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Technical Communication Among Scientists and Engineers in Four Organizations in Sweden: Results of a Pilot Study

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INTRODUCTION

With technological developments occurring on an ever-expanding world basis, it is critical for every technologically-based organization to maintain currency with technological activities both domestic and foreign. This is true, whatever may be the role of the organization. Industrial firms, research institutes and universities face essentially the same problem. None can be completely self-sufficient. They can however assume somewhat different roles and assist one another in the process. Research institutes for example, are often seen in an intermediary role, connecting their industrial clients to domestic and foreign technology. Universities can also be sources of technology for industrial firms, as well as recipients of valuable technical information from industry, and are often well connected in an international scientific network.

The first attempts to improve understanding of this process, through analysis of person to person communication networks, were made in research and development laboratories in the United States (Allen & Cohen, 1969; Allen, 1977). The methodological approach developed in that context was subsequently expanded to examine the research and development community of an entire country, in this case the Republic of Ireland (Allen, et. al., 1971; Allen and Cooney, 1973).

The present study partially replicates the earlier Irish study in the context of four organizations, involved in the field of metallurgy in Sweden. It is intended as a pilot study for a more extensive examination

of the research and development community in Sweden.

As a pilot study, its principal purpose is to test the applicability of the research method and to provide some understanding of what the results of a full scale study would be. As a consequence, the results reported in this document must be considered as tentative, at best. The only conclusions that can legitimately be drawn will be those relating to the applicability of the research method and to the need for further investigation in certain areas.

RESEARCH METHOD

The questionnaire employed in the Irish study was modified slightly and translated into Swedish (Appendix). It contains questions on such demographic variables as age, education, and previous work experience as well as a number of questions to ascertain the extent to which each individual communicates about scientific or technical matters with colleagues:

1. within his own organization
2. outside of the organization but within Sweden
3. outside of Sweden

In each case, the respondent was asked to report the name and organizational affiliation of communication partners and to indicate by code how each such contact was first established.

The questionnaire was administered to 275 engineers and scientists in four organizations. The four organizations comprised a university section, whose staff were engaged in metallurgical research; a metallurgical research institute and two steel companies (Table I). The response rate in all four organizations was acceptably high, averaging 88 percent overall.

Data were collected in the late Fall of 1980 and analyzed simultaneously at the University of Umeå and at M.I.T. (Cf. Höglund and Persson, 1981).

TABLE I

Number of Individuals Surveyed and Response Rate by Organization

Organization	Number Surveyed	Number of Responses	Response Rate
University	93	86	92%
Research institute	22	18	82
Firm A	76	73	96
Firm B	84	65	77
Total	275	242	88

From Höglund and Persson (1981)

RESULTS

Domestic Communication Outside of the Organization

Every technically-based organization must keep aware of technical developments in the outside world. Previous research (Allen, 1977) has shown this to be an extremely difficult problem for most organizations. There are strong barriers at the organizational boundary to the effective communication of technology. These can best be overcome by the development of specialized roles and effective patterns of communication. The four organizations exhibit quite different patterns in their attempts to stay attuned to technical developments in Sweden.

Level of Communication by the Technical Staff. External domestic communication is measured in terms of the mean number of technical communications per year reported by members of technical staff with someone outside of the organization. The four organizations differ significantly in this measure (Table II). The technical staff of the research institute report far more external communication than the staff

TABLE II

External Domestic Communications by Organization

Organization	Communications Per Person Per Year
University	19.23
Research Institute	71.94
Firm A	47.90
Firm B	16.23

$F = 6.85$; $p < 0.001$

of any of the other three organizations. The average member of the research institute staff communicates with an outsider about once every three days. This certainly fits the role of a research institute. Technical staff members are expected to provide technical service to other organizations. The very nature of their business requires extensive external communication.

The lowest external communication is reported by Firm B. In that firm, the average member of technical staff communicates with an outsider only a little more than once every three weeks. The staff of the

university communicate only slightly more often, with an average frequency of contact about once every 12 working days. So there is a fairly large variance in domestic communication across the four organizations. Even excluding the research institute, since its role requires a high degree of domestic communication, there is a nearly three to one ratio in the number of communications reported by Firm A and Firm B.

