





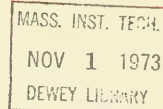
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Institutional Roles in Technology Transfer: A  
Diagnosis of the Situation in One Small Country

Thomas J. Allen and Seán Cooney

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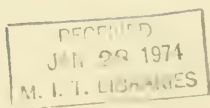
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# ABSTRACT

A survey was conducted in 1970 and 1971 of the communication patterns of 1,500 research and development scientists and engineers working in Ireland. The techniques used in studying individual firms were adapted to suit the conditions within the country.

The findings of this survey indicate that if international transfer of technology is to be fostered, more attention should be paid to the development of interpersonal and interorganizational contacts. This is not in itself a complete answer to international technology transfer, but this study suggests that it may well be the least expensive of the available mechanisms.



## INTRODUCTION

The rapid expansion of the world's store of scientific and technological knowledge presents the small nation with a particularly vexing problem in maintaining its scientific and technological communities abreast of foreign developments. To assure its survival and growth the small country must not only acquire foreign scientific and technological information, but it must also solve the more difficult problem of seeing that this information is disseminated to those points where it can be utilized.

This problem has been discussed extensively in recent years and numerous solutions have been proposed. The majority of these, however, are concerned only with the first problem, that of bringing information into the country (acquisition), and they either ignore or give only cursory treatment to dissemination. As many research laboratories have sadly learned, the mere possession of information does not guarantee its utilization by those who require it.

The problem of dissemination is a particularly difficult one. Most of the recent work in the field of technical information has gone into the development of hardware and software packages which provide at best, only partial resolution of the dissemination problem. National dissemination of scientific and technological information is highly dependent upon the ways in which science and technology are organized in the country, upon the existing institutional forms, and upon relations among both institutions and people. This is true whether the source of information is domestic or foreign. To advocate reorganizing or establishing new or additional institutions without first understanding the roles in the dissemination process of existing ones would indeed be foolhardy. As a first step, a thorough investigation must be undertaken to ascertain the respective roles and the effectiveness of the various types of institution which exist in the country.



Similarly, acquisition mechanisms must be subjected to scrutiny. The allocation of resources to different methods of information procurement should be determined on the basis of their relative cost-effectiveness. Although considerable effort has been devoted to evaluating the effectiveness of information acquisition mechanisms, this effort has been, for the most part, restricted to the evaluation of hardware and software systems. Little is known about the human element in the acquisition process. The effectiveness of mechanisms such as foreign training of scientists and engineers, employment of foreign nationals, attendance at international conferences, foreign sabbaticals, etc., must be determined. Since research into the dissemination process has shown the overwhelming importance of personal contact, such approaches to acquisition will have a natural kinship with the dissemination system. In fact, they may prove to be more effective than all of the hardware, software and print-oriented devices combined.

Any country, whatever its size, would certainly benefit from a better understanding and evaluation of its strategies for acquiring and disseminating technical information. For the small, growing nation, however, the need is at once both more acute and more capable of fulfillment. Fortunately, because of its size much more can be learned about the functioning of science in a small country. The entire country can be made a unit of analysis, and the entire scientific and technological community can be reached and studied in considerable detail, at reasonable cost.

The rationale for this approach to the problems of the small country grows out of a program of research, which was initiated at the Massachusetts Institute of Technology in 1963. The implications of this work have been widely disseminated (see, for example, Allen, 1970), and are well known in the context of individual research laboratories in government and industry, where much of the earlier studies were carried out.



More recent work suggests, however, that the relevance of these questions, and the answers provided by communication research, goes beyond the individual laboratory and deserves the attention of national governments, international organizations and other agencies concerned with the relation of information transfer or dissemination to economic development.

A pilot study was carried out (Allen, et. al., 1971) in one Research Institute, and clearly demonstrated the existence of the international technological gatekeeper as an intermediary in the transfer of technology between nations. The international gatekeepers display similar characteristics to their U.S. counterparts, being, on average, more technically competent and more productive, more highly qualified than their colleagues and reading the literature more extensively. The pilot study has now been extended to include the entire research and development community of the Republic of Ireland.

Examination of the entire R&D community of a country affords the opportunity, for the first time, of viewing the process of information acquisition and dissemination at a more inclusive system level. Individuals can now be grouped according to their organizational affiliation (or other relevant aggregations) and the roles of, and relations between institutions can be studied. More particularly, one can ask whether any of the phenomena which have been observed to operate at an individual level, within single organizations, also function at an organizational level. Do, for example, gatekeeper organizations exist, to which other organizations turn when in need of information from outside of the country? What factors influence the development of communication between organizations of various types in a country? It is to questions such as these that the present paper is addressed.





## The Survey

Ireland has a population of some three million in an area of 70,000 sq.km. Compared to many countries it is sparsely population, at a density of 42 sq.km. One of the chief causes of the sparseness of population has been heavy emigration, which continued for over a hundred years. Encouraging emigration has been the chronic high volume of unemployment or underemployment.

The Irish government in recent years has sought to stem excessive emigration and create more and better employment opportunities by a series of development programs. These have used grants to agriculture and industry, investment in state-sponsored (or "semi-state") companies and improved services to agriculture and industry. One of the objectives of policy is to improve the contribution of science to economic and social development.

A survey was conducted in 1970 and 1971 of the communication patterns of 1,500 research and development scientists and engineers then working in Ireland. The techniques used in studying industrial firms were adapted to suit the conditions within a country. Data collection was in two stages. In the first, covering one major research institute, responses were received from almost 200 scientists. These were analyzed and results published (Allen, et. al., 1971). In the national survey, responses were received from more than 1,200 or 80 percent of the population responded. Of these more than one hundred either disqualified themselves or had to be disqualified for various reasons. The principal reason for disqualification was that the respondent had become completely involved in research administration, and was no longer an active researcher. A number of other respondents either answered questions in ways that were uninterpretable or gave answers that were unusable, so for any given question the size of the sample was often further reduced, resulting in about 1,000 questionnaires, plus or minus 25, that were analyzed on any given question. This is about two-thirds of the estimated population size, and should be large enough to provide results that are valid for the population, as a whole.



