" que pueden ser de utilidad para la comprensión de los distintos tipos de migraciones emprendidas por los científicos.

Science, Technology & Society 2 : 2 (1997)
SAGE PUBLICATIONS NEW DELHI/THOUSAND OAKS/LONDON

The Uruguayan Basic Scientists' Migrations and Their Academic Articulation around the PEDECIBA

Adriana Barreiro and Léa Velho

French

Le programme intitulé PEDECIBA (Programme pour le Développement des Sciences de Base) a vu le jour en Uruguay vers la fin des années 1980 afin de faciliter la "ré-articulation" de la communauté académique locale des chercheurs en sciences de base. L'ensemble du système national de recherche a été affecté par treize années de dictature militaire. Un des objectifs principaux de la communauté des sciences de base, au cours de la période de re-démocratisation, consistait à créer les conditions de la consolidation d'une infrastructure permanente pour le développement des sciences de base: biologie, chimic, informatique et sciences de l'information, mathématiques et physiques.

Un des moyens pour atteindre ce but consiste à rapatrier un nombre important de scientifiques uruguayens ayant quitté le pays au cours des années 1970. Ce sont les chercheurs expatriés qui ont émis le souhait de retourner, et de retrouver leurs pairs restés en Uruguay afin de développer un effort collectif et autogéré.

Des références sont également faites dans cet article aux vagues de migrations qui se sont développées à l'intérieur de la communauté scientifique latino-américaine ainsi qu'à celles liées à l'exode et au retour des scientifiques uruguayens en sciences de base. D'autres données présentées permettent de mieux comprendre l'importance jouée par PEDECIBA dans la ré-articulation du système de génération de connaissance et la reconstruction l'environnement des sciences de base.

Spanish

El asi Hamado 'Programa de Desarrollo de lals Ciencias Básicas-PEDECIBA' se constituyó en el Uruguay, hacia fines de la década del ochenta, a los efectos de posibilitar la rearticulación de la comunidad académica local de cientistas básicos—luego de que el sistema de ciencia y tecnología fuera severamente castigado por la dictadura militar que se instauró en el país durante un lapso de trece años. Uno de los principales cometidos que la comunidad de cientistas básicos uruguaya se propuso alcanzar, en el transcurso del proceso de redemocratizatión, fue crear les condiciones que llevaran a la consolidación de una infraestructura permanente para el desarrollo de las siguientes ciencias básicas: Biología, Fïsica, Informática, Matemática y Química.

Entre los aspectos que revestían mayor relevancia para el logro de dicho objetivo, uno de los considerados esenciales era efectivizar el retorno, mediante la repatriación, de un gran número de cientificos uruguayos que habían dejado el país durante la década del setenta. A su vez, es importante subrayar que fueron los propios cientificos que en ese entonces se encontraban en el exterior quienes expresoron su voluntad de retornar y su deseo de unirse a los colegas que habían permanecido en el Uruguay para así llevar adelante un esfuerzo colectivo y auto-gestionario.

En este trabajo referimos a las ondas migratorias registradas al interior de la comunidad científica latinoamericana y, en particular, a aquellas relacionadas con el éxodo y retorn dc los cientistas básicos uruguagyos-explorando las razones y motivaciones subyacentes que les indujeron a regresar al país. Asimismo, presentamos diversos datos que nos permiten comprender la significancia que tuvo el PEDECIBA tanto en términos de la reconstrucción del sistema de generación de conocimientos como de la reconstruccion de un espacio fecundo para el desarrollo de las ciencias básicas.

Turning Brain Drain into Brain Gain: The Colombian Experience of the Diaspora Option

Jean-Baptiste Meyer, Jorge Charum, Dora Bernal, Jacques Gaillard, José Granés, John Leon, Alvaro Montenegro, Alvaro Morales, Carlos Murcia, Nora Narvaez-Berthelemot, Luz Stella Parrado and Bernard Schlemmer

French

Un nombre croissant de pays en développement considèrent leurs ressortissants hautement qualifiés à l'étranger comme une ressource potentielle pour le développement national. Des politiques rénovées se développement par conséquent pour récupérer ces talents expatriés. A côté de l'option rapat riement-retour-généralement mise en oeuvre dans ces politiques avec un succès variable, une seconde a récemment émergé: l'option diaspora. Elle consiste en une mobilisation à distance des intellectuels localisés à l'étranger et en leur connexion à des programmes scientifiques, technologiques et intellectuels dans le pays d'origine.