Number of Individual Contacts Within Sweden. In addition to having the highest level of communication, engineers and scientists in the research institute also maintain contact with the greatest number of individuals in Sweden (Table III). Again, this is to be expected, given

TABLE III

Mean Number of Individuals with Whom Regular Contact is Maintained Within Sweden

Organization	Mean Number of Individuals Contacted*	Proportion of Staff With at Least One Regular Swedish Contact
University	1.14	47%
Research Institute	3.33	83
Firm A	2.76	71
Firm B	2.06	63

*$F = 12.75$; $p < 0.001$

the role of the research institute. It is surprising, however, to find the university staff with the fewest domestic contacts. They were relatively low in the number of communications reported. Now it appears that even those communications are relatively concentrated. This is very surprising since previous research (Allen, 1977, Hagstrom, 1966) would lead one to expect high external communication by university staff. The university scientists in the present study average fewer contacts within Sweden than even the engineers in the two industrial firms.

External Domestic Contact by High Internal Communicators. The "technological gatekeeper" (Allen & Cohen, 1969; Allen, 1977) has been shown to be a vital link in connecting the organization to outside sources of technology. The gatekeeper is an engineer or scientist who maintains high levels of both internal and external communication. These individuals connect the communication network of their organization to networks outside. Gatekeepers are operationally defined relative to levels of communication found in their own organizations. Their number of regular internal contacts is at least one standard deviation above the mean for the organization. Their external contacts are also higher. They must be above the mean in both the number of external colleagues and number of communications with those colleagues or above the median, in journals read regularly.

All four of the organizations had gatekeepers among their staff (Table IV). From the previous research, one would expect the proportion of gatekeepers to run in the range of about ten percent of the technical staff of an organization. Three of the four organizations are above

TABLE IV

Incidence of Domestic Gatekeepers by Organization

Organization	Number of Gatekeepers	Proportion of Staff
University	19	22.1%
Research Institute	3	16.7
Firm A	12	16.4
Firm B	5	7.7

this level. The university ordinarily would not be expected to have very many gatekeepers, because of the more basic orientation of its research (Allen, et al., 1979). In fact, in this case it has the largest number. The reason for this is not immediately apparent. The very high level of external communication reported by the staff of the research institute is fairly evenly spread across the members of that staff. There are three individuals who qualify as a gatekeepers, but nearly everyone reported a high level of outside communication. This is to be expected in the role that this type of institution must play. Internal communication is more frequently a problem in research institutes, since staff can become highly client-oriented. In the present case this does not appear to be a problem. In fact the staff of the research institute report the highest average level of internal communication (Table V). Internal communication is also more evenly distributed in the research institute. The mean level of communication is high and the variance across the technical staff is relatively low.

TABLE V

Weekly Communication Choices Received Per Person

Organization	Mean Number of Choices Received	Standard Deviation of Choices Received
University	1.57	1.36
Research Institute	2.39	1.38
Firm A	1.75	1.89
Firm B	1.53	1.59

F = 1.57; N.S.

Communication as a Function of Technical Field. The 242 engineers and scientists are working in a wide variety of technical areas, ranging from metallurgy to plant construction, manufacturing engineering and computer technology. For purposes of analysis all of these technologies are aggregated into five broad categories (Table VI). All of those whose work directly concerns the analysis, synthesis and structure of metals are grouped together as "metals technology." Those concerned with manufacturing engineering and plant design are grouped under "plant technology." Those in marketing or analysis of management problems are under "management technology", and those concerned with computer control or data analysis are categorized in "computer technology."

