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TRANSFERRING TECHNOLOGY TO THE FIRM: REPORT OF A PILOT STUDY IN IRISH INDUSTRY

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ABSTRACT

This is a preliminary report on technology transfer, with data to be taken eventually from a stratified, random sample of 300 Irish manufacturing firms. The present study reports data from the first 65 of these firms.

New technology, in these instances, reached the firm almost entirely through direct personal contact, most often with people, in the same industry but outside Ireland. Little use is made of the scientific/technological infra-structure of the country in accomplishing this transfer. The implications, for this situation, of Ireland's entry into the European Community are discussed.

INTRODUCTION

In the Spring of 1971, an extensive study of technology transfer in the Republic of Ireland was begun. In the first phase of this study, a survey was made of communication patterns among all engineers and scientists performing research and development. From this survey an analysis will be made of communication structure at both the individual and institutional levels (Allen and Cooney, 1973). This will provide knowledge of how those, who are themselves responsible for advancing technology, learn of new technological developments. Such a study will, no doubt, provide interesting and useful results for the research and development community in Ireland. Still it must be remembered that the vast majority of Irish industrial firms do not undertake any research and development, at all, and were therefore excluded from the communication survey.

To fill this gap, a second phase of the overall study, was begun in the Summer of 1972. For this phase a stratified sample of manufacturing firms was selected from industrial census statistics, to be representative of Irish industry.

Characteristics of the Firms that Were Studied

The total sample includes 300 firms in 26 industries.[1] Industries were excluded from analysis for any of the following reasons:

1) If industry gross output were less than £7.5 million in 1968, or in employment was less than 1,500 in 1968, unless it has important exports or known technological innovation problems.

2) If the industry predominantly served the domestic market and had a low growth in volume of output since 1953.

3) If the study methodology were judged to be innapropriate for the industry, this could result from either of the following two situations

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[1]The author acknowledges his indebtedness to Mr. Breffni Tomlin of the Department of Business University College Dublin, for specifying the criteria for industry selection, and for performing the actual mechanics of sample selection.

a) More than two-thirds of the industry output in attributable to a few large producers (these industries will be studied separately).

b) Industries with minimal processing, mostly not on a factory model, or with production tasks determined elsewhere.

During the summers, of 1972, and 1974, and 1975, 70 firms in ten industries[2] were approached and asked to cooperate in the study. From this initial sample, there were two outright refusals, and three firms disqualified themselves because they were no longer involved in manufacturing. The firms were distributed among ten industries (Table 1) and should be taken to be representative only of those ten industries. Any attempt to generalize our findings to all of Irish Industry would, at this point be premature, however we believe that the results are interesting enough to justify this early report.

The 65 firms were mostly small in size, with but three in excess of 250 employees (Table II). This bias was introduced purposely for two reasons. First it is representative of Irish industry, generally. And second, we are particularly concerned with the problems of bringing new technology to the smaller firm where the problem of capturing new technology is particularly acute. Firms with fewer than 50 employees[3] were excluded, at this point, but will be brought in later to see whether any significant differences exist.

Research Method

The method used to determine the sources of new technology was very simple and straightforward. The general manager (or his designate), in each firm, was asked to think back over the last several years and then tell us what he thought was the most significant change, in either product or process, that had occurred

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[2] One firm is double-counted, since it appeared in the sample twice, representing two industries.

[3] One of the firms in the sample had only 33 employees at the time of the interview. They had more than 50 employees at the time that the census data were obtained upon which the sample was based.

Table I

Industries in Which Firms Were Sampled
During the Pilot Study

industry description (as used by Central Statistics Office)	description to be used in remainder of this report
Creamery butter, cheese, condensed milk, ice cream etc.	milk products
Bacon factories	bacon
Slaughtering, preservation and processing of meat (other than by bacon factories)	other meat
Canning of fruit and vegatables and manufacturing of preserves, jams, jellies, etc.	canning
Manufacture of cocoa, chocolate and sugar confectionery	chocolate and confectionery
Structural clay products, asbestos goods, plaster, gypsum and concrete products, slate and dressed stone	building materials
Manufacture of electrical machinery, apparatus and appliances	electrical & electronics
Men's and boys' clothing	men's and bcys' clothing
Chemicals and pharmaceuticals	chemicals and pharmaceuticals
Manufacture and assembly of machinery	machinery manufacture

within the firm. The principals who were involved in introducing the change were then interviewed in some depth. There were two main goals in the interview. The sources which first brought the new idea to the attention of the firm were sought first. Then respondents were asked to describe any problems that were encountered in the course of introducing the new technology, and the manner in which such problems were resolved, including any assistance that was sought or

obtained from outside of the firm.

After learning as much as possible about the firm's "innovation",[4] the interviewers went on to gather background data from the principals regarding their previous work experience, general use of information sources, and their degree of contact outside of the country.

Table II

Number of Firms in Each Industry Classification and Size Category

industry	number of employees: 50 to 99	99 to 249	250 or more	totals
milk products	6	3	0	9
bacon	2	4	2	8
other meat	2	1	2	5
canning	3	3	0	6
chocolate and confectionery	2	2	1	5
building supplies	3	3	1	7
electrical	2	2	4	8
men's and boys' clothing	5	3	1	9
chemicals and pharmaceuticals	0	3	2	5
machinery manufacture	0	2	1	3
totals	25	26	14	65

[4] The term innovation will be used in this report in a very limited sense. It is taken to mean something new to a particular firm. Even if every other firm in the industry is already using it, if it is new to the firm under consideration it will be called an "innovation."