The questionnaire, itself, requested information on demographic variables, such as age, education, field of research activity and years of technical experience, but in addition information was obtained on each respondent's present and former employers both within and outside of Ireland, and on each respondent's communication activity at three levels: within his organization; within the employers both within and outside of Ireland, and on each respondent's communication activity at three levels: within his organization; within the country outside of his own organization; and outside of the country. Data such as these can be analyzed in many ways. The present paper is concerned only with the flow of information into and among the various research institutions in the country. Once communication measurements as these have been made at an individual level it is a relatively straightforward task to aggregate them by specific organization, and to examine the relative strengths of communication bonds between organizations. This provides a measure of the extent to which technical and scientific information flows, via personal contact, from organization to organization or from sector to sector, within the country.

Each respondent was asked to report the frequency (once a month; once every six months; etc.) with which he maintained contact with those outside his organization, and the data were analyzed in terms of a high frequency network (once a month or more frequent) and a low frequency network (less than once a month, but at least once a year).

#### The Communication Bond

In order to compare the amount of communication among organizations, an index had to be developed. There are many possibilities for such an index, none of which are completely satisfactory. The one which has been chosen is one which should allow valid comparisons to be made with a minimum of distortion to the data. The index is based on the number of individuals in any organization, who are reported as communication partners by those in another organization.



$$C_{ij} = K \frac{n_{ij} + n_{ji}}{N_i N_j} 1 - e^{-\frac{N_i}{10^2}}$$

where:

$C_{ij}$  = strength of the communication bond between organization i and organization j

K = a scale factor, in this case  $K = 2 \times 10^2$

$n_{ij}$ ;  $n_{ji}$  = number of individuals in organization j or i who are names as communication partners by their counterparts in organization i or j

$N_i$  = number of respondents in the larger of the two organizations

$N_j$  = number of respondents in the smaller organization

The constant term is simply a scale factor to avoid the use of very small decimal fractions, while the exponential term is a currection factor to offset the effect of wide differences in size of organization.

## RESULTS

As mentioned above, the existence of the "international technological gate-keeper" was established in the first phase, carried out in one research institute in 1970. Although these results have already been published (Allen, et. al., 1971), it may help to mention them here, since they illustrate the implications of the national study very clearly.

The research personnel of this institute are overwhelmingly Irish by nationality (95% are citizens of the Republic or of Northern Ireland). Of the sample population, 30% had Ph.D. degrees; most of the remainder held qualifications higher than bachelor level.

The structure of the internal communication network was modelled by examining responses to the questions regarding each scientist's "most frequent" discussion partners.<sup>1</sup> This gives an index to the number of colleagues who turn

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<sup>1</sup> Respondents were asked to name colleagues with whom they communicated at least once per week.



to a given individual for information, or the number who can (potentially) be reached by information held by that person. Someone who is consulted by many colleagues is likely to be an important information source for his colleagues; he may be called a "communication star".

For such a "communication star" to also be a "technological gatekeeper" he must be well integrated into an external network of foreign information sources; he must use the network regularly, and his network must be broad enough to include a diversity of such foreign sources. Two criteria -- the frequency of foreign technical correspondence and the frequency of foreign scientific and professional meeting attendance -- were used. Each of these channels can be used frequently, and each allows contact with a large number of overseas colleagues. The degree to which they are used is therefore judged to be a good measure of integration into the external network.

The data from this phase of the survey did, in fact show that technical discussion stars do receive significantly more international technical information than nonstars, as measured by frequency of foreign correspondence and attendance at foreign scientific and professional society conferences. They also read a significantly greater number of foreign journals. The gatekeeper hypothesis is quite strongly supported. A total of 26 scientists were identified in the organization, whose communication activities fit the operational definition of a "gatekeeper".

In addition to his communication activity, the international gatekeeper displays somewhat greater technical competence than his non-gatekeeper colleagues. Those in the Institute are, on the average, significantly superior to their colleagues in both publications and patents, and a higher proportion have a Ph.D. degree. Technical performance is extremely difficult to measure, but to the extent that publication of scientific and professional papers and the acquisition





of patents serve as an indicator, the international gatekeeper is a high performer indeed.

### Sector to Sector Flow

There are three principal classes of organization performing research in Ireland. They are: the Universities, the Research Institutes and Industry. In addition, there are a number of smaller organizations including Research Sections in several government departments. There are four major universities in which some of the staff perform research in conjunction with their teaching responsibilities while others are engaged solely in research. There are three major research institutes, which are supported primarily by government funds and which perform research for both industry and agriculture. Finally there are a number of industrial firms, both private and state-sponsored, which support research and/or development work within their own organizations. These are but a very small proportion of Irish industrial firms, but it is important to see how they acquire technology, since they tend to be either the largest firms, or those in industries whose technology changes rapidly, or both. They are an important indicator of the country's capacity to maintain a competitive position in world trade. A further study involving firms which conduct little or no research is in progress.

Broadly, the main communications are provided by the universities and the research institutes. There is relatively little contact between the other organizations. The relative strengths of the bonds (Table I) show communication to be heaviest between research institutes and industry and weakest between universities and industry. If research institutes are, as it seems, the only available intermediary between more fundamental university research and the needs of industry, the communication bonds would indicate that they are performing one part of this function somewhat better than the other. The bond extending forward to



industry is nearly one and one-half times that extending back to the university base. This linking role may be clarified when communication between research departments in different organizations has been analyzed.