The computer technologists are by far, the heaviest communicators. Their field is, of course, changing very rapidly. They are not in the traditional mainstream of R&D in their organizations, and they have adapted to this situation by putting greater effort into contact with the outside world. Next in line are those concerned with the development of

Table VI

External Domestic Communications by Technical Field

Field	N	Communications Per Person Per Year
metals technology	174	23.16
plant technology	26	46.46
management technology	8	10.00
computer technology	16	105.00
other technologies	18	25.56

$F = 8.87$; $p = 0.001$

new manufacturing processes. Again this is a field that is relatively dynamic, and despite the fact that their organizations have traditionally supported these technologies, they maintain reasonably strong contact with colleagues in Sweden. Those concerned with metallurgy itself or with materials science generally communicate far less with Swedish colleagues. This may result from the fact that the organizations in this study are themselves, leaders in this area. It is probably not a situation for serious concern, at this point, since the four organizations have such a high general level of external communication. Even in metals technology, the average engineer communicates with a Swedish colleague, outside of his organization, about once every two weeks. Compared with results of previous studies, that is a fairly nigh level of communication.

Gatekeepers in Different Technologies. In order for an organization to effectively maintain contact with technological developments, it must have effective communication between its staff and outsiders in all of the technologies relevant to its interests. A very effective way of accomplishing this is through gatekeepers. The question may then be asked whether gatekeepers are properly distributed across technologies or whether they are concentrated within a few.

Viewing the four organizations as a system, it appears that the distribution of domestic gatekeepers across disciplines is somewhat uneven (Table VII). The proportion is highest in metals technology and lowest in management technology, where there are none. Computer technology is also relatively low, with 6.3 percent of the individuals in this field meeting the criteria defining a gatekeeper.

Table VII

Incidence of Domestic Gatekeepers by Field of Technology

Field	Number of gatekeepers	Proportion of those in field*
metals technology	32	18.4%
plant technology	3	11.5
management technology	0	0
computer technology	1	6.3
other technologies	3	20.0

*Proportion shown in this and subsequent tables are proportions of respondents on whom complete data are available. This number is often less than the number of respondents shown in Table I.

It is interesting to note that those concerned with metals technology in the four organizations (Table VI) have a relatively low level of

external contact. This is well compensated by the high incidence of gatekeepers in this field. In fact, despite the low level of external contact by staff generally, it may be the field that is best connected to developments within Sweden (Cf., Allen, et al., 1979). At the other extreme is computer technology. Technical staff in that field have a very high level of contact with colleagues within Sweden, but with only one gatekeeper, this contact may not be as effective in bringing current technology into the organization. In fact, it leaves three of the four organizations with no gatekeeper in computer technologies. This could be a particularly serious situation, given the pace of developments in that field.

Looking for the reasons for differences in communication patterns between metals technology and computer technology, one might speculate that it is a result of the difference in length of time that the organizations have been active in the two fields. Metals technology is, of course, central to the four organizations, and is therefore well established. The staff concerned with this technology have had sufficient time to articulate an effective communication system, employing gatekeepers to manage their external contact. The communication network of the computer technologists has not evolved to this degree. One might hypothesize then that the degree to which gatekeepers are used is a function of the length of time that an organization has been active in a given technology, and the degree to which that technology is central to the mission of the organization.

Foreign Communication

With technological developments occurring at a rapid pace world-wide,

it has become increasingly important for organizations to keep in touch with what is happening in other parts of the world. It is naturally very difficult for the average member of an organization's technical staff to develop contact with foreign scientists or engineers (Allen, et. al., 1971). For this reason, the gatekeeper phenomenon can often be important in connecting an organization to foreign technology. If those individuals, who have been able to establish foreign communication, are in close contact with their organizational colleagues, then those colleagues should have access through them to the foreign information.

Level of Foreign Communication. The four organizations differ significantly in the average level of their foreign communication (Table VIII). As with domestic communication, the research institute reports the highest level. While this might have been expected in the case of

TABLE VIII

Foreign Communications by Organization

Organization	Communications Per Person Per Year
University	2.37
Research Institute	17.28
Firm A	16.11
Firm B	9.88

$F = 7.34$; $p = 0.0001$

domestic communication, foreign communication is not directly necessitated by the work of the research institute. It is, however, a role which research institutes should play. They should be

intermediaries or "gatekeeping institutions" connecting domestic firms to foreign technology. It is a role, however, that few of them ever do well. At least at this point, it would appear that the institute presently under examination is performing the function satisfactorily.

