TECHNOLOGY TRANSFER THROUGH STAFF MOBILITY: I

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Technology is one of the great forces of our time. Interacting with science and with economics (each subject to its own dynamics) it helps shape the present and future of individuals, companies and whole countries. An early study by Solow (1957) attributed to 'technical progress' 87.5 per cent of the increase in output per man-hour in the U.S. between 1909 and 1949, attributing only 12.5 per cent to increased use of capital. Later work has reduced the estimated size of this effect, but it remains true that a substantial part of the increase in living standards since the Industrial Revolution can be put down to technology.

The impact of technology on our daily lives is now so obvious, and even greater impact so imminent, that it has become a commonplace of public debate. In Ireland, there is a further dimension, as we contemplate the growing size of our labour force, trying to decide how technology will affect employment prospects, and to decide an industrial policy to help meet its challenge. To a great and increasing degree, the survival and growth of companies, and the prosperity of countries, depends on their ability to manage technology. No company or country, however large, is or can be self-sufficient: all must import technology by some means from the rest of the world, as the data in table 1 show.

It is sometimes suggested that technology is virtually a free good, available throughout the world with little cost and difficulty by patent searches, 'reverse engineering' and so on. Nothing could be further from the truth. Unlike science, whose results can readily be communicated or diffused through publication and colleague networks, technical know-how is often of a highly specific kind, learned by experience and not readily communicable [Sahal, 1981, p. 197]. Nor is it always easy to unlock the secrets of complex machines or chemical compounds — at least quickly enough to avoid being left behind in the competitive race. Allen *et al.* (1979, p. 697) state the problem well:

> Science may be said to be universal . . . A scientist . . . is fully

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Table 1: *Number of Patent Applications filed by Nationals and/or Residents as Percentage of the Total Number of Patent Applications filed in each Country, 1960-1980*

	% Total Number of Patent Applications in each Country				
Country	1960 %	1965 %	1970 %	1975 %	1980 %
Belgium	13	11	8	8	15
Denmark	19	17	12	14	17
France	40	37	30	30	39
Germany	64	57	50	49	50
Italy	32	26	23	24	39
Japan	73	74	77	85	87
Netherlands	18	15	13	13	25
United Kingdom	51	44	41	39	47
United States	79	77	74	64	60
IRELAND	n/a	12	12	12	14

n/a – Not available.

Source: Irish Science and Technology Statistics, 1984, Dublin: National Board for Science and Technology.

> capable of understanding the nature of the problems and approaches employed by other scientists in his specialty anywhere in the world. The universal nature of the problems and the existence of shared language and methods permit effective communication across organizational and even national boundaries.
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> Technology, on the other hand, is not universal. Technology is highly localized in that problems are defined in terms of interests, goals, and local culture of the organization in whch they are being attacked. Similar technological problems may become defined in very dissimilar ways by organizations working on them because these organizations have often different objectives and value systems . . .
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> A consequence of organizational differences is that technological problems are defined to fit the particular strengths, professional orientation, and objectives of the organization. Certain types of solutions, which may be perfectly acceptable in one organization, simply will not work when applied to the same problem in another organization . . . As a result, the externally defined solutions perform less well, and an inverse relationship is observed between external consultation and technical performance.

As a consequence of these barriers to the free flow of technical knowledge, even very large and sophisticated companies fail in their attempts

to import it, unless it comes through members of their staff who can understand and translate outside messages into internally usable information – the so-called technological gatekeepers [Allen, 1977]. For this reason, writers have in recent years turned their attention away from mechanisms such as licensing, and toward the movement of people as a means of technology transfer, particularly from more developed to less developed countries. Bums (1969) wrote:

> the mechanism of technological transfer is one of agents, not agencies: of the movement of people between establishments, rather than routing of information through communications systems.

Given the increasing importance of technology, of Ireland's need to import it, and of people as a mechanism of transfer, we decided in 1981 to carry out an exploratory study in the area. At that time and since, there has been considerable questioning and indeed criticism (much of it unrealistic) about the contribution of multi-national companies to our industrial development. We therefore decided to combine these themes and to carry out an empirical study of technology transfer by those who left multi-national companies, our general hypothesis being that technology enters the country via these companies and is diffused by staff mobility.

Study Method

We chose to study two manufacturing subsidiaries of a large multinational company in the electrical and electronics field. They were chosen because they are established for many years and because they are large by Irish standards. Hence, they could be expected to have lost a substantial number of people, especially given the growth of the Irish electronics sector since their arrival. Because quite detailed information was being asked for, which could be got only by interview, the study was confined to these two firms.

