

THE MIGRATION OF SCIENTISTS AND ENGINEERS TO AND FROM THE UK

A report on a study by the Science and Engineering Policy Studies Unit
of the Royal Society and the Fellowship of Engineering

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Foreword

For some years there has been an increasing concern that among factors adversely affecting science, technology and engineering in the UK is a growing loss of talent abroad - the so-called 'brain drain'. In order to secure both a sounder basis of data on this subject and an in-depth review of the perceptions of the scientific community, the Science and Engineering Policy Studies Unit of the Royal Society and the Fellowship of Engineering has undertaken a study of the inward and outward flows of scientists and engineers to and from the UK. Necessarily, to achieve depth, the scope of the study had to be limited, and it was restricted to those working in Biochemistry, Chemistry, Earth Sciences, Electronic Engineering and Physics, who left or came to the UK between 1975 and 1985.

This report describes the results of that study. It is based largely on a questionnaire survey of university departments, research groups and industrial, governmental and research council establishments. The report has been endorsed by the Councils of the Royal Society and the Fellowship of Engineering.

The numerical scale of migrants identified here would not generally be considered large in comparison with the overall size of the groups that migrants left or joined. But, as the survey revealed, the significance of migration, inward or outward, lies not only in counting heads but also in the intellectual capacity of the migrants, their collective and individual experience and the period of time they spend in any one institute or country. The majority of those leaving the UK did so for long-term posts abroad; most foreign scientists and engineers coming to Britain from overseas came for relatively short periods. The assessment of losses and gains in terms of the health of UK research must inevitably combine factual analysis with a more subjective judgement of the impact of individual movements.

Thus, although almost as many 'experienced' scientists and engineers entered the UK as left, our data provide no grounds for complacency. We found that, over the ten year period of our study, many 'recent PhDs' left the UK without having taken up employment in this country. A greater proportion of these young people emigrate permanently, or for long periods, than was the case 25 years ago. The number of Fellows of the Royal Society resident in the USA at the time of their election has risen progressively over the past two decades, illustrating that an increasing proportion of our most talented scientists have been among those who have left the UK.

The report is published in the hope that it will contribute to a sounder framework against which to judge the capacity of the research system in the UK to continue to meet the needs of the nation in its wealth-creating activities.

Sir David Smith, Sec.R.S.
Chairman, SEPSU Steering Group

May 1987

Summary

This report describes a study of the migration of scientists and engineers to and from the UK which was carried out by the Science and Engineering Policy Studies Unit of the Royal Society and the Fellowship of Engineering. It was initiated in the summer of 1985, when there was renewed concern that increasing numbers of experienced scientists and engineers were leaving the UK to work abroad. The study aimed to collect quantitative evidence about such emigration and the extent of any similar flow of foreign scientists and engineers to the UK. It became increasingly evident during the study that a proper assessment of the impact of migration depended as much on the quality of migrants as on their number, although quality is clearly more difficult to measure.

Section I describes the background to the study and its design. Five broad fields of science and engineering were selected - Biochemistry, Chemistry, Earth Sciences, Electronic Engineering and Physics. These were chosen, not because they were thought to be particularly affected by migration, but rather because they covered a broad spectrum of scientists and engineers, both in newer disciplines and in well established ones. The emphasis was on science subjects, so the results may not be typical of all engineering disciplines. Moreover, it cannot be assumed that the results are applicable to scientific disciplines outside the study.

The main method of collecting data was a questionnaire survey of all heads of university departments in the selected disciplines and of leaders of some university research groups. Information was requested on members of departments (most engaged in normal academic teaching and research activities), and on members of research groups (most engaged primarily in research), who had left or entered the UK during the period 1975-85. The questionnaires asked for details about the migration of young research workers (postgraduate and postdoctoral) as well as about more senior staff. Similar questionnaires were sent to appropriate industrial, Government and Research Council establishments. Respondents were asked to give the names of migrants to eliminate double-counting and to increase accuracy by ensuring that the data referred to specific individuals, rather than to vague, and possibly misleading, impressions of the numbers involved.

Almost 750 questionnaires were sent out and 568 (77%) were completed and returned; the response from industry, Government research establishments and Research Council institutes was not as good as that from universities (83%). 82 industrial, Government and Research Council establishments, 301 university research groups and 185 university departments responded (not including heads of departments of Earth Science, who were included in a separate survey by the Institution of Geologists).

Section II presents the main results of the survey. The completed questionnaires named 617 'experienced' British scientists and engineers, and a further 314 British postgraduates, almost all 'recent PhDs', who had left the UK during the years 1975-85. Respondents also named 685 scientists and engineers who had entered the UK from abroad; of these, 183 were British who returned to the UK from overseas, and of the 502 foreigners, about 130 were 'recent PhDs' or equivalent, including 15 who stayed to work in this country after completing postgraduate studies here. Information was not sought on foreign students who came to this country to study for higher degrees and left immediately on completing their courses.