The university staff once again show the lowest average level of external communication. This is even more surprising than the low level of domestic communication observed earlier. Derek Price's (1963) vision of the "affluent academic commuter" evidently does not hold true in the present context. The average member of the university staff has very little contact outside of Sweden.

Number of Individuals Contacted Outside of Sweden. The staff of the research institute and the two firms have contact with an average of one to two individuals outside Sweden, with whom they maintain regular technical communication (Table IX). On the average, the university staff

TABLE IX

Number of Individuals with Whom Regular Contact is Maintained Outside of Sweden

Organization	Mean Number of Individuals Contacted*	Proportion of Staff With at Least One Regular Foreign Contact
University	0.65	24%
Research Institute	1.72	67
Firm A	0.95	58
Firm B	1.11	45

*F = 7.06; p = 0.001

appear at this stage of the analyses to be the most poorly connected internationally. Fewer members of the university staff have foreign colleagues, and the mean number of foreign colleagues is the lowest of the four organizations. Probing the data a bit more deeply, however, one finds that those in the university who have foreign contacts have a broader range of contacts than is found in the other three organizations (Table X). This leads one to speculate on the possibility of a channelling of foreign communication through particular individuals.

TABLE X

Number of Foreign Colleagues With Whom Regular Contact is Maintained by Those Individuals Who Have at Least One Such Contact

Organization	Mean Number of Individuals Contacted
University	2.67
Research Institute	2.58
Firm A	1.83
Firm B	1.55

International Gatekeepers. The gatekeeper phenomenon occurs at the organizational boundary and can be concerned with either domestic or foreign communication. An international gatekeeper is defined in a manner similar to a domestic gatekeeper, with the exception that external contacts must be located outside of the country and in the present case, an individual must have had regular contact with at least two persons outside of Sweden.

All four organizations have individuals who play this role (Table XI). The research institute has the highest proportion of international gatekeepers, indicating that it has probably adapted well to its role of staying in touch with foreign technology. The other three organizations all have what would appear to be a reasonable proportion of their staff performing this role. In these other three organizations, the gatekeepers handle proportionally more of the foreign communication. In fact, in the Firm B, where they represent the smallest proportion of staff, they report three times more foreign communication than their colleagues.

TABLE XI

Incidence of International Gatekeepers

by Organization

Organization	Number of Gatekeepers	Proportion of Staff	Proportion of Foreign Communications
University	8	10.4%	22.7%
Research Institute	3	16.7	12.4
Firm A	9	12.7	13.4
Firm B	5	7.9	23.5

Foreign Communication as a Function of Technical Field. The differences across technical fields are not as dramatic in foreign

communication, as they were with domestic communication (Table XII). The computer technologists have the highest level of foreign as well as domestic communication, but this case the margin is not as great. Those concerned with management technologies are nearly equal to the computer specialists in their degree of foreign communication. Again metals and materials technologies are lowest.

TABLE XII

Foreign Communication by Technical Field

Field	N	Communications Per Person Per Year
metals technology	174	8.18
plant technology	26	11.69
management technology	8	19.13
computer technology	16	19.63
other technologies	18	7.67

$F = 2.01$; $p = 0.09$

International Gatekeepers in Different Technologies. As in the case of domestic gatekeepers, it is important to check across technologies for the incidence of individuals who will function effectively to maintain contact with foreign developments. Here again there is some variation across fields, but the concentrations are slightly different for international gatekeepers than they were for domestic gatekeepers (Table XIII). This may well reflect the relative state of development of different technologies within Sweden. Metals technology, for example,

has the highest proportion of domestic gatekeepers and it is nearly highest in the proportion of international gatekeepers as well. Computer