Illustrative Cases of "Innovations"

The following examples are presented to illustrate the general nature of the new technology and the kinds of information source from which it was derived.

Tumble Processing of Hams

This is a process in which a number of hams are tumbled together in a large rotating cylindrical container. Over the course of several hours, by a process that is not fully understood, protein migrates to the surface of the ham, thereby increasing the overall yield of the ham by some three to four percent.

The production manager in one Irish bacon factory first became aware of this technique when he saw it being used in a Danish firm some twelve years ago. He put it down at that time as being something of considerable interest but far too expensive for his scale of operations. Then, about two years prior to the interview, he learned that a British manufacturer was supplying the necessary equipment at a price that he could now afford. He learned of this through suppliers' representatives, who visit the plant occasionally. Once he expressed an interest, the supplier sent representatives to conduct a demonstration. The purchase was negotiated. Very few problems were encounted with the process, and these few were solved by the staff of the firm, with no need to seek outside help.

Ultra High Temperature Cream

The general manager of a large creamery was aware that long life milk, capable of resisting spoilage for relatively long periods without refrigeration, had been produced in Switzerland since about 1960. Since the export of cream was a very attractive possibility, if some way could be found to prevent rapid spoilage, the possibility of producing a long life cream seemed attractive. It was felt that there would be a good market in Ireland, especially in the rural areas for long life cream and to the housewife it would be even more appealing than long life milk.

Further investigation revealed that the Swiss were using a steam injection process and had originally packaged their milk in cans, but changed over to foil-lined paper "tetra pack" containers in 1964 as a result of the development in

Sweden of an aseptic packaging process using this container.

At this stage, a delegation was sent to Switzerland to scrutinize ultra-high temperature milk processing. The firm then brought in a technical man from Bord Bainne,[5] built a facility to house the experimental operation and obtained an ultra-high temperature milk processing plant, and an aseptic tetra-pack packaging unit from Swedish suppliers. The problem was not to convert all of this to the production of ultra-high temperature cream. The Swedish suppliers were generally helpful in suggesting ways to adapt their plant to the higher viscosity encountered in cream. The actual details of the conversion had to be developed by a joint project team conprising representatives from the firm, An Bord Bainne,[5] An Foras Talúntais,[6] and a professor of agriculture engineering, from one of the universities.

A Tunable Modulation Meter

Electronic modulation meters have always presented the technician with a problem. They require an almost endless process of balancing various adjustments before a reading can be made. In one Irish firm, this problem was enough to stimulate an engineer to action. He decided to develop a modulation meter that would be essentially self-tuning, and that would perform the balancing process electronically over a board frequency range. All of his development was conducted within his own firm. The stimulus was internal, and he never sought any assistance, other than provision of standard components from outside his firm. The firm provided him with the necessary time and resources to accomplish the development and were able to diversify into an entirely new product line as a result.

Canning of Mushrooms

The manager of an Irish cannery, while visiting London, happened to stay in

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[5]The Milk Marketing Board.

[6]The Agricultural Research Institute

the same hotel as a manager from a British subsidiary of a large American food distributor. During the course of their stay, the two met, got into a general conversation over the problems of the industry, and eventually onto the topic of canning and marketing mushrooms. The man from the British firm reported back to his superiors that he knew of a firm that was potentially capable of meeting the firm's need for an additional supplier. Shortly after that, the British firm approached the Irish cannery on a formal basis with a proposal they would be willing to buy a substantial quantity of canned mushrooms for marketing in the United Kingdom, if the cannery could scale up their output sufficiently, while maintaining quality standards. The cannery, as a result, made an investment in new machinery and undertook a one year development project. They were helped in this project by the British firm and by a domestic machinery broker who advised on the type of machinery needed. They also visited The Netherlands to see a mushroom cannery in operation and to discuss the general problems of this process with a Dutch cannery. Some of the necessary machines were purchased from the Dutch firm. A British can manufacturer was also very helpful. Representatives of that firm visited, the cannery, ostensibly to provide assistance with the process of seaming the cans, in fact, they were extremely valuable in passing along other information. From their experience in working with many canneries, they had acquired considerable knowledge of the entire process and are able to provide advice on the cooking, packing and wrapping operations, as well.

Process Simplification

One chemical firm had formerly purchased herbicide acids in powder form from foreign suppliers. They then were required to mix the powder with an appropriate solvent for the product was eventually employed in a liquid form. The only reason for purchasing the material in powder form had been ease of

shipping. The acids are originally produced as liquid, and the manufacturer had to dry them into powder for shipping.

With the advent of liquid cargo containers that could be transferred directly from ship to truck-bed, it became apparent to the general manager of this firm that the drying stage could be dispensed with. He contacted shippers and suppliers and negotiated to have his supplies shipped in liquid form. This not only reduced his initial costs, it decreased inventory requirements, and allowed him to move his order date closer to the season, in which farmers would need his product. This enabled him to make more accurate predictions of market requirements, reduced the probability that he would over or understock the material.