Both emigration from the UK, and to a lesser extent immigration to the UK, increased slightly during the period from 1975 to 1985. However, the number of scientists and engineers who migrated each year would not generally be considered large in comparison with the size of the groups or establishments they left or joined. For postdoctoral research assistants and more senior members of university research groups, the emigration rate averaged about 2% annually; it was much lower for staff (generally more senior) from university departments and from industry, Government and Research Council establishments (0.5% annually, or less). The emigration rate for British 'recent PhDs' from university research groups, although difficult to measure with accuracy, appears to be rather higher. The immigration rate to university research groups (excluding those coming to study for higher degrees) was 2.9% per year, while rates to university departments and the non-university sectors were all less than 0.4% per year. In assessing impact, direct comparisons of emigration and immigration rates would be misleading; other factors such as staff experience and seniority are important, and these are in turn affected by the size of a research group and other inflows and outflows.

Almost three-quarters of those emigrating from universities in the UK previously held short-term posts or equivalent, most in research groups; about one quarter left long-term posts (more than three years), the majority in university departments. Most of those emigrating from industry or from Government and Research Council establishments left long-term posts. It appears that those in long-term posts were least likely to emigrate, those in short-term posts more likely, while those not yet in employment were most likely to do so.

Most emigrants were said to have taken up long-term posts abroad. Half the 'recent PhDs' named as having left university research groups, and an even higher proportion of other university emigrants, were said to be in such long-term posts. This contrasts with twenty-five years ago, when a greater proportion of 'recent PhDs' who went abroad subsequently returned to the UK. The majority of emigrants from British universities went to universities and similar organizations abroad, while those from industrial, Government and Research Council establishments were more likely to be employed by industrial or commercial establishments overseas.

In contrast to emigrants, the great majority of foreign immigrant scientists and engineers came to work in the UK for periods of less than three years and then returned home or moved to other countries. Those foreign immigrants who took up long-term posts in the UK were only a quarter of the number of British emigrants (excluding 'recent PhDs') who went to such posts overseas. However, most British scientists and engineers who returned to the UK took up long-term posts. Few foreign postgraduates remained to work in the UK after obtaining higher degrees.

Most of the immigrants who came to work in universities and Government and Research Council establishments had left university posts overseas or had come directly from studying abroad.

Almost 90% of all those who left the UK during 1975-85 went to North America, Western Europe or Australia, with the majority (about 60%) going to North America, as in previous years. The largest group of immigrants were British returning from abroad. The nationalities of foreign immigrants were fairly evenly distributed: the largest group was from Western Europe.

The reasons most commonly given for emigration were career opportunities abroad and career limitations in the UK, followed by higher rates of pay (particularly by respondents from university departments) and better research facilities abroad. Foreign immigrants to the UK were thought to be attracted largely by a desire to widen their experience. British scientists and engineers returning to the UK were generally said to have done so for personal and family reasons.

There were some differences between disciplines in rates of emigration and immigration. However, where comparisons were possible of other characteristics of migration, we did not find major variations between disciplines.

In addition to these factual conclusions from the questionnaire data, an attempt was made to assess the quality of migrants and the effects of migration on UK research.

Assessing quality is difficult; inevitably, we had to rely on respondents' own assessment of the ability of those leaving or joining their groups or establishments. Generally, both emigrants and immigrants were considered to include many talented scientists and engineers, but because foreigners working for only short periods in the UK could not fully replace those British scientists and engineers who had left for permanent posts abroad, the resulting net loss of talent was regarded as having an adverse effect on British research, particularly in universities. We found evidence to support this view; this included the high level of qualifications of most emigrants, the small, but significant, number who had previously held senior posts in comparison with the much smaller number of foreign scientists and engineers who took up such posts, and the increasing number of Royal Society Fellows, born in the UK, who choose to live and work outside the UK.

Section III reports respondents' views on migration and their suggestions for ways to alleviate the problems caused by emigration from the UK. University respondents stressed how difficult it was to replace both junior and senior researchers who emigrated, and the majority were also concerned about the increasing movement of talented graduates and new PhDs out of science to more financially rewarding employment in this country. Attracting either British or foreign students for postgraduate or postdoctoral research was becoming more difficult. Industrial respondents were less concerned about the effects of emigration, although these may be different in disciplines not covered by this study.

There was widespread concern among respondents from universities and Government and Research Council establishments that emigration would increase in future as other industrialized countries offered greater incentives and opportunities to scientists and engineers, in contrast to the current climate of decreased 'real' spending on civil research in the UK. Among suggestions made to counter what was seen as a significant loss of talented researchers abroad were increased long-term funding for research, a better career structure for university research staff, the revival of schemes to attract past emigrants back to the UK, and an increased number of longer-term, though not necessarily tenured, posts in universities. It was felt these would encourage more young scientists and engineers, both British and foreign, to regard a research career in UK universities as a desirable alternative to employment abroad, or in the UK in industry or outside science. There is some indication that the 'new blood' schemes reduced emigration rates in 1983 and 1984.