Table I

The Strength of Sector to Sector Communication Bonds (Monthly or More Frequent Contact)			
		Communication Bond ( $C_{ij}$ )	
between	and	research institutes	industry
universities		0.285	0.098
research institutes		--	0.422

Of course, the universities are not the only source of new knowledge. In fact, the research institutes themselves may often be the leaders in creating knowledge, particularly of the sort that would be relevant to industrial innovation so, to some extent, the research institutes may be able to operate independently of the university. The communication with which the institutes should really be concerned is the one with industry. In this sense, the situation presented in Table I is probably not a bad one.

In addition to creating knowledge through their own efforts, the research institutes have developed a network of contacts with foreign universities, research institutes and firms. This network allows them to tap information sources elsewhere in the world, as well as from the universities.

#### Foreign Contacts by Sector

The three main research sectors differ both in the extent and amount of foreign contact by their research staff (Table II). Surprisingly, the three research institutes show the lowest frequency of foreign communication. It is not surprising that the universities have strong foreign ties, particularly to the U.K., but it



Table II

Foreign Contact by Research Sector	
Foreign Communication Index ( $C_{if}$ )*	
universities	0.851
research institutes	0.356
industry	0.449
* $C_{if} = \frac{n_{if}}{N_i}$	
where: $n_{if}$ = number of individuals in foreign countries with whom contact is reported by individuals in sector i	
$N_i$ = number of individuals reporting in sector i	

is surprising to see a higher degree of direct foreign contact by industry than by the research institutes. The temptation is to explain this as a result of foreign ownership of industrial firms, a common enough situation under the programs for industrial development which have been pursued for more than a decade. The fact that slightly more than half of the research staff in the industrial sector are employed by semi-state firms however, discounts this explanation. The greater number of the foreign contacts are maintained by private (rather than state sponsored) firms. Not all of these are foreign owned, however, while nearly half of the foreign contacts, themselves, are employed by organizations other than industrial firms.

University contact, in addition to being greater in number, are more evenly spread around the world (Table III). The research institutes and industry turn more frequently to British sources for their information. This situation will undoubtedly alter somewhat with the entry of Ireland into the European Economic Community. Links by all three sectors to the North of Ireland are uniformly weak. Of course, there are fewer contacts available in the North, than in the



Table III

Location of Foreign Contacts by Sector					
research sector	Great Britain	Continental Europe	United States	other countries	North of Ireland*
universities	0.382	0.204	0.174	0.063	0.053
research institutes	0.209	0.090	0.027	0.032	0.047
industry	0.291	0.120	0.019	0.019	0.006
* Not included as foreign in the totals					

U.S., Britain or Continental Europe. Even so, one would expect far more contact with a community of scientists who are culturally, linguistically and geographically so close.

#### The Flow from Institution to Institution

Within each research sector, are a number of institutions. These institutions are connected among themselves to varying degrees, and the coupling to other sectors varies considerably from one institution to the next.

Communication Among the Universities. The two major universities have between them a total of five campuses, one of which was too small to be distinguished in this analysis. Of the remaining four (which will be referred to as A, B, C, and D), two are in Dublin, the capital, and two in other cities. The Dublin campuses account for about two thirds of the research staffs in the sector. The level of communication between university personnel is given in Table IV.

Communication between A and D is the strongest of the six possible pairings. Campus C is, as regards communication, the most isolated of the four. The bond between A and B is moderately strong. Generally, the more physically isolated campuses had the weakest communication bonds.

The Position of the Universities. The universities are more closely linked to the public sector than to any of the other segments of the research community in





Table IV

Communication Among the Four Universities  
(Monthly or More Frequent Contact)

	Communication Bond ( $C_{ij}$ )		
	Univ A	Univ B	Univ C
University D	0.412	0.067	0.096
University A	-	0.236	0.079
University B	-	-	0.040

Ireland. Three of the four have very strong communication bonds (Figure 1). Only C (possibly because of its geographic location) has failed to develop strong contact. A is responsible for most of the university communication with research institutes. D and B have a moderate level of contact, while C's is light.

Only D and A have even a moderate level of communication with industry, and then only with state-sponsored firms. None of the universities have even moderate contact with private industry.

The colleges of technology, medical research institutions and other academic institutions show, at best, a moderate degree of interaction with the universities. In some of these, however, one would expect communication to take place with only one part of a university (e.g., a medical school). Final judgment on this situation therefore must await analysis of university communication at the departmental level (to be reported in a later paper).

Foreign Contact by the Universities. All four universities show similar level of Foreign Communication (Table V). C, somewhat surprisingly, is the leader showing an even higher level (proportional to its size) of contact with Britain than D.