RESULTS

Data were obtained on 63 innovations. Two of the firms, one in the meat packing industry, the other in the building materials industry were unable to uncover any significant change, over the past 30 years, in their method of operation. In the former case, the firm's general manager gave more than the usual amount of time to the interviewer, and was exceptionally helpful, but had to confess that the firm was run in essentially the same way that it had been under his grandfather's management. In the latter case, there is some reason to suspect that the firm was merely attempting to avoid the bother of an interview. What they claimed was that they had no significant change in either product or process in over 30 years and that there was therefore no one available competent to discuss the last change.

Disregarding these two firms, the mean age of the remaining 63 innovations is about three years. There is some difference across the ten industries (Table III), but these should not be taken as measures of the degree of "innovativeness" of the industries. As a matter of fact, two of the industries with the most complex innovations (electrical & electronics and milk products), are above the mean

in length of time between introduction of the innovation and our interview.

The age of the innovations is presented mainly to provide some idea of the reliability of the data. Presumably, the data will be less reliable, the further back in time that respondents had to recollect events.

Table III

industry	mean time since introduction of innovation (years)
milk products	4.5
bacon	2.9
other meat	3.0
canning	1.6
chocolate, confectionery	2.0
building materials	4.2
electrical & electronics	3.4
men's and boys' clothing	4.7
chemicals and pharmaceuticals	0.8
machinery manufacture	1.4

Idea Sources

Sources for initial ideas were many and varied. Almost a quater of the messages[7] came from within the firm (Table IV), indicating a reasonably high level of innovativeness on the part of the firms, themselves. It is worth noting that while there is a slight tendency for foreign-owned firms to generate more ideas internally, that this difference is not significant statistically (Table V).

[7] When a respondent cited one or more sources as contributing components of the initial idea, each was credited with having supplied a "message."

TABLE IV

Sources of Initial Ideas for Innovations

	number of messages	proportion
internal to the firm	33	23.6%
external to the firm	107	76.4
Total	140	100.0

TABLE V

Internal Generation of Innovative Ideas by Foreign-owned and Irish Firms

ownership of firm	proportion of messages generated: (N=140)	
	internally	externally
Irish	21.2%	78.8%
foreign	30.6	69.4

$X^2=0.84$ $p>>0.10$

Considering information coming from outside of the firm (Table VI), several points should be made. First of all there is the usual discovery that nearly all of the information is obtained through direct personal contact. About eight percent of the messages were delivered through documentation (Cf., Allen, 1966; Myers and Marquis, 1969; Langrish, et.al., 1972). Then there is the degree to which other firms serve as sources of new technology. Seventy-nine percent of the messages came directly from other firms. Sixty-three percent came from firms outside Ireland.

Once again, technology is found to flow through informal channels. The role of documentation is relatively insignificant. But so too are the formal agencies established to introduce new technology into industry. At the low frequency end of the spectrum, we see that none of the ideas resulted from any work in universities either Irish or foreign. Furthermore, the government sponsored research institutes (Institute of Industrial Research and Standards; An Foras Talúntais; and An Foras Forbartha)[8] together account for less than two percent of the messages. The position of the universities is not surprising, although this does not make it any the less distressing. The situation with the research institute is both surprising and distressing. One of the goals in establishing such institutes is that they produce new concepts and ideas with a potential for new products and processes in Irish industry.

Far more important than any of these is direct contact between firms, even between apparent competitors! Suppliers, of course, are the most important source, since so many of the new ideas involved the introduction of some new piece of production equipment.

The number of ideas coming from firms in the same industry is surprising until one examines the location of the firms. Most of them are foreign.

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[8] Responsible for research in support of industry generally; agriculture and food processing; and physical planning and construction, respectively.

TABLE VI

Sources (external to firm) of Initial Ideas for Innovations

source	number of messages	proportion (percent)
supplier or vendor	32	29.9%
domestic	3	
foreign	29	
firm in same industry	31	29.0
domestic	7	
foreign	24	
parent firm	10	9.3
domestic	2	
foreign	8	
private consultant	5	4.7
domestic	0	
foreign	5	
trade journal	7	6.5
customer	6	5.6
domestic	1	
foreign	5	
government department	4	3.7
trade fair	4	3.7
domestic	2	
foreign	2	
firm in different industry	3	2.8
domestic	3	
foreign	0	
government sponsored research institute (IIRS; AFF; AFT)*	2	1.9
publications other than trade journals	2	1.9
industry association	1	0.9
university	0	0
Total	107	99.9

* Institute of Industrial Research and Standards; An Foras Forbatha; An Foras Talúntais.

Furthermore, very few of the foreign contacts are with British firms. They are primarily with firms located on the continent. These apparently do not (or did not, prior to Ireland's entry into the EEC) see the Irish firms as competing in the same market. They were therefore quite free with information. In a typical scenario, an Irish manager might visit a trade show on the continent, and be invited on a plant visit by representatives of a Danish, Dutch or German firm. While there he would encounter some new manufacturing technique, that he would later introduce into his own firm (Cf. the Tumble Processing of Hams case, on p. 5).