Section IV summarizes other information on migration. A quantitative analysis is given of data collected centrally by the Universities' Statistical Record on the numbers and destinations of academic staff leaving UK universities. Statistics collated by the National Science Foundation in the USA on the rate at which scientists and engineers from the UK gain permanent immigrant status are also examined. Some qualitative evidence about emigrants is given by an analysis of the geographical distribution of Fellows of the Royal Society (excluding Foreign Members). Of the total Fellowship, the proportion living in the USA rose from less than 3% in 1960 to about 8% in 1986; the proportion living in the USA at the time of their election rose from almost 4% in 1960-62 to more than 13% in 1984-86.

Section V is a summary of the main findings of the questionnaire survey and related information from other sources.

Section VI discusses these findings and the views expressed by respondents, and considers them in the broader context of the international movement of scientists and engineers.

Section VII contains tables and figures giving details of the results described in section II.

In summary, the study indicated that migration in the disciplines and sectors considered was not numerically large during the decade 1975-85. However, differences in the length of stay and nature of work of British scientists and engineers who left the UK, in comparison with those of foreigners who came to this country, mean that simple counting of heads underestimates the net effect. Moreover, respondents to the questionnaire were concerned about the quality of those leaving and difficulties in replacing them adequately. It was therefore generally believed that the impact of emigration, particularly for universities, was much greater than the numbers involved might suggest.

The evidence we collected about the quality of migrants was necessarily less rigorous than information about their numbers and characteristics. However, when allied with respondents' views on migration, it suggested that the net outflow of talented scientists and engineers, both young researchers and established leaders, was having significant adverse effects on British research.

Within any sector of employment, losses overseas can be made up by new entrants, by lateral movement or by replacements from overseas. The losses through emigration reported in this study will have been offset to some extent, and may be sustainable. However, there must be some cause for concern about the continuing loss of young, qualified and trained scientists and engineers who are not yet in permanent employment in this country and who represent a considerable investment of national resources.

The disciplines that we surveyed are central to scientific research but may not be typical. Different migration patterns might be found in other disciplines, especially those that are relatively new and developing rapidly. Our data on engineers represent too small a sample to allow extrapolation to all engineering. There are also difficulties in extending our data on the four science disciplines studied to obtain migration rates for all science, partly because of uncertainty about what proportion of the total relevant scientific population was covered by our survey.

Short-term emigration from the UK can valuably broaden an individual's experience, but the permanent emigration of significant numbers of well qualified and experienced scientists and engineers was widely regarded as a matter for serious concern, particularly among the university community and in Government and Research Council establishments. It was considered by many respondents as one more symptom of a decline in the health of UK science and engineering, and within the context of a perceived worldwide shortage of qualified professionals, as an additional pressure on an already overstressed system.

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I Background and Study Design

Background

The migration of scientists and engineers to and from the UK was chosen for investigation by the Science and Engineering Policy Studies Unit (then the Policy Studies Unit (PSU)) because it was widely believed that growing numbers of skilled and experienced scientists and engineers were leaving the UK to work abroad permanently. The study set out to discover whether this impression was accurate. It is also set out to find whether there was a corresponding inflow of scientists and engineers to the UK from other countries, and the extent to which this balanced the outflow in quality and quantity.

Concern about the so-called 'brain drain' of scientists and engineers from the UK, particularly to the United States of America, was much publicized in the sixties. The growth of research areas such as biotechnology and information technology, where world demand for trained specialists is said far to outstrip the current supply, has again focused attention on the number of skilled people who are leaving the UK to work abroad permanently.

Previous Studies

Two early UK studies of migration were the Royal Society study of emigration of scientists from the UK undertaken by an ad hoc committee chaired by Sir Gordon Sutherland in 1963, and the 1967 report by the Committee on Manpower Resources for Science and Technology. Numerous short articles, general papers and conference proceedings concerning the 'brain drain' have been published since these early studies, but few concentrate on specific scientific areas or provide detailed data.

The pilot study of 'The Biotechnology Brain Drain' (1983) carried out by the Institute of Manpower Studies at Sussex University for the SERC is an exception, but many other recent studies tend to concentrate on the migration of scientists from developing countries, and most studies comment on the difficulty of obtaining complete or reliable data. Some early reports have since been criticized for the suspect methods or assumptions made when collecting figures on migration. Further, an OECD paper published in the early 1970s suggested that many of those who left the UK during the fifties and sixties later returned, and concluded that much of the concern expressed then about emigration was unfounded (Young, 1973).