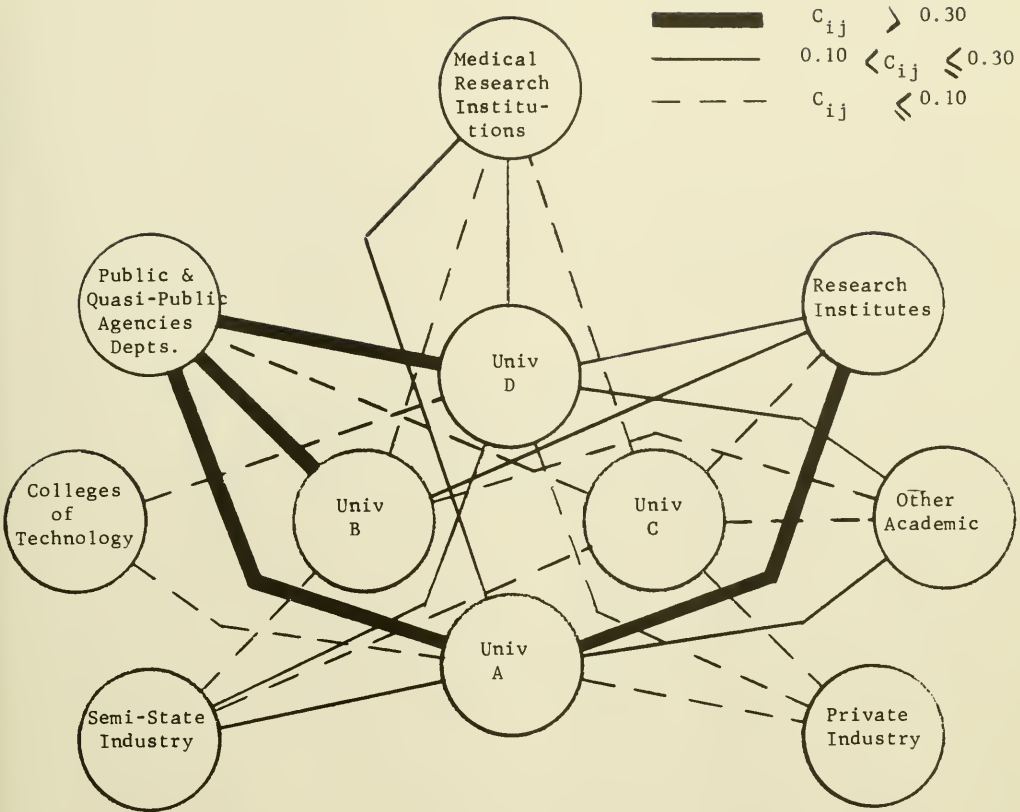


Figure 1. The Position of the Universities (Based on Communication Frequency of Once a Month or more often)



Campus A has established the strongest ties to the continent, and leads in communication with the United States. D has far more contact with the North of Ireland than the other three.

Foreign contact is primarily with university personnel, although a high proportion is with the staff of "research institutes" abroad. This is something of a "catch all" category for all laboratories that are not clearly universities or industrial. It includes personnel from foreign government departments and

Table V

Location of Foreign Contacts by the Four Universities				
location of contacts	Communication Bond ( $C_{if}$ )			
	Univ D	Univ A	Univ B	Univ C
Great Britain	0.459	0.346	0.264	0.478
university	0.294	0.231	0.181	0.366
research institute	0.156	0.093	0.055	0.116
industry	0.009	0.022	0.028	0
Continental Europe	0.147	0.275	0.195	0.116
university	0.101	0.110	0.139	0.087
research institute	0.046	0.110	0.042	0.029
industry	0	0.055	0.014	0
United States	0.138	0.187	0.167	0.188
university	0.092	0.143	0.139	0.159
research institute	0.018	0.033	0.014	0
industry	0.028	0.011	0.014	0.029
Other Foreign	0.046	0.044	0.097	0.101
university	0.037	0.033	0.069	0.029
research institute	0.009	0.011	0.028	0.072
industry	0	0	0	0
Total Foreign	0.790	0.852	0.723	0.883
North of Ireland	0.101	0.039	0.069	0
university	0.101	0.033	0.055	0
research institute	0	0.006	0.014	0
industry	0	0	0	0



universities and some quasi-public research organizations, as well as such governmental research institutions as the U.K. Atomic Energy Authority laboratories at Harwell and the Naval Research Laboratory in the United States.

### The Research Institutes

There are three major research institutes in Ireland. Their spheres of activity are broadly speaking Industry, Planning and Environment and Agriculture and Food.

Communication Among the Research Institutes. Communication between the three research institutes is at a weak to moderate level (Table VI). It is neither as low in frequency as the lowest of the university pairings, nor as high as the highest. Institutes I and III have stronger communication bonds with II than

Table VI  
Communication Among the Three Research Institutes  
(Monthly or More Frequent Contact)

	Communication Bond ( $C_{ij}$ )	
	Inst. I	Inst. II
Institute III	0.074	0.104
Institute I	-	0.210

they have with each other, but the amount of communication could probably be increased generally in this sector, with beneficial results.

The Position of the Research Institutes. Institute II clearly dominated the institute sector (Figure 2). It is the only institute to show a high level of interaction with other parts of the research community. It is responsible for the majority of contact with the universities, and is the only research institute to