Au début des années 1990s, la Colombie a commencé à mettre en application cette option, de façon systématique et constante, à travers la création du 'réseau Caldas, réseau Colombien des scientifiques et ingénieurs à l'étranger. Cette expérience a été étudiée pendant les 4 dernières années par une équipe de recherche Franco-Colombienne. L'article déploie des résultats de cette étude. Il contextualise en premier lieu l'option diaspora et l'expérience Colombienne en la mettant en perspective historique parallèlement à d'autres politiques conçues pour traiter la question des migrations de personnes qualifiées. Puis il décrit de qu'est la diaspora S&T en terme d'acteurs et de dynamiques. Son fonctionnement à travers le réseau Caldas est alors présenté par l'analyse de trois aspects importants: la liste électronique sur INTERNET, les associations locales (noeuds du réseau) et quelques projects conjoints entre des membres de la diaspora et ceux de la communauté C olombienne. Une dernière partie tire la signification de cette expérience, ses succès et ses limites et suggère des indicateurs et des méthodes qui pourraient permettre de la développer ailleurs.

Spanish

Un numero creciente de paises en desarrollo esta considerando sus ciudadanos altamente calificados en el exterior como un recurso potencial para el desarrollo nacional. Por consiguiente, renovadas politicas se estan desarrollando con el objectivo de recuperar estos talentos expatriados. Al lado de la opción repatriacion-retorno-generalmente implementada con un exito variable en estas politicas, otra ha recién emergido: la opción diaspora. Consiste en la movilización a distancia de los intelectuales en el exterior y en su conexión con programas científicos, tecnologicos y culturales en el pais de origen.

Al principio de la decada de los noventa, Colombia empezo a aplicar sistematicamente y consistentemente esta opción a través de la creación de la "red Caldas, red Colombiana de los científicos e ingenieros en el exterior". Esta experiencia ha sido estudiado durante los ultimos 4 años por un equipo de investigación Colombo-Francés. El articulo despliega resultados de este estudio. Contextualiza primero la opción díaspora y la experiencia Colombiana en una perspectiva historica, paralelamente a otras politicas diseñadas para tratar la problematica de las migraciones de gente calificada. Describe en seguida lo que es la diaspora CyT en cuanto a actores y dinamicas. Su funccionamiento a través de la red Caldas esta presentado por el analisis de tres aspectos importantes: la lista electronica a través de INTERNET, las asociaciones locales (nodos de la red) y algunos proyectos conjuntos entre miembros de la díaspora y otros de la comunidad en Colombia. Una ultima parte seca la relevancia de esta experiencia, sus logros y sus limites y sugiere unos indicadores y metodos que podrian ayudar a desarrollarla en cualquier lugar.

From Brain Drain to Reverse Brain Drain: Three Decades of Korean Experience

Hahzoong Song

French

Cet article examine trois décennies de l'expérience coréenne de la fuite des cerveaux et les politiques gouvernementales traitant de ce phénomène. Les résultats confirment le rôle majeur des facteurs économiques dans la décision de rentrer ou de rester (aux États-Unis) pour les scientifiques et ingénieurs coréens (SIC) ayant obtenu leur doctoral aux États-Unis. Cependant, dès que le différentiel des conditions économiques se resserre, les facteurs psychologiques et émotionnels deviennent de plus en plus importants. Cette étude suggère en particulier que les valeurs liécs au Confucianisme constituent un élément sous-jacent aux décisions prises par les SIC expatriés. Ainsi, cette étude souligne l'importance d'inclure une analyse culturelle dans l'étude du phénomène du brain drain.

Le gouvernement coréen s'est efforcé de rapatrier autant de scientifiques et d'ingénieurs que possible au cours des années 1960 to 1970. Toutefois, l'efficacité des mesures prises au cours de cette période s'est révlee très limitée. Au fur et à

mesure que l'économie coréenne continuait de s'améliorer, de nombreux scientifiques et ingénieurs ayant étudié à l'étranger ont souhaité retourner en Corée à partir des années 1980. Le gouvernement coréen a alors adopté une politique visant à utiliser l'expertise des Coréens à l'étranger, tout en laissent à ces derniers le choix de leur résidence.

Spanish

Este artículo examina tres décadas de la experiencia coreana en fuga de talentos, que puede ser calificada como 'de la fuga de talentos a la fuga de talentos reversa', así como de las políticas gubernamentales para manejar este problema.

Resultados de un estudio confirman el papel principal de los factores económicos en decisions de retorno o permanencia de los científicos e ingenieros coreanos (CICs) que obtuvieron PhDs en los Estados Unidos. No obstante, cuando se reduce la differencia en las condiciones económicas entre las alternativas, los factores psicológicos y emocionales destacan como siendo importantes. En particular, este estudio sugiere que algunos valores del confucionismo funcionan como elemento subyacente de las decisiones de los CICs. En consecuencia, este estudio indica la importancia de incluir un análisis cultural en el estudio de las cuestiones de la fuga de talentos.