Few studies have attempted to investigate the pattern of immigration to the UK and much of the recent debate on the so-called 'brain drain' has focused on the outward flow of scientists from the UK, which could well lead to a one-sided view of a complex situation. It would be irresponsible to draw undue attention and create widespread alarm on the basis of such an analysis, if there were in fact a compensating inward flow both of returning British scientists and engineers and immigrants from other countries. The gain from inward migration and the consequent loss of scientists and engineers by other countries, particularly developing countries, ought not to be ignored.

In the early summer of 1985, shortly after this SEPSU study began, the ABRC conducted an enquiry into recent emigration of staff from selected university research groups. Over forty research groups were asked about the number of research staff and postgraduate students leaving them for appointments overseas during the last five years. Although the results were based on a very limited sample, the report pointed to evidence of 'a serious loss of talent'.

Management and resources

The Council of the Royal Society appointed a Task Group to oversee the present study, chaired by Professor G.K. Radda, F.R.S. The other members of the group were Professor W.J. Albery, F.R.S., Professor D.P. McKenzie, F.R.S., and Dr J.C. Walling. The Task Group reported to the SEPSU (formerly PSU) Steering Group.

The study was carried out by Jane Silverleaf, a member of SEPSU, and took the equivalent of about fifteen months during the period June 1985 to May 1987. Dr P.M.D. Collins, the Head of SEPSU, directed the study.

Scope

It was decided that the study should collect data from as wide a population as possible and thus attempt to gain a representative picture of migration in research generally, not just within the university sector.

Five broad areas of science and engineering - Biochemistry, Chemistry, Earth Sciences, Electronic Engineering and Physics - were chosen by the Steering Group for investigation. They were chosen, not because they were thought to be particularly affected by migration, but rather because they covered a broad spectrum of scientists and engineers both in newer disciplines and in well established ones.

Since there were relatively few engineers in the disciplines selected, except for Electronic Engineering, the emphasis was on science subjects. The results therefore may not be typical of engineering generally. Further, the detailed results may not be directly applicable to scientific disciplines outside the study.

We did not attempt to define the five disciplines too closely, but asked respondents to state their particular specialization and that of any migrants they named, so we could analyse our data more narrowly, if necessary.

Study Design

The first few months of the study were spent partly determining the most appropriate methods of collecting reliable data on migration, given the resources of the Unit, and partly discovering whether any data collected for other purposes could provide additional information on migration. However, central statistics, both British and foreign, are rarely detailed enough to measure the movement of scientists and engineers; there are also considerable problems of comparability, and insufficient disaggregation of the available data.

Amongst several possible approaches, we investigated the feasibility of analysing the membership of learned and professional societies to discover the number of British members now working overseas, and the number of foreign members working in the UK. Apart from problems of confidentiality, insufficient detail in records and the sheer size of such a (necessarily manual) analysis, it was decided that the membership of any professional or learned society was unlikely to reflect migration. For instance, emigrants from the UK may let their membership of UK societies lapse and join equivalent foreign societies, and many foreign scientists and engineers join British societies because of their international role, as their UK counterparts join societies abroad.

We eventually decided that a questionnaire survey would be the method most likely to collect representative and reliable data on migration. Some time was spent developing and piloting questionnaires which were to be sent to a wide variety of research organizations, seeking information about the movement of scientists and engineers into and out of the UK during the last ten years. The survey was intended to collect information about the migration of scientists and engineers, both those at the start of their careers and those who had reached a level of seniority where they might be individually head-hunted.

Questionnaire Sample

Between November 1985 and early January 1986 we sent more than 750 questionnaires to selected university research group leaders in the five disciplines chosen for study; to all heads of department in four of the five disciplines and to selected Government, Research Council and industrial research establishments and institutes.

Questionnaires to University Research Group Leaders

The questionnaires to university research groups were designed to elicit information mainly about the movement of postgraduate and postdoctoral researchers. The research group leaders were chosen from lists of holders of SERC awards between £40 000 and £100 000, from NERC award holders and from research groups named in the latest available edition of 'Research in British Universities, Polytechnics and Colleges' (RBUPC) published by the British Library. Where possible, we tried to choose at least one research group in each university for each of the five disciplines, and then added additional groups in proportion to the total number of groups listed in the appropriate discipline in the 'RBUPC'. We hoped in this way that our sample would not be biased to particular universities or locations. We also tried to choose research group leaders at different grades so that both newer and well established groups were represented.

Questionnaires to University Heads of Department

We sent a similar questionnaire to all university heads of department in four of the five subjects asking for information about the movement of more senior university staff (equivalent to assistant lecturer or above).