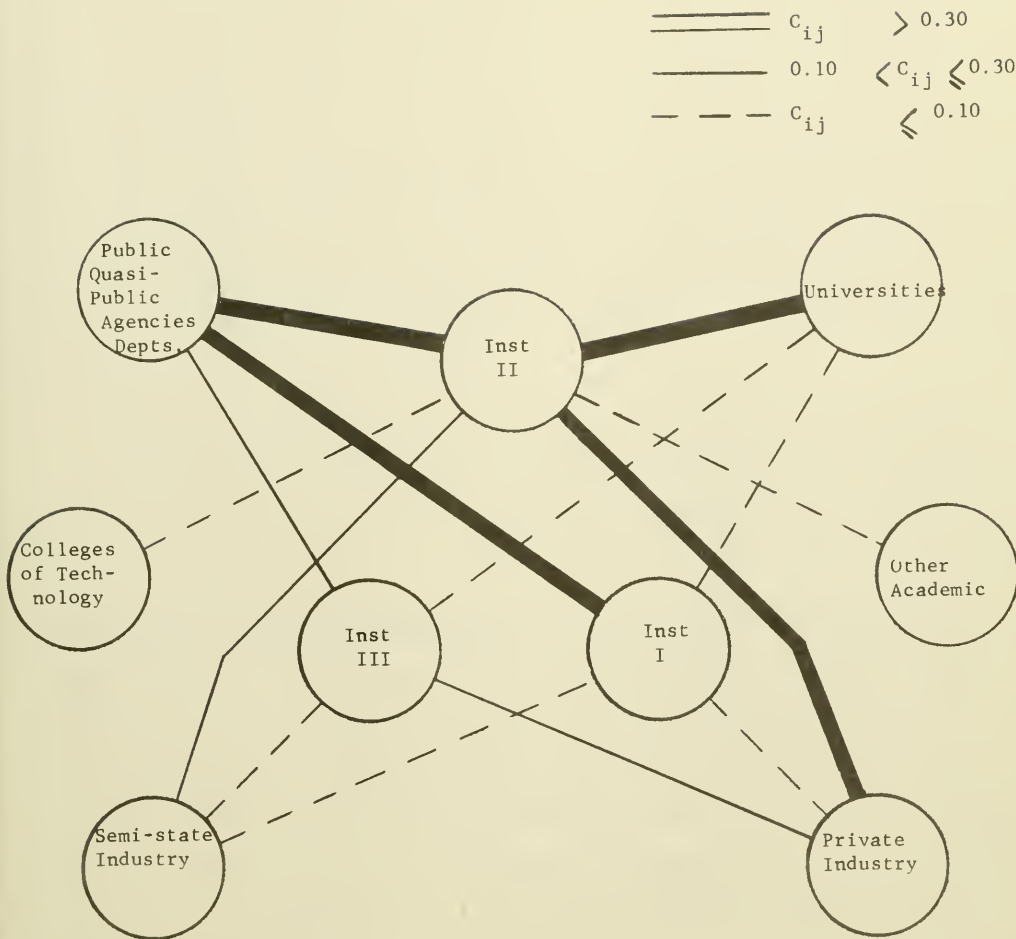


Figure 2. The Position of the Research Institutes  
(Based on a Communication Frequency of  
Once a Month or more often)



show a high level of contact with private industry. It must be remembered, however, that the only industrial firms surveyed were those which themselves carried out research and development. That necessarily excludes many firms; perhaps it excludes a higher proportion of the firms served by the I and III than of those served by II. On the other hand, the survey in no way prevented individuals in any of the institutes from reporting contacts they had with people in any industrial firm, whether or not it is supported R&D. So the results are, at best, a little dismaying. This is especially true for state-sponsored industry, which is not linked by strong bonds with any of the three institutes.

When contacts that occur less often than once a month are included in the analysis (Table VII), there is little change in the results. There is apparently much that can be done to strengthen communication bonds between the research institutes and industry.

Foreign Contact by the Research Institutes. Institute III has developed the greatest number of British contacts, but reported no contacts outside of Europe (Table VIII). Institute I has developed contact in a large number of countries around the world, but the actual number of individuals is still small. It has the lowest index of foreign contact of the three. Institute II has well developed contacts throughout the world, and maintains its contacts across a wide variety of institutions. It is the only one of the three that comes even close to the universities in the extent of its foreign contact.

Institute III could certainly stand to develop stronger communications with American firms, universities and research institutes. It will probably develop more communication with the continent now that Ireland has joined the European Community. Its overwhelming contact with British sources probably indicates too great reliance on these as compared to other foreign sources. A broader base of



Table VII

Communication Between the Research Institutes and Industry  
(Yearly or More Frequence Contact)

and between	Communication Bond ( $C_{ij}$ )		
	Inst III	Inst I	Inst II
semi-state industry	0.077	0.066	0.261
private industry	0.182	0.057	0.510

Table VIII

Location of Foreign Contacts by the Three Research Institutes

location of contacts	Communication Bond ( $C_{if}$ )		
	Inst III	Inst I	Inst II
Great Britain	0.500	0.200	0.390
university	0.167	0.080	0.084
research institute	0.333	0.120	0.253
industry	0	0	0.053
Continental Europe	0.125	0.080	0.223
university	0	0	0.024
research institute	0.083	0	0.175
industry	0.042	0.080	0.024
United States	0	0.080	0.070
university	0	0.040	0.024
research institute	0	0.040	0.034
industry	0	0	0.012
Other Foreign	0	0.040	0.046
university	0	0	0.012
research institute	0	0.040	0.034
industry	0	0	0
Total Foreign	0.625	0.400	0.729
North of Ireland	0	0.120	0.090
university	0	0	0.060
research institute	0	0	0.012
industry	0	0	0.018



contact might stimulate innovative ideas, and this as we have seen, is the purpose of R&D aimed mainly at economic development. Institute I is a relatively new organization, so perhaps it has not had time to properly develop a range of foreign information sources. It should certainly pay attention to the critical effort a good foreign network of sources can have on a small country's information intake.

Communication Among Other Parts of the Research  
and Development Community

The network of the remaining portions of the R&D community is a somewhat sparse one (Figure 3). This category includes among others Government Departments; local authorities; and agencies concerned with meteorology, ordnance survey, geological survey, and forestry plus a number of quasi-public agencies. With the exception of the block called "other public agencies and departments", which has strong communication with the medical field and with semi-state industry, there is just very little communication among other agencies.

This network better than any other displays the central role played by the research institutes and universities in integrating the flow of communication in Ireland. Not only do they directly support most of the research and development work performed in the country, but without the communication links which they provide, other organizations supporting research would have little or no chance of learning of developments outside their own organizations.

Much of this report could be taken to be critical of the performance of the universities and research institutes in communicating among themselves, with other organizations in Ireland and with scientists abroad. But without their contribution to integrating information, the universities with foreign science, and the research institutes within the country, the communication network would be very poorly connected.