TABLE XIII

Incidence of International Gatekeepers by Field of Technology

Field	Number of Gatekeepers	Proportion of Those in Field	Proportion of Foreign Communication
metal technology	20	12.2%	23.1%
plant	1	4.0	3.5
management technology	0	0	0
computer	2	12.5	11.8
other	1	10.0	17.0

technology which had only one domestic gatekeeper is a little better off internationally, since there are two individuals maintaining effective contact with foreign technology in this important area. On the average, computer technologists have the highest level of foreign as well as domestic communication; they also would appear to have a reasonable proportion of international gatekeepers in the four organizations. Unfortunately, however, when the data are examined more carefully it becomes apparent that there are only two gatekeepers in this field. Since one individual is classified as both a domestic and an international gatekeeper. Furthermore, both of these people are employed in the same organization. So unless there is effective communication among the four organizations, three of the four will probably not be able to keep up effectively with developments in computer technology.

Literature as a Source of Technology

Early research on technology transfer and communication among engineers and scientists concentrated on the literature, almost to the exclusion of direct personal contact. Later research clearly demonstrated that in most cases, it is personal contact that is most often responsible for the exchange of information. This does not mean, however, that the literature is unimportant, and it would be an error of equal magnitude to neglect literature now as it was to neglect personal contact earlier.

The questionnaire allowed respondents to indicate the frequency with which they referred to different forms of written information, in their work. Specifically, they were asked to indicate the frequency at which they used textbooks, journals, patent literature, vendor documentation, internal reports and computerized literature surveys.

There is as expected a wide dispersion in the frequency of use of these different forms of literature (Table XIV). Most people refer to books, at least on a monthly basis, and most use vendor documents and industry reports. Refereed journals, patents and computer surveys are less frequently used. These results are very similar to those reported by Allen (1977) for engineers in the United States.

Organizational Differences in Literature Use. One would expect some differences in the pattern of literature use as a function of organizational type. Since literature has been shown to be more heavily used by basic research scientists (Allen, 1977), university staff would be expected to show greater frequency of use generally and perhaps particularly in the case of refereed journals. Industry people, on the

TABLE XIV

Cummulative Distribution of Use of Different Forms of Literature

literature source	Cumulative proportions using at least once/week	at least once/month	at least once/year
books	52.0%	76.4%	94.6%
refereed journals	10.0	34.3	69.5
patent literatures	3.2	14.8	48.7
vendor documentation	19.4	52.0	77.2
industry reports	18.2	54.2	76.9
computer surveys	4.9	14.8	58.6

other hand, might make more use of patents, internal reports and vendor documentation.

In fact, university researchers do make proportionally greater use of literature (Table XV). About one-third of their information exchanges involve reading. This compares with 10 to 15 percent in the other three organizations. These results are similar to those found in earlier studies in the United States.

Turning to specific types of literature, the differences are not as great as one might expect (Table XVI). University staff do read refereed journals and engineers in industry do use industry reports more, butthe differences are not at all very great. The greatest difference appears in the use of books, which university staff do far more than industry people.

TABLE XV

Literature Use as a Proportion of All Communication by Organization

Organization	Frequency of use (month^{-1})			Literature as proportion of total
	literature	internal contact	external contact	
University Research Institute	17.0	30.8	7.9	34.3%
Firm A	11.1	103.2	7.4	9.1
Firm B	11.3	53.6	5.3	16.1
	8.9	70.6	2.2	10.9

TABLE XVI

Proportion Consulting Literature at Least Once Per Week as a Function of Organization and Type of Literature

Literature source	Organization			
	University	Research Institute	Firm A	Firm B
books	72.1%	61.1%	34.3%	43.1&
refereed journals	14.0	11.1	11.0	3.1
patent literature	4.7	0	4.1	1.5
vendor documentation	14.0	16.7	26.0	20.0
industry reports	15.1	22.2	24.0	12.3
computer surveys	10.5	5.6	1.4	1.5

Differences in Literature Use by Field. As in the case of organization, one would expect literature use to also vary by field. Some fields such as chemistry make far greater use of the literature than others. While the member of technical fields represented in the present study is not very great, one would expect to find some differences between, for example, metallurgists and computer technologists.