In both the questionnaires sent to universities, we asked respondents to supply, in confidence, the names and addresses of those who had gone to work overseas or had come from abroad. This allowed us to eliminate any duplication that the two questionnaires produced, and also provided a list of migrants that we could follow up to discover more about individual motives and experiences, if at a later date this was decided to be worthwhile. Asking respondents to name individual migrants also served as a safeguard against exaggeration.

We tried to ensure that the sample of university research group leaders and heads of department was as accurate as possible, and that the sample did not include large numbers of staff who had retired or moved to other posts since the information from which we chose their names had been prepared. We therefore checked all the names chosen against other sources and asked the appropriate professional and learned societies to supply up-to-date lists of heads of department from their central mailing lists. We are most grateful to all the societies which supplied such information and to their staff who gave advice and information during the initial stages of the study, as well as to the NERC and SERC staff who supplied current lists of award holders.

As an additional precaution, we asked the university research group leaders we identified to pass on our questionnaire if they did not consider they were the appropriate respondent for the group. The final response rate (see table 1.1) was over 80% for the university sector; we felt this justified the considerable time we spent choosing and checking the sample.

Questionnaires to Government and Industrial Research Establishments

A similar questionnaire was sent to Government and industrial research establishments which employ scientists and engineers in at least one of the disciplines studied. Industrial companies were initially chosen from a list (supplied by SERC) of companies with a substantial number of CASE studentships. We felt that such companies would have an active interest in research. However, to ensure that we included both large and small companies, this list was supplemented from other sources. The questionnaires were sent to the Director of Research, although in several cases they were passed to the personnel department for completion.

Questionnaires to Research Council Institutes

Questionnaires were also sent to the AFRC, MRC, NERC and SERC asking for information about the migration of staff working in the five disciplines in their research institutes. Two of these Research Councils asked us to contact the Research Institutes directly, and so questionnaires were sent to all Directors of their Research Institutes. The other two Research Councils said they would construct a combined reply for all Institute staff from central records, but only one was able to do so; NERC eventually wrote to say that it had been unable to extract the detailed information requested from records kept centrally or by the Institutes themselves.

Survey by the Institution of Geologists

Questionnaires were not sent to heads of departments of Earth Science since the Institution of Geologists was concurrently conducting its own survey of migration of Earth Scientists and Geologists and had decided to send questionnaires to all university heads of department in these disciplines. To avoid duplication, we therefore agreed that we would not send our own questionnaire to these heads of department or to certain industrial firms also covered by the Institution's survey, but instead exchange information collected about the migration of Earth Scientists with the Institution.

However, it was not possible to include the results of this survey directly in our report because of differences in approach and statistical difficulties in amalgamating their questionnaire data with our own. Our information about Earth Sciences was thus more limited than that for other disciplines. However, we decided to retain the information on the movement of Earth Scientists working in university research groups and in industrial and Government research establishments, since it did not show strong variations from the other disciplines.

Response

Several industrial companies wrote to say that they did not keep records of destinations when staff leave, or if they did, this information was either confidential or would require considerable effort to extract and involve staff time that they could not justify.

The Government Research Establishments to which we sent questionnaires included several Defence establishments, and most of these responded that they could not participate in the study since the information we requested was not kept or was subject to security restrictions.

However, the general response rate was good - the overall rates of reply (after reminder letters had been sent, and inappropriate replies deducted) are given in table 1.1. We are most grateful for all the detailed replies we received and for the time and effort many organizations and individuals spent providing this information.

Table 1.1

Questionnaire Response

| | Research Group Leaders | University Heads of Dept | Total | Industry | Govt/ Res. Cncl | Totals |
|------------------------|---------------------------|--------------------------------|-------|----------|--------------------|--------|
| Biochemistry | | | | | | |
| Sent | 71 | 46 | 117 | | | |
| Returned | 64 | 44 | 108 | | | |
| % response | 90 | 96 | 92 | | | |
| Chemistry | | | | | | |
| Sent | 97 | 66 | 163 | | | |
| Returned | 81 | 57 | 138 | | | |
| % response | 84 | 86 | 85 | | | |
| Earth Sciences | | | | | | |
| Sent | 45 | - | 45 | | | |
| Returned | 30 | - | 30 | | | |
| % response | 67 | - | 67 | | | |
| Electronic Engineering | | | | | | |
| Sent | 57 | 41 | 98 | | | |
| Returned | 42 | 31 | 73 | | | |
| % response | 74 | 76 | 75 | | | |
| Physics | | | | | | |
| Sent | 99 | 63 | 162 | | | |
| Returned | 84 | 53 | 137 | | | |
| % response | 85 | 84 | 85 | | | |
| Totals | | | | | | |
| Sent | 369 | 216 | 585 | 94 | 62 | 741 |
| Returned | 301 | 185 | 486 | 41 | 41 | 568 |
| % response | 82 | 86 | 83 | 44 | 66 | 77 |

Notes:

- Numbers Sent exclude those who replied stating that the questionnaire was inapplicable (29 respondents). These included establishments where no scientists or engineers were employed in the disciplines studied, and replies that had been included in another return from the same university department.
- Numbers Returned exclude those who did not supply sufficiently detailed information to be included in the data analysis.
- Questionnaires were not sent to heads of Earth Science departments since these were included in a survey by the Institution of Geologists.
- Totals for Industry and for Government and Research Council establishments are not divided between disciplines since many of the establishments concerned employ staff in several disciplines.