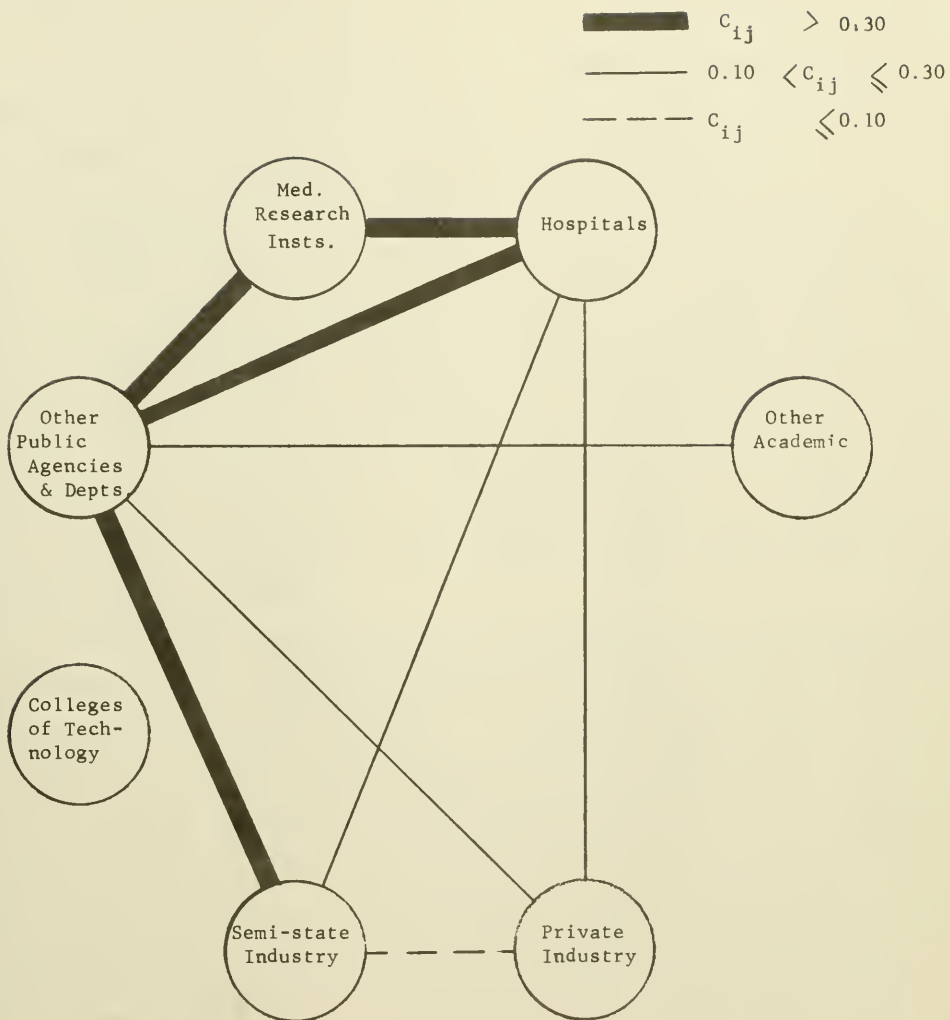


Figure 3. Communication Among Other Parts of the Research and Development Community



### A More General View of the Network and Discussion

We entered the present study, if not with tightly structured hypotheses, then at least with some preconceptions of what a communication network in a small country like Ireland might look like. These preconceptions have not been completely supported, but neither have they been completely denied.

One might expect, for example, that the research institutes would form a buffer stage between less directed research of the universities and the needs of industry. And, in fact, we find that they do play this role, to some degree. Communication between research institutes and universities and between research institutes and industry is much stronger than direct university-industry communication. But then, not all research institutes are equally effective in establishing these bonds (Figure 4). State-sponsored industry, in particular, fails to receive the communication it must be assumed to need, either directly or through this buffer stage.

In a similar way, one might expect the universities to be the principal link to foreign sources, while research institutes play a secondary role, with both passing the information along to industry. In fact, the universities do have the strongest foreign contact, but they communicate little of this information directly to industry. Moreover the research institutes, generally, have neither the amount nor the diversity of foreign sources that industry itself has developed. Partly through the mechanisms of foreign ownerships, but largely through sheer need (Cf., Allen and Reilly, 1973) industry appears to have developed its own foreign information sources. This is not entirely unsatisfactory, but it does have several discomfoting features. Judging from the extent of their foreign contacts, both the research institutes and the universities should be able to perform a "gatekeeping" role for industry. The gatekeeper, however, must both have extensive outside contact and also be highly sought for