Surprisingly, the proportional use of literature does not vary much by field (Table XVII). The overall mean is 18.1 percent, with the five technical fields varying from this average by relatively small amounts. Those concerned with manufacturing technology make greatest proportional use of literature, but as we shall see, this is primarily a particular type of literature.

TABLE XVII

Literature Use as a Proportion of All Communication by Technical Field

Field	Frequency of use ($month^{-1}$)			Literature as proportion of total
	literature	internal contact	external contact	
metals technology	12.2	53.7	2.6	17.9%
plant technology	12.9	37.6	4.9	23.4
management technology	10.4	46.8	2.4	17.4
computer technology	13.1	72.0	10.4	13.7
other technologies	17.1	65.6	2.8	20.0

There is some variation in the use of different types of literature by the five fields (Table XVIII). All fields but management make great

use of books. Those concerned with manufacturing technology or computer technology make greatest use of vendor literature. Internal reports are used about equally by all fields. Patents were used only by

TABLE XVIII

Proportion Consulting Literature at Least Once a Month as a Function of Technical Fields and Type of Literature

Literature Source	Technical Field				
	metals technology	plant technology	management technology	computer technology	other technology
books	52.0%	53.9%	12.5%	56.3%	64.7%
referreed journals	10.9	7.7	12.5	0	11.8
patent literature	4.0	0	12.5	0	0
vendor documentation	12.6	42.3	12.5	37.5	41.2
industry reports	17.7	19.2	12.5	18.8	23.5
computer surveys	5.1	7.7	12.5	0	0

metallurgists and management technologists. Exactly what purpose the latter had for patent information is not clear, but it could involve the filing of patents or patent litigation of some form.

Gatekeepers and the Literature. Domestic gatekeepers, it will be recalled, are defined in terms of either external personal contact or literature use. So they will, by definition be heavier users of the literature, but it might be interesting to see whether they differ from their colleagues in the way in which they use that literature.

Gatekeepers make significantly greater use of nearly all literature sources, but particularly the patent literature and computer literature searches (Table XIX). The greater use of computer retrieval is probably the result of their greater sophistication in literature use and in library science generally. Surprisingly, the difference in use of refereed journals is not very strong.

TABLE XIX

Proportion of Domestic Gatekeepers Using Different Forms of Literature at Least Once Per Week

Literature Source	Proportion of: Domestic gatekeepers	others	p
books	66.7%	49.3	0.05
refereed journals	18.0	8.4	0.07
patent literature	10.3	2.0	0.01
vendor documentation	20.5	19.02	N.S.
industry reports	30.8	15.8	0.05
computer surveys	15.4	3.0	0.01

Characteristics of Gatekeepers

Although keeping abreast of foreign and domestic technological developments are two quite distinct functions, the people who perform these two functions are very often the same. There is a very high degree of overlap between the roles of domestic and international gatekeeper. Of the 41 individuals classified as gatekeepers, 23 perform both the domestic and international functions. Nearly all of the international

gatekeepers are also domestic gatekeepers. Forty-nine percent of the domestic gatekeepers also perform the international function.

The overlap between the two sets of gatekeepers is part of a more general phenomenon. Foreign and domestic communication are highly intercorrelated ($r = 0.42$) for all technical staff members.

Domestic gatekeepers have generally been found to be high technical performers who are at relatively low managerial levels (Allen, 1977). They do not differ in age from their organizational colleagues but do tend to have been employed by their present organization slightly longer. There is also a slightly higher proportion of doctoral degrees to be found among the gatekeepers. International gatekeepers show similar characteristics with the additional consideration of significantly greater foreign work experience. The proportion of foreign university degrees has been found to be no greater among international gatekeepers, however.

Gatekeepers in the four organizations, are very similar in most respects (Table XX). They are approximately the same age as those found elsewhere and do not differ from their organizational colleagues, in this respect. They tend to have been associated with their current organizations somewhat longer, but the difference, in this case, does not reach statistical significance. Both international and domestic gatekeepers tend to be somewhat more experienced, although these differences are significant only for domestic gatekeepers.