II Questionnaire analysis

Number of migrants named by respondents

A total of 931 British scientists and engineers who left the UK for overseas posts during the years 1975-85 were named in the 568 completed questionnaires. Of these, 617 were 'experienced' scientists and engineers and 314 were postgraduates, almost all 'recent PhDs'.

Questionnaire respondents also named 685 scientists and engineers who entered the UK from abroad during the same period; of these, 183 were British who returned to the UK from overseas, and of the 502 foreign immigrants, about 130 were 'recent PhDs' or equivalent, including 15 who stayed to work in this country after completing postgraduate studies here.

We deliberately asked respondents to exclude from their replies foreign postgraduate students who stayed in this country for not more than three or four years to study for a higher degree. These foreign students do not represent long-term immigration to the UK, since most leave the country on completion of their degrees. This was confirmed by respondents who, despite our instructions, did name foreign postgraduate students who were in the UK to study for higher degrees. Most were reported to have returned to their home countries and we included in the analysis only those named by these and by other respondents who remained to work in the UK after completing their studies. In contrast, it had been suggested that many of the British graduates who go abroad to take higher degrees fail to return to the UK and thus become permanent emigrants. Since such students would not be members of any university research group in this country they were not covered by our survey. However, we obtained information about those British postgraduates who went abroad shortly after taking a higher degree and these were included in our analysis.

Several respondents named individuals who had left or come to the UK but who were not directly part of the group or institution sampled, but were employed in similar specializations in other institutions. These were not included in the analysis since we wished to compare the numbers migrating with the size of the groups involved, and because they were not collected systematically.

A few respondents could supply only very general statements about staff movements during the past decade, and this limited information was not included in the analysis. We also excluded one establishment which employs both British and foreign scientists on short-term contracts and encourages their movement to and from related organizations abroad. These movements were not of the kind we were investigating.

Several of the industrial firms we contacted were unable to supply details of staff leaving the UK or coming from abroad, explaining that migration had not been a sufficiently important problem to date to warrant keeping such records.

Tables 2.1A and 2.1B (all tables and figures mentioned in this section are given in section VII) show the number of named scientists and engineers leaving or entering the UK by each of the four categories of respondent, and also show what proportion of the respondents reported no migration in either direction. 67% of all university respondents, and 61% of Government and Research Council respondents, reported some migration, whether to or from the UK, during the past decade; by contrast, fewer than 50% of industrial respondents reported any staff movement to or from the UK. However, the number of immigrants from abroad who join Government and Research Council establishments is in some cases restricted by regulations that forbid the employment of foreign nationals in such establishments.

Population represented by respondents

The questionnaire replies necessarily represent a sample of the total British research effort and so cannot give a complete picture of migration in the five disciplines studied. It is difficult to assess what proportion of the total relevant scientific and engineering professional population was covered by our survey: total figures for those employed in individual disciplines in the industrial sector are not readily available, and in the university sector the total number of research workers in particular disciplines is difficult to measure accurately from central sources (which tend to be structured around departments or cost centres rather than disciplines). Varying definitions and demarcation between disciplines also complicate comparison of our survey data with available central statistics.

However, we asked all respondents to give some indication of the size of the professional population to which these migrants relate. In the case of university research groups and departments we asked for the average size of specific grades in the group or department during the last ten years. For industrial, Government and Research Council establishments, we asked for the number of scientists and engineers (graduate or equivalent) currently employed in R&D departments in the five relevant disciplines. Although the figures for the non-university group are not averages, they provide some guide to the total population during the ten year period; it is reasonable to assume that many Government and Research Council Institutes are likely to have contracted in recent years, and so present numbers may underestimate the average population for these establishments over this period and thus overestimate migration rates.

The estimated total populations for each of the above categories (Research group leader, head of department, industry, Government and Research Council establishments) are included in table 2.2A.

Although the total number of respondents from Industry and Government and Research Council establishments was not large, it can be seen that they represented a large population of scientists and engineers.

Rates of migration

a) By category of response

To estimate the rate of migration, we compared the number of migrants in each category with the corresponding estimated population. From table 2.2A it appears that the total number of migrants who left or entered the UK is small in comparison with the total number of scientists and engineers in the research groups, departments and establishments they left or joined. For postdoctoral research assistants (PDRAs) and more senior members of university research groups, the emigration rate was slightly under 2% per year. University heads of department reported an emigration rate of about 0.5% a year, while industry, Government and Research Council establishments indicated lower rates - less than 0.3% per year.