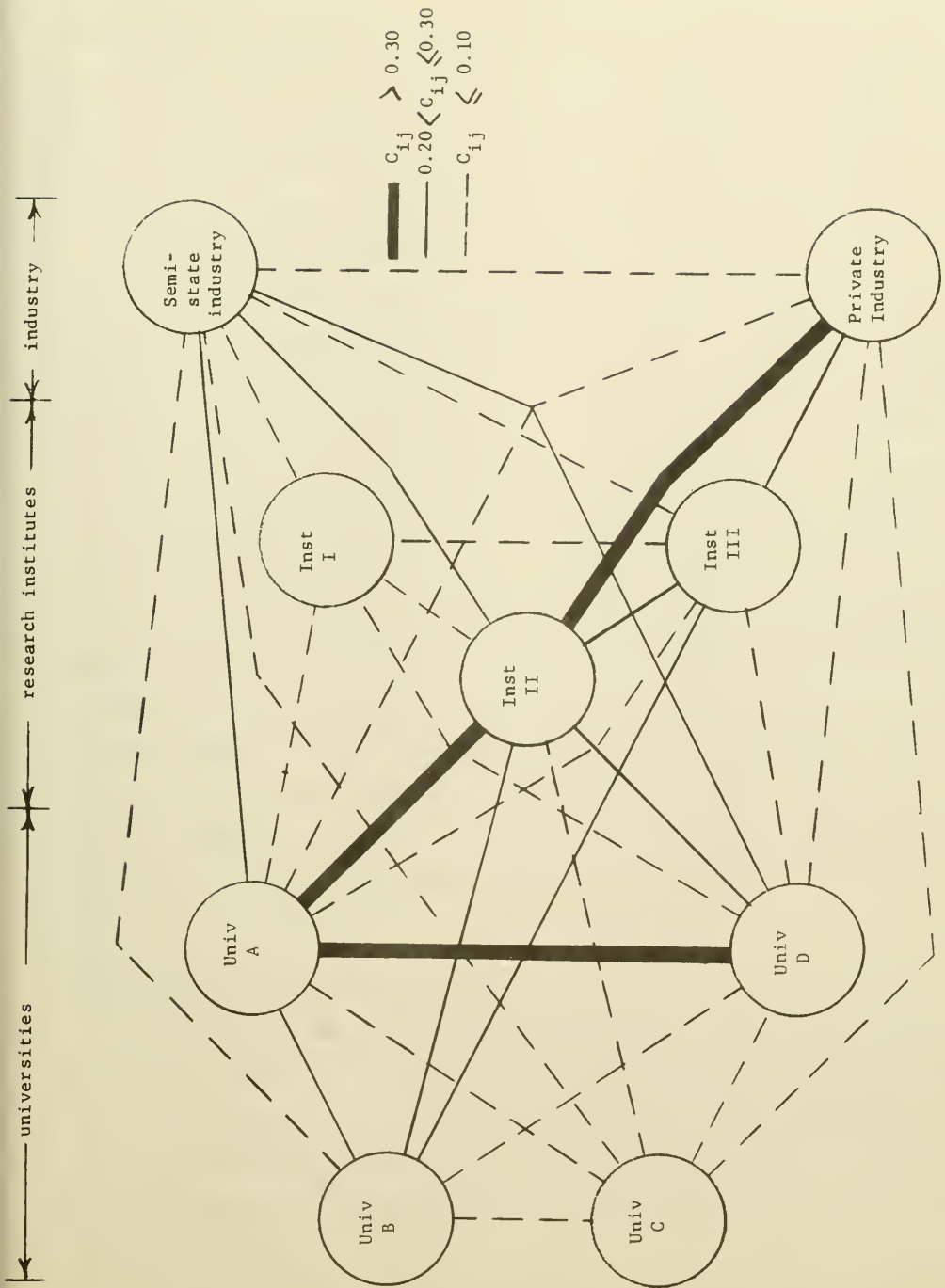


Figure 4. Level of Monthly Contact Among Major Research Institutions



consultation by colleagues within his organization. The four universities and three research institutes do, to some degree, meet the first of these conditions. What most of them lack, though, is a strong communication bond with industry. With the possible exception of Institute II, none of these seven organizations has assumed a gatekeeper role, between Irish industry and foreign technology.

Industry has apparently found it more useful to develop its own foreign sources, directly. There is certainly nothing wrong with an industrial firm keeping abreast of foreign technology in this way, but at a system level it appears terribly inefficient. Moreover, if an industrial firm learns of a foreign development, competitive pressures and the general isolation of the individual firm tend to severely limit the dissemination of that information. The research institutes or universities, being free of such competitive pressure, should make such information more generally available. This is particularly critical in the case of the small domestically-controlled firm, which often has neither the business associations nor the resources to allow it to cultivate foreign sources of technology.

↳ The research institutes were established to bring new technology to industry, and it is a stated policy of the National Science Council to encourage co-operation between universities and industry. It is therefore, surprising and disturbing to find so little communication between these elements of the R&D community.

#### The Development of Communication Bonds

It is one thing to say that communication between any two organizations or between sectors should be improved, but it is quite another thing to specify just how one would go about it. Fortunately, participants in the survey were asked (by means of coded categories) to indicate how they first met each of the individuals, outside their organization, with whom they regularly discuss scientific





and technical subjects. There was a total of 1,282 such contacts for which respondents indicated the way in which the contact first came about. Of these, 495, or 38.5 percent were with scientists or technologists in other countries. This statistic, in itself, is impressive, showing the extent of foreign contact by Irish scientists.

### Domestic Contacts

Of the remaining domestic contacts, 36 percent were the result of working relationships, between individuals in different organizations that were in effect at the time of the study. Work relationships, or project membership are a very strong determinant of communication patterns (Walsh & Baker, 1972). For the present purposes, however, it is more important to determine how those contacts, which were not required by the nature of the work, came about. These, it seems, are caused most often by people becoming acquainted through working together in the same organization (Table IV). In these cases, the contact had

Table IX

Sources of Domestic Communication Contacts (787 Instances)	
	proportion (percent)
participation in current working relationship	36.1
previously worked together in the same organization	19.1
met in university	13.6
met through professional society membership or conference	11.9
introduced by mutual acquaintance	6.2
formerly had working relationship	3.1
other	<u>10.0</u>
	100.0



either worked in the respondent's organization and then changed jobs; the respondent had formerly worked in the contact's organization; or both had worked in a third organization. Job mobility, to the extent that it exists, appears to be a very important determinant of inter-organizational communication.

Acquaintances made in the university are next in line of importance. These include professor-student relations, as well as relations among former students. In a small country, such as Ireland, with a limited number of university departments in any field, one might expect that a reasonable number of scientists would, in any specialty, have known one another from university days. Still, to find such a strong effect on inter-organizational communication patterns is somewhat surprising.

Professional society conferences and meetings rank fourth in importance. Most of these were, of course, held within the country. Nevertheless, a surprising number of Irish scientists meet one another for the first time, while attending a conference in another country.

Introductions and former working relationships account for less than 10 percent of the total. An important point, to be made here, concerns the difference between the number of communication contacts resulting from current work relations and the number from past work relations. The work-induced force to communicate is apparently very strong, but not terribly persistent.

Finally, the category "other" in Table IX includes a vast range of reasons, from the use of common facilities to family relationships. The most commonly cited reason in this group, though, is that of having common research interests. Apparently, one member of the pair learns of the other's research, probably through the published literature, and then seeks more direct and continuing contact with the second party.



Sector to Sector Contacts. The experience of having worked together in the same organization is the dominant underlying cause of communication among the three sectors of the R&D community in Ireland (Table X). This is especially true in

Table X

Sources of Communication Contacts Between Individuals in Different Sectors (Excluding Current Working Relationships)			
way in which contact was established	universities and research institutes	research institutes and industry	universities and industry
previously worked together	28.4%	22.8%	36.1%
met in university	28.4	13.5	22.2
prof. society or conference	21.0	34.0	19.5
mutual acquaintance	16.0	6.8	2.8
former working relationship	3.7	0	8.4
other	2.5	22.8	11.1

the case of the universities, in which former students and former staff members maintain contact with their old research teams for some period after joining research institutes or industrial firms. Just how long these relationships endure is not known at this point, but will be the subject of further investigation. At any rate, the existence of people, particularly in industry, who have recently left a university, provides a potential for improving contact between universities and the other two sectors. Such people should be encouraged to keep up with the work of their old university research groups, and be given some form of inducement to maintain contact with their old colleagues.