The 25 individuals in the four organizations, who are acting as international gatekeepers have slightly greater amounts of both foreign work and educational experience, but in neither instance is this experience significantly longer than that of their colleagues. However,

TABLE XX

Characteristics of Gatekeepers

	Domestic Gatekeepers (N=39)	Others (N=230)	p	International Gatekeepers (N=25)	Others (N=217)	p
Age	37.4	35.5	N.S.	38.6	38.6	0.09
Years with the organization	8.5	6.9	N.S.	9.4	6.9	0.07
Years of experience	11.8	8.0	0.03	12.6	8.2	0.05
Years of foreign experience	--	--	--	1.1	0.6	N.S.
Years of foreign study	--	--	--	6.8	4.4	0.08
Proportion with doctoral degree	28.2	5.9	0.001	20.0	8.3	0.06

the proportion of international gatekeepers, who have been abroad for more than one year to work or study, is significantly higher. A significantly higher proportion of international gatekeepers are educated to the doctoral level.

Foreign Experience of International Gatekeepers. In Ireland, international gatekeepers were more likely to have worked outside of their country than were their colleagues (Allen, et al., 1971). They did not differ from their colleagues in the proportion who had studied outside of the country. Foreign work experience rather than education was instrumental in leading to the development of gatekeepers' foreign contacts. For Swedish engineers and scientists, in the present study, the pattern appears slightly different (Table XXI). There is a slightly greater tendency for international gatekeepers to have studied rather than worked abroad, or at least to have had some form of foreign experience. The result is not so differentiated as the Irish case. This is a point requiring further investigation.

TABLE XXI

Foreign Experience of International Gatekeepers Compared With Their Colleagues

Type of Foreign Experience	Proportion of		p
	Gatekeepers	Others	
work	4.6%	3.2%	N.S.
study	13.6	4.6	0.07
either or both	18.2	5.5	0.02

Other Comparisons With Results in Ireland

In 1971, a similar survey was performed of all R&D engineers and scientists in the Republic of Ireland (Allen & Cooney, 1973). Since the Irish survey included a larger number of institutions and a broader variety of disciplines and work, a comparison of results from the two studies cannot lead to any firm conclusions. Nevertheless, it is interesting to observe some of the similarities and differences to see whether these point toward any interesting topics for future investigation.

Communication Among the Three Sectors. When the level of communication among the three sectors (university, research institute, industry) is computed on the basis of the number of communicating pairs, some striking differences emerge (Table XXII).

The three sectors are generally more closely connected in the Irish case. This is especially true of the communication between research institutes and industry. It must be remembered, however, that there was a substantial degree of variance in this measure among the Irish research institutes. Since the present study involves but one Swedish research institute and two firms, one must be very cautious in drawing conclusions at this point.

Ways in Which Domestic Contacts Were First Established. Each respondent was asked to indicate for each of the individuals, with whom he reported communication, just how he first met that person. This was done with a code describing a number of different ways of initially establishing acquaintance.

TABLE XXII

Strength of Communication Bonds* Among the Three Sectors

	Country			
	Sweden		Ireland	
	Research	Industry	Research	Industry
University	0.11	0.10	0.29	0.10
Research	--	0.05	--	0.42

$$*C_{ij} = \frac{(N_{ij} + N_{ji})\,(1 - \exp(-N_j/100))}{N_i\,N_j}$$

Cij = strength of communication bond between sector i and sector j
K = a scale factor, in this case, $K = 2 \times 10^2$
Nij, Nji = number of individuals in sector i or j who are named as communication partners by their counterparts in sector j or i
Ni = number of respondents in larger of the two sectors.
Nj = number of respondents in the smaller of the two sectors.
(Allen & Cooney, 1973).

The most impressive aspect of this portion of the results is the degree to which labor mobility has functioned to establish inter-organizational communication (Table XXIII). In both countries, this is the predominant factor influencing domestic communication. It accounts for nearly one-third of all reported inter-organizational communications.