El gobierno coreano trató de repatriar a tantos científicos e ingenieros como fuera posible en los años de 1960 a 1970. A medida que la economía coreana continuó mejorando, muchos de los científicos e ingenieros educados en el extranjero quisieron regresar a Corea en los años de 1980. Desde entonces, el gobierno coreano adoptó una política de utilizar la experticia necesaria de los coreanos en el exterior, mientras que los ayudaba a elegir sur residencia por mismos.

Phasing Scientific Migration in the Context of Brain Gain and Brain Drain in India

V.V. Krishna and Binod Khadria

French

L'analyse de l'expérience indienne des migrations de person es hautement qualifiées au cours des cinq dernières décennies fait ressortir trois périodes distinctes présentées dans cette article: 1940 à 1960, 1970 à 1980, et 1990 jusqu'à aujourd'hui. Au cours de la période qui a suivi l'indépendance jusqu'en 1960, l'Inde n'a pas été véritablement affectée par la fuite des cerveaux. Les politiques officielles d'expansion du secteur universitaire et de renforcement du système national de recherche ont créé une demande qui a conduit à la mise en place d'une politique de formation des ressources humaines à tous les niveaux et a permis de faire revenir en Inde des scientifiques indiens établis à l'étranger a cours de cette première période. A partir de 1970, l'Inde commence à être confrontée au problème de l'exode des cerveaux. Plusieurs facteurs aussi bien d'ordre économiques que sociologiques, notamment la

surproduction de personnels hautement qualifiés sont responsables de cette évolution. Bien que l'on puisse discerner plusieurs tendances au cours des années 1980 et 1990, l'Inde continue à perdre une partie importante de ses ressources humaines scientifiques et techniques, et ceci en dépit des opportunités nouvelles créées dans le halo du phénomène de globalisation. Tout gain visible à court terme sous forme de retour ou d'investissement est en grande partie neutralisé en raison du manque de politiques appropriées appliquées sur un long terme. Cet article plaide pour la mise en place immédiate de programmes au niveau national qui tiendraient compte du problème de la fuite de corveaux.

Spanish

Cinco décadas de la experiencia de la India en la migración de personal altamente calificado, tal como se presentan en este trabajo, caen ampliamente en tres períodes distintos pero que se superponen: de los años de 194) a la década de 1960, de 1970 a los años de la década de 1980 y de los años de 1990 en adelante. En el periíodo post-independiente hasta la década del 60, la India realmente no experimentó la tendencia de la fuga de talentos. El patrón de demanda creado en este período temprano por las poliíticas oficiales de expansión del sector universitario y fortalecimiento de la infraestructura de ciencia y tecnologíía condujo a poliíticas de recursos humanos para el adiestramiento y la educación superior e incluso atrajo del extranjero a algunos cientiífícos indios establecidos. Comenzando con los años de 1970, la India empezó a experimentar el problema de la fuga de talentos y various factores económicos y sociológicos fueron responsables de ello, incluyendo un exceso de provisión de personal altamente calificado y la falta de demanda de ese personal. Aunque diferentes tendencias son discernibles durante los 80s y 90s, el caso general presentado aquií muestra que la India contınúa perdiendo sus recursos humanos cientiíficos y técnicos, a pesar de las nuevas oportunidades creadas por la tendencia actual de la globalización. Cualquier logro de corto plazo visible en la forme de ganancia de talentos y que detiene el proceso de fuga probablemente será neutralizada por la falta de poliíticas apropiadas de largo plazo. El artiículo urge intervenciones ımmedıatas de poliítica para encarar el problema de la fuga de talentos de la India.

BACK ISSUES

Science, Technology & Society

Volume 1 ■ Number 1 ■ January–June 1996

Editorial/ The Social Construction of Leprosy in Columbia, 1884-1939 DIANA OBREGÓN/ Agronomía Afranceada: The French Contribution to Mexican Agronomy, 1880–1940 JOSEPH COTTER and MICHAEL A. OSBORNE/ Small Player Advantage in a New Game: Capturing Opportunity as Developing Countries from the New Globalism of Technology STEPHEN C. HILL/ A Science Policy to Cope with the Inevitable? JEAN-JACQUES SALOMON/ Science and Technology in a Democratic South Africa—New Challenges and New Policy Directions DAVID E. KAPLAN