Our estimated rates of emigration from universities of more senior staff agree with those derived from an analysis of data collected by the Universities' Statistical Record. This also shows that the overall number of university scientific and engineering staff leaving the UK for posts overseas, is small in comparison with the total related university population (see section IV).

The rate of emigration from university research groups of British postgraduates who had completed a higher degree is more difficult to measure, since the total postgraduate population (1190) in the groups surveyed included foreign postgraduates and also those at different stages in their courses. However, some estimate can be made using information from the Universities' Statistical Record (USR) for the years and disciplines covered by the survey. This suggests that approximately two-thirds of all the postgraduate students in our survey population were British, with a lower proportion in Electronic Engineering research groups and slightly higher proportion in Biochemistry, Chemistry, Earth Sciences and Physics research groups. USR data also suggest that each year between 40% and 50% of all such postgraduate students complete their higher degree, again with slight variations between disciplines. Using these proportions indicates an average rate of emigration for British 'recent PhDs' of approximately 9% per year for the period 1975-85. This agrees well with figures published by the USR on the first destination of British postgraduates who obtained higher degrees.

Our estimated rate for postgraduate emigration is considerably less than that reported in the 1963 Royal Society study. For the period 1957-61, about 35% of all 'recent PhDs' emigrated each year (more than 20% to the USA alone). Further, the total number of PhDs awarded annually at that time was much smaller than in the period 1975-85. The variation between disciplines was not dissimilar to that found in the present survey.

The USSR data also provide an indication of the rate of emigration of British graduates who left the UK directly after taking a first degree (who were not covered by our survey). Annual rates for the science disciplines covered in our survey averaged less than 3% and were somewhat lower for Electronic Engineering.

Immigration rates for university research groups were 2.9% per year (postgraduate immigrants not remaining in the UK after study were excluded and so the corresponding population excluded all postgraduates). University heads of department reported an annual immigration rate of about 0.4% and industry, Government and Research Council establishments reported annual rates of less than 0.2%.

Direct comparisons of emigration and immigration rates would be misleading; other factors such as staff experience and seniority are important, and these are in turn affected by the size of a research group and other inflows and outflows.

b) By discipline

Table 2.2B shows the rates of migration for each separate discipline. As before, the average number migrating per year was compared with the corresponding estimated total population in the groups or establishments which responded. Postgraduates ('recent PhDs') are shown separately from other more senior members of university research groups; immigration rates are not given for foreign postgraduates, since the number who remained in the UK after studying for a higher degree was too small for meaningful analysis by discipline.

The estimated annual emigration rate for 'recent PhDs' from university Earth Science research groups was well above the overall average for all disciplines; this may be partly because many necessarily work overseas, but for multinational organizations with British connections. The emigration rates for 'recent PhDs' from Biochemistry research groups was slightly above the average, and from Electronic Engineering groups considerably below the average. For more senior members of university research groups there was little variation between disciplines, except for Physics, for which there was a higher than average annual rate of emigration. Heads of department reported a higher emigration rate in departments of Electronic Engineering than for other disciplines. Rates for Electronic Engineers were slightly higher in industry than for other disciplines. Biochemistry staff in Government and Research Council establishments showed a higher rate of emigration than other disciplines. However, because of the small numbers in some subcategories and the low response rate from industry, Government and Research Council establishments, such distinctions between disciplines are not very reliable.

Immigration rates also varied slightly between the disciplines studied, with higher rates for postdoctorate and more senior staff in Chemistry university research groups, slightly higher rates for staff in university departments of Biochemistry, and lower rates for departments of Physics. Immigration rates from industry and from Government and Research Council establishments were higher for Biochemistry and Chemistry than for other disciplines. Again, the small numbers in some subgroups affect the reliability of such comparisons.

Other factors made direct comparisons between disciplines difficult. The estimated total population and the number of migrants named for Earth Sciences were smaller than for other disciplines, partly because heads of university departments of Earth Science were not included in our survey and the NERC did not supply details of the movements of its staff. Generally, we did not find major variations between responses according to discipline.

Quality of Migrants

Since overall rates of emigration and immigration are broadly similar for 'experienced' scientists and engineers, the net effect of migration on UK research will depend mostly on the relative quality of migrants, on whether emigration is permanent or short-term, and on the extent to which those leaving the UK are replaced either by other British scientists and engineers or by others from abroad. Lengths of stay of emigrants and immigrants are discussed in a later section. The 1985 ABRC survey of emigration from selected university research groups also recognized the importance of quality. However, assessing the quality of those migrating is difficult; indeed, agreement on what constitutes 'quality' is almost impossible. However, some attempt has been made to assess the quality of migrants through such factors as relative seniority and qualifications. These are discussed in later sections of this report.