Even within the firms, coverage had to be restricted, because of the large number who had left and because of the impossibility of tracing many of those who left from lower levels of the organisation. We therefore decided to study only those who left from supervisory or managerial positions, or their equivalent grades. A total of 155 names was listed, of whom 116 could be traced to their current place of employment. Successful interviews were completed with 82 of those traced (70% coverage). Of the remainder, 11 refused and no appointments could be secured with the others despite repeated attempts. As far as possible, therefore, the respondents constituted a census of leavers from the relevant grades of the target organisations.[1]

Detailed interviews were held with the 82 respondents, focussing on technology transfer and on relevant biographical details. The approach to establishing the occurrence of technology transfer was as follows. Respondents were asked to describe any innovation in which they had been involved with their current or previous employers, since leaving the source company. Following Shepard (1967), an innovation was defined as "activity of a technical or managerial nature in which the recipient organisations did not previously engage but commenced to undertake in a sustained way." Thus, innovations could consist of new or modified products, and of new or modified technical or managerial processes, where new meant novel to the organisation, even if it had been introduced elsewhere. The respondent was asked to describe his part in the innovation, tracing the sources of the idea and of solutions to problems in its development. In this way we could see how far the source company had contributed in a specific way to particular new actions by recipient companies. By using this 'critical incident' technique, generalities could be avoided, and specific instances of technology transfer pinpointed.

The results of the study are in two parts, and will be published serially in forthcoming issues of this journal. The first part is a description of staff mobility, describing the characteristics of respondents, of the companies they went to and of the jobs they took up. The second part deals with technology transfer by respondents, describing the innovations they made, the influence of the source company, the conditions facilitating transfer and the implications of the study for industry policy.

This article describes the characteristics of the source company and of the respondents. These are important, not merely to set the background to the study, but to establish whether we should expect *prima facie* to see any transfer of technology.

Company Characteristics

The source companies are subsidiaries of a large U.S. multinational corporation. The parent operates in various fields ranging from such high-technology areas as aerospace and nuclear reactors to ordinary consumer electrical and electronic products. In 1982, it had sales in excess of $25 billion, and total employment (world-wide) of over 350,000. It spends over $1 billion per year or approximately 6 per cent of revenue on research and development and operates in practically every continent.

The two Irish subsidiaries selected for the study together employ

about 1,600 people. Both companies, large by Irish standards, are in the electronics manufacturing business. Company A deals mainly in consumer electronics and Company B is engaged in the manufacture of electronic components. Both companies are regarded as leaders in manufacturing and management technologies in Ireland. They both have sound training programmes which link up with the parent company training activities. On account of these facts, many college graduates see the Irish subsidiaries as a desirable first stop for the acquisition of experience. And in keeping with this role, the company has a policy of recruiting graduates as trainee managers who are given exposure in a variety of business functions without expecting more than a handful to stay on.

We undertook a study of the companies to ascertain their potential to transfer technology. The review revealed that both companies were rich sources of manufacturing and quality control technologies on the technical side. It was also noted that, contrary to the criticism often levelled at multinationals, both companies now engage increasingly in developmental and design work. The projects completed indicated a reasonable amount of transferable development and design technology. On the management side, we noted that both companies were strong in financial (cost management in particular) systems, personnel management, data processing and business analysis. One company now also has a fledgling marketing function.

Respondent Characteristics

Having established that the source companies have significant potential for technology transfer, we examined the characteristics of respondents to see if we could form any conclusions about their ability to do so. The characteristics we examined were their function in the source companies, their educational background, the hierarchic level from which they left, and their experience. The results are summarised in table 2, the overall results in the first column and the more detailed results in the remainder.

Overall Results

We shall discuss first the overall findings because the summary disguises some relevant details.

Function Given that both companies are basically manufacturing subsidiaries, with one only recently developing a small marketing activity, it is not surprising that most respondents left from a technical function: 30 per cent from manufacturing, 16 per cent from plant engineer-

Table 2: *Characteristics of Respondents, Overall and by Major Sub-Group*

Characteristic	Total Respondents	Highest Level of Education		
		Technician	Graduate, Previous Experience	Graduate, Direct Recruit
	(n = 82)	(n = 31)	(n = 25)	(n = 26)
Function	per cent	per cent	per cent	per cent
Technical	72	68	52	96
Other	28	32	48	4
Hierarchic Level				
Top	6	7	4	8
Middle	77	52	96	88
Supervisory	17	41	–	4
Experience				
Prior	59	74	100	–
No prior	41	26	–	100
1-2 years with company	31	17	36	42
3-5 years with company	31	31	24	37
Over 5 years	38	52	40	21
1 job with company	30	24	36	30
> 1 job with company	70	76	64	70

ing and 12 per cent from quality control, the three largest sub-areas. The major non-technical functions represented were accounting and finance (11 per cent) and personnel and industrial relations (11 per cent).

Respondents were asked about functions other than the ones from which they left. There was little movement between major areas: 96 per cent of those who left from a technical function had always been technical, while 80 per cent of those who left from administration had always been there (the other 20% were personnel people – mainly in training – who had formerly been technical). Although there was little movement between areas, there was considerable movement within them. Over 50% of respondents had worked in a sub-area other than the one from which they left.