In the case of Irish and British firms, there appears less transfer of information, within the industry, presumably due to the pressures of competition. Now, what about Ireland's entry into the European Economic Community? Will that make the Irish appear as competitors to continental firms, and close off this supply of technology? The evidence on this is incomplete, but thought-provoking (Table VII). The comparison of data gathered in 1972 (prior to EEC

Table VII

Sources of Ideas Before and After Ireland's Entry into the Common Market

idea source	proportion of messages	
	1972	1974 & 75
foreign firms in the same industry	25.0%	8.3%
other	75.0	91.7

$X^2=2.31$ $p=0.14$

entry) with that of 1974 and 1975 would indicate some possibility that continental firms are becoming a less reliable source for new technology. The data in Table VII should be interpreted with some care, however. First of all the difference is far from significant statistically. In addition, the data were taken from entirely different industries in 1972 and in 1974 and '75. The only way to test conslusively for a difference would be to return to the same industries that were surveyed in 1972. This is a distinct possibility, which will be considered in future research planning.

Foreign Ownership

More than one-fourth (27 percent) of the firms are subsidiaries of foreign firms. Judging from the data in Table VI, one might conclude that foreign parent firms were relatively insignificant sources of new technology for their subsidiaries. Looking only at the foreign-owned firms, however, the picture is somewhat different. In the case of foreign subsidiaries, 32 percent of the idea generating messages came from parent firms. This was the principal source of new technology for this set of firms (Table VIII).

There are a few other slight, but not quite significant differences between the Irish and foreign firms studied, thus far. For example, Irish firms tend to obtain more of their technology from within their own industry (Table IX). Since most of the firms, from which they obtain ideas are outside of the country, this may be a source which is more available to domestic firms, than to subsidiaries of multi-nationals. As argued earlier, the donor firms did not see the Irish as competitors. They presumably did see the multinationals in that way and were less willing to share ideas with them. Of course, if EEC entry has closed this source to Irish firms, then they will lose this advantage. This is an area deserving further study.

TABLE VIII

Sources (external to the firm) of Innovative Ideas as a Function of Ownership

source	proportion of messages (percent)	
	Irish-owned firms	foreign subsidiaries
supplier or vendor		
domestic	2.4%	4.0%
foreign	28.0	24.0
firm in same industry		
domestic	6.1	8.0
foreign	25.6	12.0
parent firm		
domestic	2.4	—
foreign	—	32.0
private consultant		
domestic	0	0
foreign	4.9	4.0
trade journal	8.5	0
customer		
domestic	1.2	0
foreign	6.1	0
government department	4.9	0
trade fair		
domestic	2.4	0
foreign	2.4	0
firm in different industry		
domestic	0	12.0
foreign	0	0
government sponsored research institute (IIRS; AFF; AFT)*	2.4	0
publications other than trade journals	1.2	4.0
industry association	1.2	0
university	0	0

* Institute of Industrial Research and Standards; An Foras Forbatha; An Foras Talúntais.

TABLE IX

Comparison of Irish and Foreign Firms in the Extent to Which Ideas Came from Firms in the Same Industry

	Proportion* of Idea Generating Messages from Firms in Same Industry as Recipient
Irish Firms	21.9%
Foreign Subsidiaries	8.6

*Documentary sources excluded in calculating percentage
$X^2=2.21$, $p=0.15$

Table VI illustrated very clearly the failure of the universities and research institutes as source of new technology for industry. Table VI is based on the entire sample, including both Irish and foreign-owned firms. When the two are separated, an interesting difference appears. None of the foreign subsidiaries obtained ideas from universities, research institutes, government agencies, or industry associations (Table X). These sources served only native Irish firms. There is therefore a slight tendency for Irish firms to substitute for lack of a foreign parent by turning to these bodies. And this is exactly the function they are supposed to perform. The evidence would indicate that these bodies are performing this needed function, but not to the extent necessary. Foreign subsidiaries obtain one-third of their new ideas from the parent firms. Irish firms obtain less than eight percent of their new ideas from these non industrial research institutions. There is still a considerable distance to go before the role of "substitute parent" is completely fulfilled.

To reiterate the opening point, the differences between Irish and foreign

firms are weak but intriguing. It will be interesting to see, as more data are gathered, whether these tendencies are reinforced or diminished.

TABLE X

Comparison of Irish and Foreign Firms in the Extent to Which Ideas came from Non-Industrial Irish Research Organizations

	Proportion* of Idea-Generating Messages from Universities, Research Institutes, Government Departments and Industry Association
Irish Firms	7.3%
Foreign Subsidiaries	0

*Documentary sources excluded in calculating percentage
p=0.11 (Fisher Exact Probability Test)

Inter-Industry Variation

The ten industries differed in the extent to which they used different sources for new ideas. Some relied more than others on internally generated ideas; and some showed greater use of foreign sources (Table XI).

Table XI

Location of Idea Sources by Industry

industry	sources*		
	within firm	domestic contacts	foreign contacts
milk products	16.0%	28.0%	56.0%
bacon	28.6	21.4	50.0
other meat	10.0	0	90.0
canning	22.2	33.3	44.4
chocolate & confectionery	25.0	16.7	58.3
building materials	23.1	7.7	69.2
electrical & electronics	58.3	0	41.7
men's and boys' clothing	21.4	28.6	50.0
chemicals & pharmaceuticals	33.3	11.1	55.5
machinery manufacture	25.0	25.0	50.0

*excluding written sources

The largest variance is in the use of foreign sources.