The question of whether emigrants from the UK are adequately replaced by newly qualified and other British scientists and engineers is difficult to measure and again will depend on the research experience and 'quality' of those leaving or returning from abroad. Some would argue that, given the acute shortage of scientists and engineers, any outward migration must be damaging to British science and engineering, while others argue that some international movement is necessary to keep science 'healthy'.

We asked all respondents how many of the migrants they named they would regard as 'outstanding'. Although this is a very subjective question and is open to different interpretations (for example, an outstanding research student may not become an outstanding research group leader), we felt that this might provide a further qualitative measure of migration. Generally, respondents appeared to treat this question seriously: few refused to answer it or listed all the migrants they named as outstanding without careful thought. Several qualified their answers, explaining that although those who had left or joined were 'good' they could not be classified as 'outstanding'.

Overall, of all the emigrants from the UK who were still working abroad, more than 40% were said to be 'outstanding'. However, Government and Research Council establishments indicated that fewer of their emigrants were 'outstanding' (20%). We asked university research group leaders to distinguish between senior and junior (postgraduates and postdoctoral research assistants (PDRA)) group members. Nearly 60% of senior and 40% of junior members who had emigrated were regarded as 'outstanding'. We did not ask other respondents to make any distinction between grades when answering this question, since the number of migrants involved was likely to be so small that individuals might have been identified and this might have deterred some respondents from answering.

Over 30% of the immigrant scientists and engineers to the UK who were still in the UK were also regarded as 'outstanding'. Again, fewer working in Government and Research Council establishments were regarded in this way (12%), while 74% of senior and 30% of more junior members (PDRA only) who had joined university research groups from abroad were regarded as 'outstanding'.

Effects of emigration on British research

Over half the respondents commented on the effects of emigration of British scientists and engineers on British research, either generally or in their particular specialization (table 2.3A). Of the respondents who did not reply to this question, most reported no migration to or from the UK and so did not complete the sections of the questionnaire seeking opinions on the effects of migration and the reasons behind it.

Of the 323 who did respond, 73% of university, Government and Research Council respondents thought that emigration from the UK was having an adverse effect, but less than half of industrial respondents thought so. When asked to qualify this effect further, 45% of university, Government and Research Council respondents considered it serious and 22% of minor importance. Of the remaining 6% of these two groups, several stressed in written comments that the effects of emigration would become a more serious problem in the next few years, and believed that this would lead to a worsening of the research base in the UK. A smaller number answered that, in comparison with the current effective reduction in funding for university research and equipment, migration from the UK was less important, although others argued that these issues were connected.

Thus respondents in university and Government research establishments generally regarded emigration as a more serious problem than those in industrial research organizations. Table 2.3B shows how respondents from university research groups or departments responded to the question on the effects of emigration according to their discipline. It appears from this breakdown that there are relatively small differences in attitude within universities between the disciplines studied.

Ease of replacement of emigrants from the UK

Respondents were asked 'How easy has it been to find replacements of equal calibre for those who have gone overseas?' This question was answered by 50% of all respondents. As table 2.4 shows, 68% of university respondents said that, when permitted, it was difficult to find such replacements. A small number said that the difficulty varied with the seniority of the staff who left - it was easier to replace younger, less experienced staff. Answers to this question varied to some extent with the discipline of the emigrants - over 90% of those who responded from departments of Electrical and Electronic Engineering said that it was either fairly or very difficult to replace staff who left to go abroad, while in departments in the other four disciplines, approximately 60% of those who answered said it was difficult to replace losses.

The response from Government and Research Council establishments was similar to the university response, but industrial respondents were equally divided between those who considered it difficult to find replacements and those who thought it was easy.

Reasons for migration

We asked respondents if they could list the most common reasons that persuaded the named scientists and engineers to migrate to or from the UK. Although it is difficult to judge the motives of other people, we thought that many respondents would have some idea of the motives of the migrants.

Tables 2.5A to 2.5C list the reasons given by each group of respondents. Each respondent was asked to choose a maximum of three from a list of motives that are generally thought to be associated with migration and to supplement the list as appropriate.

The most common reasons why scientists and engineers were believed to have left the UK were career opportunities abroad and career limitations in the UK. Rates of pay, the desire to widen experience and research facilities abroad were also thought to be influential. Higher rates of pay abroad were considered particularly attractive to staff leaving university departments.

In contrast, the most common reason given for the immigration of non-British scientists and engineers to the UK was the desire to widen experience, perhaps not surprising since the majority were only in the UK for not more than three years on short-term appointments. The status of science and research facilities in this country relative to immigrants' home countries was also considered to be important.

British staff were most often thought to have returned from periods spent working abroad for personal reasons, usually family ties, or by the desire to educate their children within the British system.