Next to job mobility, professional society meetings and conferences provide an effective mechanism for promoting contact among sectors. This is especially true in the case of research institute and industry relations. The professional conference provides an excellent vehicle for forging new acquaintanceships and



among scientists and renewing old ones. To stimulate inter-sector communication, agenda should be set in such a way that industry personnel are attracted, and then research institute and university staff should be encouraged to attend.

While it may be a bit more difficult to induce university attendance, attendance by the staff of the research institutes should not present so much of a problem.

Contacts Within Sectors. Job mobility once again is a critical factor in promoting communication, among university faculty and staff (Table XI). It is less important in the case of research institutes and of industry. In the former, there were very few contacts for which information was obtained concerning how the two individuals first met,<sup>2</sup> so the data in the second column of Table XI have little meaning. In the case of industry, associations among firms (belonging to the same group of firms; contractual relationships; etc.) are the overwhelming determinant of communication contacts. In other words, formal organizational relationships are most important in that sector. In general, however, communication among industrial firms, particularly semi-state firms is very poor. Perhaps greater job mobility among semi-state firms might improve this situation. At any rate, it is certainly something, along with greater conference attendance that could be seriously considered.

Foreign Contacts. As stated earlier, nearly 40 percent of communication contacts are with individuals outside of the country. It is interesting to note once again that job mobility is an important factor in this, at least in the case of universities and research institutes (Table XII). This is very interesting, since it presents a positive aspect of the tremendous brain drain that Ireland has suffered. In recent years, Irish universities have produced trained personnel at a rate far exceeding the economy's capacity to absorb them.

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<sup>2</sup> This question was not included in the questionnaire administered to An Foras Taluntais, the largest of the three research institutes.





Table XI

Sources of Communication Contacts Among Individuals in the Same Sector (Excluding Current Working Relationships)			
way in which contact was established	contact among		
	universities	research institutes	industry
previously worked together	30.8%	0%	11.7%
met in university	23.4	0	20.6
prof. society or conference	13.9	0	11.7
mutual acquaintance	12.7	0	5.8
former working relationship	2.2	100	5.8
other	17.0	0	44.2

Table XII

Sources of Foreign Communication Contacts (495 Instances)				
way in which contact was established	contacts by individuals in			
	universities	research institutes	industry	other
previously worked together	38.3%	26.4%	8.1%	21.0%
met in university	10.3	26.4	6.8	13.6
prof. society or conference	20.6	36.8	35.1	22.2
current working relationship	12.5	0	23.0	16.0
former working relationship	3.8	0	6.8	7.4
mutual acquaintance	5.6	5.2	6.8	11.1
other	9.0	5.2	13.5	8.6

Consequently a very high proportion of Irish graduates are forced to seek employment in other countries. The present data would indicate that there is a reverse flow as well, and that the combination of the two will provide very definite long term benefits to the Irish economy. It is not known, at this point, whether job



mobility produced few foreign contacts by the industrial sector, because returning emigrants did not go to work for industrial firms or for other reasons, but the fact remains that it is extremely important for the other sectors.

The returning emigrant scientist brings back with him not only a range of technical skills developed during his foreign employment, but a cadre of foreign personal contacts to help him maintain those skills, as well. The data here further support the finding by Allen, et. al. (1971) that foreign employment is the critical factor in developing international gatekeepers. The emigrant, who has spent some time working in an R&D organization outside the country is a potential gatekeeper. He must first be attracted back home, then properly integrated into a research organization, and finally provided with the wherewithal to maintain his contact with foreign colleagues. But to begin with, he must be attracted into returning home. A strong program to attract back emigrants in critical skill areas would have an enormous potential for technology transfer. The form for such a program will be treated in subsequent papers in this series, following further analysis of the data, and more intensive consideration of the emigration problem.

Before leaving the subject of foreign contacts, the reader should note the importance of professional society conferences. It is a bit surprising to see that these are more important for research institutes and industry than they are for university staff. Nevertheless, they remain important. Since most of these were foreign conferences, the data would provide an argument for increased travel budgets, to promote conference attendance. In addition, since the returned emigrant is more likely to know some of the foreigners attending a conference (Cf., Allen, et. al., 1971), he should be given some consideration when selecting the people to be sent. Again, this is a subject to be given more careful consideration in a subsequent report.



## Conclusions

It appears that the scientist's ability to keep abreast of foreign technological developments through personal contact is an effective way for a country to import technological information. It also appears to be a relatively inexpensive way; the cost of allowing an individual to maintain his foreign contacts through periodic travel is quite small. The present evidence indicates that his external contacts are most effectively developed through active research experience in a foreign country.

The implications of these results are unambiguous. If international transfer of technology is to be fostered, nations should seek to open those channels through which information flows most effectively. They should assist able, domestically educated research personnel to do research abroad. They should encourage researchers to have foreign sabbaticals, fellowships, and other forms of extended foreign technical experiences. They should help gatekeepers to perform their role as an efficient mechanism for transfer by providing funds to maintain existing contacts through foreign travel. They should stimulate contact among organizations by the mechanisms described in this paper. They should assist organizations in properly developing their specific roles vis à vis technology transfer. The development of interpersonal and inter-organizational contacts is not in itself the complete answer to international technology transfer. It is, however, an essential part of the process. Where it works it is doubtless the least expensive of the available mechanisms -- and we are now learning ways to further improve its effectiveness.



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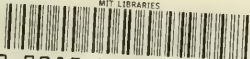
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