Inter-industry variation of this sort should not be terribly surprising. The ten industries differ greatly in many respects, including their structure, technological development and degree of foreign ownership.

One might expect technology flow patterns, therefore, to be dependent upon such industry characteristics. In more specific terms, it can be hypothesized that:

1. Firms from industries with a more advanced degree of technological development (e.g. electrical & electronics; chemicals & pharmaceuticals) will have a higher proportion, than other industries, of internally generated ideas. This should result from the fact that firms in such industries normally have at least a few technically trained personnel on their staff. Such personnel should be more capable of developing feasible new product ideas or process modifications.
2. Firms from less technologically developed industries will rely more on idea sources outside of the firm, and the location (domestic or foreign) of these sources will be determined by:
   a. the strength of the relevant technological infra-structure, as it exists in Ireland. Where the technological infra-structure is strong, there will be greater use of domestic sources; where it is weak, foreign sources will dominate.
   b. the degree of foreign ownership of firms in the industry. Where foreign ownership is high, there will be greater use of foreign technology sources, and vice versa.

Comparing the two high technology industries (electrical & electronics and chemicals & pharmaceuticals) with the others (Table XII), we see that the evidence strongly supports the first hypothesis. Firms in high technology industry are more self-reliant in terms of new technology.

Comparing industries on the basis of domestic technological infrastructure is a bit more difficult. There is evidence, however, that would argue that the food processing industries might have a more developed technological base in Ireland (Herzog, 1975). An Foras Taluntais is the largest of the research institutes, and a substantial amount of food-related research is pursued both in that institute and in the universities. The first part of the second hypothesis

TABLE XII

Location of Technology Sources Used in High Technology Industries

industry classification	sources*	
	within firm	outside of firm
high technology (electrical & electronics; chemicals & pharmaceuticals)	47.6%	52.4%
other	20.9	79.1

*excluding documentation
$X^2 = 5.33$, $p = 0.02$

TABLE XIII

Location of Technology Sources Used by Firms in the Food Processing Industries

industry classification	source*	
	domestic	foreign
food processing	28.5%	71.4%
other	20.0	80.0

*Sources external to the firm, excluding documentation

$X^2 = 0.638$, N.S.

was therefore tested by comparing food processing with other industrial sectors, in terms of the extent they rely on domestic sources of technology (Table XIII). The data exhibit a slight but non-significant tendency of good processing firms toward domestic technology sources. The relationship is certainly not strong enough to support the hypothesis.

Many of the firms in the sample are subsidiaries of foreign firms. As such, they might be more inclined toward foreign sources of technology. In fact, there is little support in the data for this hypothesis either (Table XIV). Both Irish and foreign firms obtained three-fourths of their idea-messages outside of the country. So there is not support for the hypothesis that ownership influences the extent to which domestic technology is used.

TABLE XIV

Location of Technology Sources Used by Foreign Subsidiaries

	source*	
	domestic	foreign
Irish firms	25.6%	74.3%
Foreign subsidiaries	25.0	75.0

*Sources external to the firm, excluding documentation

$X^2 = 0.041$, N.S.

Nature of the Innovation

Out of the 63 innovations, 21 were product innovations, while 42 were process innovations. This ratio of 1 to 2 in favor of product and component innovations found in the Myers & Marquis (1969) study of commercially successful innovations in U.S. industry. The prevalence of process innovations in

the present study is probably due to the nature of the industries that were studied. The proportion of process innovations varies widely among industries, ranging from 20 percent in the chocolate and confectionery industry to 100 percent in chemicals and pharmaceuticals (Table XIII). It is tempting at this point to speculate that this might be a result of ownership, with foreign firms being more inclined, toward process improvements for existing products, and domestic firms searching for new products. The data clearly do not support this possibility (Table XIV).

TABLE XIII

Proportion of Process Innovations by Industry

industry	proportion (percent)
milk products	66.7%
bacon	87.5
other meat	100.0
canning	66.7
chocolate & confectionery	20.0
building materials	83.3
electrical & electronics	25.0
men's and boys' clothing	66.7
chemicals & pharmaceuticals	100.0
machinery manufacture	66.7

$X^2 = 18.59, \quad p < 0.05$

An alternate explanation stems from the recent work of Abernathy and Utterback (1975). All of the industries, with the exception of electrical & electronics and chemicals & pharmaceuticals are relatively mature.

TABLE XIV

Proportion of Process Innovations by Irish and Foreign Firms

	proportion of process innovations
Irish Firms	72.3%
Foreign Subsidiaries	52.9

$X^2 = 1.34$, $p >> 0.10$

Most of the firms in the sample are in what Abernathy and Utterback (1975) call a "specific" stage of development. The product has become standardized, production volume is relatively high and cost has emerged as the primary basis of competition. Abernathy and Utterback argue that for fairly obvious reasons, process innovation will dominate in this stage. This is the situation in which most of the firms were found in all industries, with the possible exception of the electrical and electronics industry. This along with chocolate and confectionery are the only industries with a predominance of product innovation. The electrical and electronics industry is much closer to what Abernathy and Utterback call the "fluid" stage of development. Here product design is subject to radical change, product characteristics are in flux and the emphasis of product innovation is on improved functional performance, rather than cost.