Volume 1 ■ Number 2 ■ July–December 1996

Special Issue: ***Changing Trends in Science Policy***

Guest Editors: MERLE JACOB ■ AANT ELZINGA

Editorial/ Introduction: Changing Trends in Science Policy MERLE JACOB and AANT ELZINGA/ Science and Technology Policies in Developing Countries: A Political Analysis of Latin American Practice and Prospects MARIA-INÊS BASTOS/ Formulating an S&T Policy for Sri Lanka in the Context of Globalisation TISSA VITARANA/ Science and Politics in Latin America: The Old and the New Context in Argentina PABLO KREIMER/ The Politics of Science Policy in the Periphery of Europe: The Case of Portugal MARIA EDUARDA GONÇALVES/ The Transformation of the Research System in the Czech Republic ST. PROVAZNÍK, A. FILÁCEK, E. KRÍZOVÁ-FRÝDOVÁ, J. LOUDIN and P. MACHLEIDT/ Sociocultural Dimensions of Technological Learning HEBE VESSURI and MARIA VICTORIA CANINO

SAGE PUBLICATIONS
New Delhi ■ Thousand Oaks ■ London

NOTES FOR CONTRIBUTORS

1. Authors should provide four copies of their contributions. Articles must be typed in double space, on one side of the page only, with generous margins on all four sides. Contributors must provide their affiliations and complete mailing addresses on the article. All contributions should be sent to the Editors, *STS Journal*, C/o NISTADS, Dr. K.S. Krishnan Road, New Delhi 110 012, India. Books for review should be sent to the Book Review Editors directly—S. Irfan Habib, NISTADS, Dr. K.S. Krishnan Road, New Delhi 110 012, India; or P. Petitjean, REHSEIS, CNRS, 27, rue Damesme, Paris 75013, France.
2. Notes should be numbered serially and presented (in double space) at the end of the paper, not at the foot of each page. An acknowledgement should be treated as an unnumbered footnote. Notes should contain more than a mere reference.
3. References should be typed in double space at the end of the article after notes. In the text the author-date system should be followed—for example, '(S. Irfan Habib 1987: 112)' or 'Kumar (1994: 21)'. Citations should be first alphabetical and then chronological for each author. Page numbers are essential when quoting from a source. The details are as follows.

   (a) Petitjean, P., C. Jami and A.M. Moulin, eds (1992), *Science and Empires: Historical Studies about Scientific Development and European Expansion*. The Netherlands: Kluwer Academic Publishers.
   (b) Sharma, Arvind (1972), 'British Raj and Indian Economic Development: The 19th Century as a Case of Controversy and Methodology', *Indian Economic Journal*, 19 (3), pp. 443–59.
   (c) Krishna, V.V. (1996), 'A Portrait of Scientific Community in India: Historical Growth and Contemporary Problems', in J. Gaillard, V.V. Krishna and R. Waast, eds, *Scientific Communities in the Developing World*. New Delhi: Sage.

4. British spellings to be used throughout.
5. Universal 's' in '-ise', '-isation' words.
6. Single quotes throughout. Use double quotes only within single quotes. Quotes of more than 45 words to be separated from the text with a line space.
7. Use '1980s' and 'nineteenth century'. Dates should be cited as '22 November 1960'.
8. Spell out numbers from one to ninety-nine—100 and above to remain in figures. For exact measurements like distances and percentages use figures.
9. Use of italics to be minimised but used consistently. So also in the case of diacriticals.
10. Tables and figures to be indicated by number '(see Table 8)', not location '(see Table below)'.
11. Include a final stop in abbreviations ('p.', 'vol.') but not in contractions ('Mr', 'Dr'). No stops to be used between capitals ('USA' not 'U.S.A.').
12. If punctuations are part of quoted matter they should be placed within the closing quote: 'They are beating the child!' However, 'They spoke of "the green" '.

OF RELATED INTEREST

TECHNOLOGY AND THE RAJ

Western Technology and Technical Transfers to India, 1700–1947

♦

Editors

ROY MACLEOD ♦ DEEPAK KUMAR

The case studies in the book have convincingly dispelled any residual belief in the 'value neutrality' of technology. The authors focus on key relationships in the history of Western technology in British India...

— Financial Express

To understand and interpret the prevarications of society, culture and technology, an integrated study of history in all its manifestations is warranted...[this] compilation provides a key role to that end.

— Business Line

This book is fascinating because it seeks to translate the history of technology into the material culture of economic relations...in the transition to modern India. [The book] provides a rich treasury of experience, which none of us can afford to forget, or neglect.

— Deccan Herald

[This book contains] careful, in-depth studies of various aspects of the history of technology in British India.... Scholars and students of history, economic development and the history of science and technology will find this a stimulating addition to the subject.

— The Hindu

220x140 mm/348 pp./hb/1995

Sage Publications
New Delhi / Thousand Oaks / London