Education Of the 82 respondents, 31 had a technician level qualification or less (15 had no post-secondary education).[2] Of the 51 graduates, 32 had a primary degree only, while 19 had higher degrees. Not surprisingly, most qualifications at technician and primary degree level were in engineering (12 out of 16 technicians, 31 out of 51 primary degrees). Higher degrees had a more managerial orientation: 15 out of 19 were either in industrial engineering (7) or in business administration (8).

Hierarchic Level Reflecting the shape of organisations, few left as chief executive or head of function. The vast majority left from the ranks between supervisor and head of function. This in part reflects the company's policy of 'over-hiring' young graduates and maintaining an open door policy of expecting most of them to leave.

Experience About three respondents in five had worked elsewhere before joining the source company. A fair proportion of respondents (31 per cent) left the company within two years of joining, but more (38 per cent) remained for longer than five years. The vast majority had had more than one job during their tenure.

Conclusion The overall picture which emerges is of a highly educated group, with substantial experience gained in a variety of jobs, largely within technical and manufacturing management. We might conclude on this basis that their capacity for transferring technology should be substantial, particularly in the area where technology and management overlap.

Detailed Results

It is possible, by multiple cross-classification, to produce many more detailed findings than those reported above. We decided to report only those details which significantly altered or amplified the picture already presented, which were important in their own right, or which had clear implications for technology transfer. Most analyses met none of these criteria. As we examined the data, however, a pattern of findings emerged, all of which related in some way to the respondents' qualifications and experience. This pattern suggested that the respondents could meaningfully be grouped into three distinct clusters, internally homogeneous and different from one another.[3] It therefore seemed appropriate to report the results of the more detailed analysis by showing the profiles of each cluster in table 2 and by discussing them below.

Technician-Level Group. This cluster consists of those whose highest level of education was at National Diploma level or below, though this by no means implies that they left from technician-level jobs. As might be expected, a large proportion left from supervisory level positions (41 per cent), which was virtually never the case with graduates. On the other hand, a substantial number left from middle management, and they equalled graduates in the (very limited) extent to which they left from the head of function level. The vast majority of them had had prior experience before joining the company, and they were far less likely than graduates to leave soon, as well as more likely to stay for more than five years. Their greater tenure was reflected in a slightly

greater tendency than graduates to have held more than one job, most of which were in technical areas. We see in these technician-educated leavers, therefore, a group in whom a greater depth of experience may compensate for any educational handicap in conducing to technology transfer.

Experienced Graduates. There were two clearly distinguishable subsets of graduates – distinguishable not merely in terms of the variables reported here, but in terms of a definite impression made during the interviews and which can be remarked on but not captured in the data. One group consisted of graduates who had come to the company from other firms, and who split about 50/50 between technical and other functions. (In fact, none of those graduates who left from an administrative position came direct from college, the companies obviously preferring to hire experienced personnel than to train them themselves). Virtually all left from middle management and, although far more likely than the first group to quit early, a substantial proportion remained for more than five years. This group, then, should have considerable potential for technology transfer in the light of their qualifications, experience and seniority.

Direct Recruit Graduates. These were the most distinctive sub-group. We mentioned before that the company had a policy of hiring and training technical graduates in excess of its long-run ability to retain them, and that these positions were highly sought after. These direct recruits were more homogeneous and had a more homogeneous experience of the company than any other group. If not exactly an elite, they shared a consciousness of having gone through a demanding learning experience, with all that entails. That the company was successful in its policy is clear from the figures. Of all groups this is the one whose members are most likely to leave early. In spite of that, they are quite likely to have held more than one job – reflecting the companies' policy of job rotation as part of training. Although this group might appear on the face of it to have less potential for technology transfer than more experienced graduates, the fact that they were highly selected as part of a formal development programme, and that they were ambitious enough to move in search of greater autonomy (the most frequent single reason given by them for leaving) might compensate for their lack of experience.

Conclusion

The companies selected for the study showed significant potential as a source of technology, including managerial technology. The respondents who left the company showed significant potential to act as agents of technology transfer, by virtue of their education and experi-

ence. Three sub-groups of respondents emerged, perhaps differing in potential, but each with substantial capability based on different mixes of experience, education and training.

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NOTES

1. Because they do not constitute a random sample from any defined population, numbers based on these respondents are not the subject of statistical inferences. No confidence limits or significant levels will be reported: the numbers are to be interpreted as they stand – the results of an exploratory study with no claim to general applicability.
2. Technician-level embraces post-secondary qualifications up to the NCEA National Diploma or a U.K. Higher National Diploma.
3. This clustering was not achieved by using formal statistical cluster analysis techniques. The heterogeneity of the clusters can be seen in table 1. Their internal homogeneity was established by inspecting in detail profiles of various sub-groups.