While electrical and electronics can be considered at the "fluid" stage, in which product innovations predominate, this is probably not true of the chocolate and confectionery industry. The firms in that industry would seem to be in Abernathy and Utterback's "specific" stage. Why then so many product innovations? This would appear to be an exception to the Abernathy and Utterback theory. A partial explanation lies in the fact that many of the new product innovations were critically dependent upon the development of new manufacturing processes. For example, in the case of one product innovation, a new type of candy bar, the critical problem to be solved was a process problem. A machine had to be specially developed to bind the chocolate covering to the nougat interior. It was the development of this machine, which made the new product possible. This does not meet the requirements of the "specific" stage, perfectly. It is really a combination of two innovations, both product and process. But the process development does not have cost reduction as its principal aim. Nevertheless, the evidence might allow the categorization of this industry as somewhere between the fluid and specific stages.

The net result of all of this, is simply that the high incidence of process innovation in the sample should not be surprising. At least according to the Abernathy and Utterback theory, this was determined by the nature of the industries surveyed. Future analysis will be directed at industries, which the theory would predict to be more inclined toward product innovation. This will provide a more rigorous test to see whether there might be factors in the Irish situation which make process innovation more likely.

The Problem Solving Phase

After a firm decides to go ahead with a new product or process, it normally encounters a series of problems which must be solved before implementation is successfully completed. While many of these problems can be solved by the staff of the firm, aid is often sought from outside. Two-thirds of all the

Table XV

Sources Used in Solving Problems Associated With the Introduction of the Innovation

source		number of messages	percent
internal to the firm		34	33.3
parent firm		8	7.8
	domestic	0	
	foreign	8	
firm in same industry		9	8.8
	domestic	2	
	foreign	7	
firm in different industry		2	2.0
	domestic	2	
	foreign	0	
supplier or vendor		32	31.4
	domestic	11	
	foreign	21	
customer		1	1.0
	domestic	1	
	foreign	0	
private consultant		9	8.8
	domestic	8	
	foreign	1	
government-sponsored research institute (IIRS; AFF; AFT)		2	2.0
government department		2	2.0
university		1	1.0
trade journals		1	1.0
other publications		1	1.0
Totals		102	100.1

problem solving messages originated outside of the firm (Table XV). The most important category outside the firm is, not surprisingly, the supplier or vendor. The manufacturer of production equipment is normally bound under warranty agreement to solve any problems which arise with the use of his equipment.

Private consultants are also engaged frequently at this stage. However, there is still precious little resort of the research institutes, and even less to the universities.

While foreign sources are still the most important, domestic sources do increase in importance, at this time (Table XVI). This is the point at which the research institutes might be especially helpful, if a means could be devised to encourage firms to approach them when they encounter problems in implementing new technology. Of particular interest, at this point, is the extent to which the research institutes are bypassed, in favor of private consultants. Granted that in some instances, the consultants were paid for by government grants, the fact remains that the research institutes should be able to fare somewhat better, than they do, in this competition.

TABLE XVI

Location of Problem Solving Information Sources

	proportion of instances used*	
	idea generation	problem solving
within the firm	23.6%	33.3%
domestic outside the firm	17.6	28.4
foreign	52.1	36.3
documentary	6.4	1.9

$X^2 = 10.8 \quad p < 0.02$

Development of Foreign Contacts

The principals, who were interviewed were generally well acquainted outside of their country. A substantial majority had actually worked outside of the country for some portion of their career. The typical Irish manager, in this study, is an ardent traveller. We have grown accustomed in recent years to seeing parties of Japanese businessmen, complete with cameras, in nearly every air terminal in the world, combing the industrial hinterlands for hints of a profitable technology. At least insofar as Western Europe is concerned the Irish need second place to no one. The Irish managers, who were interviewed in this study, were inveterate travellers, taking in at least one foreign trade show per year, often coupling this trip with a visit to a foreign firm in the industry or to a supplier of equipment used in the industry.

DISCUSSION AND PRELIMINARY RECOMMENDATIONS

If we take each of the results, in turn, there are a number of lessons that may be gleaned from these data. First of all, the importance, once again, of direct personal contact, in transferring technology.

Personal Contact and Investment in Documentation Systems

The overwhelming dominance of personal contact in technology transfer has been replicated in study after study, yet it is consistently ignored by policy-makers (cf. Cooney & Allen, 1975). If one's goal is to introduce new technology into Irish industry (or the industry of any other country), then it should be obvious by now that documentation retrieval and reprint services will not accomplish the goal. More than that, they are not only ineffective but since they divert scarce resources from more worthwhile programs, their net contribution is negative.

Of course, one of the reasons for the concentration of effort in documentation services is that they are relatively easy to implement. Promoting effective personal contact is not quite so easy. Nevertheless, there can be

no excuse for pursuing ineffective programs, because the alternative is difficult. We must develop policy that effectively utilizes the one proven approach to transferring technology.

The Role of the Research Institute

The next question, that arises, is concerned with the sources of technology or the direction of technology transfer. At the present time, we observe certain sources of technology which are utilized and other potential sources which are not used at all. This differential usage could be the result of either the perceived value of the sources or of the ease with which information can be obtained from them. Allen and Gerstberger (1973) research would indicate that is more likely the latter than the former. One should then not be led to the conclusion, that the technology sources being used are the only ones of any value. There may be forces inhibiting the use of even more effective sources.

The research institutes are a case in point. They were established to develop technology that would contribute to the economic development of the country. Judging from the data, they are of little value to industry as sources of new technology. The Institute of Industrial Research and Standards deserves special mention in this respect. Several of the people who were interviewed, without knowing entirely, the purpose of the study, volunteered their opinion of the IIRS. These were unanimously negative in their appraisal. The comments, furthermore dealt both with the substance of IIRS activities, which were deemed, of low quality and irrelevant to industry needs, and to the inaccessibility of even this irrelevant information. IIRS has no concept of what the small businessman needs in terms of technology, that they have no mechanisms for properely assessing these needs, and that, "whatever they may be doing up there, it couldn't possibly be of much value."

Now the task of an organization, such as IIRS is an extremely difficult one. It is not able to focus on a single industry or even subset of industries. It must be all things to all firms. Were it able to focus on a particular segment of industry with a narrow set of technological needs, then there might be some hope for its meeting those needs. As it is, the task is a hopeless one. A point well supported by the present data. The organization is not really aiding industry, and it would be better abandoned.

But what about a more narrowly focussed organization, such as An Foras Talúntais? The present data do not show its performance in technology transfer to be very high, either. That is true. But there is certainly some chance for improving this performance, so long as An Foras Talúntais' efforts are focussed on the food processing sector. There is for example, evidence that communication between An Foras Talúntais and R&D performing firms, in the food industry is very good (Allen & Cooney, 1974). This institute has developed strong relations with the firms, who themselves perform R&D. This tendency to better serve the R&D performing firms stems directly from the orientation of the institute toward research. It established itself early as a preeminent research contributor. This attracted those who understood and appreciated research to it. Its personnel, because of their background and orientation, were able to understand and appreciate the problems faced by industrial R&D, in their specific fields of competence. As a result, An Foras Talúntais is able to effectively augment R&D performed by Irish firms in the food processing sector.

When it comes to firms, who do not support R&D, this type of rapport has yet to develop. This is perfectly understandable, particularly by an author who has recently visited many such firms. These firms tend to be using very backward technology, and to have little appreciation of what benefits might stem systematic attempts at developing new products or processes. It is somewhat difficult for a person trained in academic research to understand and com-

municate with the principals in such firms.

This is not an impossible problem, however. Increased exposure of one to the other will increase mutual respect and understanding, and should ease communication. This is absolutely necessary before these firms, which so desperately need improved technology, can be helped. The agenda for An Foras Talúntais must emphasize the need for increased interaction with food processing firms, particularly those which support little or no R&D, themselves.

Criticism is often heard of the tendency of institute personnel to be too concerned with "basic" research and publication. Naturally people are going to work on problems that lead to publications and publications only, if these are the only kinds of problems that come to their attention. But if they are presented with problems of a practical nature and encouraged by the reward system to pursue these, there is no reason why they won't find these problems just as appealing.

We would not argue that all of this will come about automatically or even easily. In some cases it will require a marked change in outlook on the part of the researcher. In some instances it will be impossible to interest an individual in applied problems. We would argue that these cases are rare and that in most cases the institute scientist is most concerned with working on interesting and important problems. Our main point is that there are problems in industry, which are both scientifically interesting and important, but that the scientist must be brought into direct contact with them before he can become aware of this simple fact.

One way of initiating such a process would consist of having teams of R&D personnel visit a sample of firms periodically, preferably just prior to project review and budgeting time. This team would be knowledgable in the technologies, underlying the firms' activities and would seek out problems and areas which might be improved by systematic research or development effort.

A case in point: at the time of the first interviews, no one really understood why the process of tumbling hams together for a period of time results in protein migration and increased yield. This appears to be a reasonably fundamental research problem with very definite practical benefits. There are no doubt a very large number of such problems, begging to be undertaken. A research institute must actively seek out such problems. A first step would be the suggested formation of technically competent teams of individuals from potentially relevant disciplines to go on site inspections of firms in specified industries. The team's goal would be not to help specific individual firms, but rather to search out general problem areas where the applications of their research might benefit an industry. The experience of catologuing areas for potential improvement of either production processes or products will prove invaluable in directing and selecting research projects later on. That is why it is strongly suggested that such tours be tied to the project selection and budgeting cycle.

Another possible incentive to interaction between industry and both universities and government research institutes would be to funnel at least part of the government's funding of the universities and research institutes, through industry. Industrial firms would be provided budgets, or vouchers, that can only be spent to support research in a research institute or university. The firm, itself, however, has complete authority within these limits over selection of both project and source, and may even choose not to spend the money, at all.

Such a scheme would motivate industry to be more directly concerned with the activities of the institute or university department. Most research institutes have boards or steering committees to oversee their activities now. Such boards are often little more than "rubber stamp" affairs. They have neither the time nor the inclination to delve very deeply into an institute's activities.

If they were spending money (even someone else's money) in an institute, they would be much more careful in monitoring the activities of that institute, and in seeing how the money was spent.

For their part, institute personnel will quickly seek out customer interests once the fact becomes clear that the customer had money to spend on research. Twenty years in one or another type of R&D organization has convinced the author that researchers are eminently capable of discovering a customer's needs once it becomes clear that the customer has money to spend. That is not to say that they will completely re-orient their work. They will adapt, and try to convince the customer that his needs will be met, if they pursue their interests. The customer can allow himself to be convinced or seek his help elsewhere. Through this negotiation process, both user needs and supplier capabilities become more fully explicated and understood by both sides. The work of the institute cannot help but become more relevant and more widely used by industry.

The Role of the Universities

This strategy should promote university/industry as well as research institute/industry interaction. Since this is, perhaps, a more difficult problem, there are other approaches which might be tried, as well. Trinity College, for example, has recently established an Industrial Liaison Office (Wallace, 1971). This has now been followed by similar operations at University College, Galway and Univeristy College, Cork. A single liaison officer per university, however, is hardly sufficient to such an enormous task. The Massachusetts Institute of Technology has been reasonably successful in pioneering such a function in the United States. Even after taking account of the disparity in size (M.I.T. has a faculty size of about 950), the scale of operations of the Industrial Liaison Office at M.I.T. is much larger than is being attempted in Irish Universities. The M.I.T. program is primarily aimed at raising money for the university. While this is not a necessary goal of the program in

Ireland, firms could be asked to contribute something to offset the cost of the program. The M.I.T. program is now experimenting with a new mechanism to stimulate faculty interest in cooperation. Faculty are allotted points for different forms of cooperation: two points for entertaining an industrial visitor for an hour in the faculty member's office; six points for participating in a symposium for industry; eight points for a plant visit; and so on. Ten percent of the income from the program is then distributed to the faculty in proportion to their point totals for the year. This money is not taken in the form of income, but can be used to supplement other funds for the procurement of computer time, purchase of needed instrumentation, or support of research staff. The plan has been in operation for two years and faculty response has been very strong. The total number of points accrued by the faculty (a measure of involvement) increased by 32% from the first to the second year of the program. In addition to the overall increase in activity, there was an increase in the number of participating faculty, as well. University faculty can determine as well as anyone, which side of the bread carries the butter. They behave accordingly. A program of this sort can serve as a two-way stimulus. It not only provides an incentive for faculty to see that the results of their work reach potential users; it opens a channel through which the university researcher can be influenced, in his selection of research problems. This is not to say that he sacrifices any of his freedom, in this regard. Rather, he is now provided with more information, and should be able to make a better decision, whether it is in accord with industry's current desires, or not.

Foreign Ownership

Since so many of the firms in Ireland are subsidiaries of foreign firms, it is interesting to note the different patterns that have developed for foreign and domestically owned firms. Foreign firms are overwhelmingly the captive of their parent. Parent firms are heavy providers of technology. That this

technology is biased in terms of the overall corporate plan is a foregone conclusion. While this is not necessarily bad, it can stifle creativity in the subsidiary, and prove extremely frustrating to the more inventive or entrepreneurial managers, in the subsidiary. There is among the cases, at least one local project, which was strongly discouraged by a foreign parent firm. There were also some stories volunteered of "very promising" projects which had been quashed, because they did not fit well in the overall business plan of the multinational. This can be extremely frustrating for local managers and can stifle projects of potential value to the country.

Nevertheless, there is no denying the evidence that parent firms serve as a rich source of technology for their subsidiaries, and may have a generally positive effect on domestic technological development.

The domestic firm, being denied access to foreign technology through a foreign parent, has effectively substituted for this by direct contact with firms outside of the country. This is an avenue denied to the foreign firm by competition. The potential closing of this channel to the domestic firm is a situation that deserves close attention. There is some evidence, although still relatively inconclusive, that this is happening. Future research must be addressed to this possibility.

As continental European firms come to perceive the Irish as direct competitors, they will become less willing to share their technology. Attempts should be made to increase the amount of informal contact between Irish firms and firms in America and Japan. This would compensate for the loss of European contact.

Domestic Technology

In the technologically more advanced industries (chemicals, electronics, etc.), we find a significantly higher proportion of internally generated ideas.

There is also a slight, but non-significant, tendency for firms in these industries to be less reliant on foreign technology. There is no evidence that the firms in these industries are being aided at all by the technological infra-structure of the country. They are not helped by the research institutes and universities any more than firms in other industries. One might suspect that, since these firms have developed, on their own, a slightly higher degree of technological sophistication, that they might find some basis for greater interaction with the research institutes and universities. The data indicate very clearly, that this has not happened. This is equally true for both Irish and foreign-owned firms.

Ireland has, in certain areas, developed a reasonably sound technological base in its universities and research institutes (cf. Herzog, 1975). Unfortunately this system operates largely independent of the industries, which it could potentially support.

This is a situation that is certainly not unique to Ireland. Most small countries have attempted to aid the technological development of their industry through support of research in universities and research institutes. What evidence there is, on the effectiveness of these measures (cf. Utterback, 1975) would indicate that this strategy has generally failed. The universities and research institutes may develop a very high degree of technological competence, but this is seldom successfully utilized by industry. Drastic measures are called for, to stimulate such utilization. Unless the situation can be radically improved, there can be no justification for government support of such a system.

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