TABLE XXIII

Means by Which Contact Between Engineers or Scientists in Different Organizations was First Established (Excluding Current Working Relationships)

mechanism	Sweden (n=306)	Ireland (n=478)
previously worked together in the same organization	28.4%	31.4%
professional society meeting or conference	5.5	19.6
committee membership	25.2	--
met in university	10.7	22.4
introduced by mutual acquaintance	7.5	0.2
other	22.3	16.4

This is particularly true in universities, where almost half of the relationships were established in this way (Table XXIV). In the research institute and industry, about one-fourth of the relations resulted from the movement of staff between organizations. In the research institute, the Swedish system of committees proves to be an important device for establishing inter-organizational relations.

If one were to see in certain industries in the United States that inter-organizational mobility were the principal cause of inter-organizational communication, it would not be terribly surprising. One expects high labor mobility in at least some American industries. In Europe, on the other hand, labor mobility of technical professionals, has been thought to be relatively low. The results at this point, do not indicate that mobility is high, but do show that when it occurs it has important effects on inter-organizational communication.

TABLE XXIV

Means by Which Contact Between Engineers or Scientists was First Established as a Function of Sector

Mechanism	sector		
	University	Research Institute	Institute
previously worked together in the same organization	42.5%	26.1%	21.4%
professional society meeting or conference	1.7	0	8.0
committee membership	15.2	58.6	20.8
met in university	16.9	6.5	10.0
introduced by mutual acquaintance	6.7	0	9.5
other	11.9	10.8	33.8

In fact, the staff of the four organizations have been relatively mobile over their careers (Table XXV). A very high proportion (52 percent) had worked for another Swedish organization before joining their present employer. The mean number of previous employers is 0.71. The mean length of time between shifts of employer is 4.1 years. The proportions of staff, who had previously worked for another organization is nearly as high as that reported for Israel, Britain and the United States.

TABLE XXV

Interorganizational Mobility of Technical Professionals

Country	Sector of Industry	N	Proportion Changing Employer at Least Once	Mean Number of Employers
Sweden	University	86	36.1%	1.7
	Research Institute	18	61.1	2.0
	Industry	138	60.1	2.0
Israel**	Universities	532	64.5	2.2
	Government	43	58.0	2.8
U.S.**	Aerospace Industry & Government	2933 3551	75.0 65.0	3.0 2.7
U.K.**	Mechanical Engineers	387	82.0	3.2

* Excluding foreign experience.
**Reported in Goldberg, et al. (1981)

Development of Contacts by Domestic Gatekeepers. Gatekeepers differ significantly from their colleagues in the manner by which they develop contacts with Swedish colleagues ($X^2 = 19.08$; $p < 0.01$). They are, for example, more likely to have met the colleague as a result of committee membership (Table XXV). This is an indication that gatekeepers are perhaps more likely to be nominated to committees. They are also more likely to have met the colleague at a conference, or to have been introduced by a third party.

TABLE XXVI

Means by Which External Domestic Contact Was First Established by Domestic Gatekeepers (Excluding Work Relationships)

Mechanism	Proportion of Instances
previously worked together in the same organization	26.0%
professional society meeting or conference	7.8
committee membership	35.1
met in unversity	10.4
introduced by mutual acquaintance	10.4
other	10.4

Foreign Communication by Sector. When a similar comparison is made of the degree of foreign communication by the three sectors, the Swedish and Irish cases again appear somewhat different (Table XXVII). Respondents in the two Swedish firms reported a greater number of foreign contacts than did their industrial counterparts in Ireland. This is in spite of the large number of foreign firms in Ireland, and the somewhat more advantageous geographic position of that country. The Swedish research institute, moreover, reported nearly five times the amount of foreign contact reported by Irish research institutes. This is even more striking because of the magnitude of the difference. The presence of foreign

TABLE XXVII

Foreign Communication by Sector

Sector	Foreign Communication Index (N_{fi}/N_i)	
	Sweden	Ireland
University	0.66	0.85
Research Institute	1.61	0.36
Industry	0.52	0.45

N_{fi} = number of foreign contacts reported in each sector.
N_i = number of respondents in each sector.

firms in Ireland probably should not affect the degree of foreign contact by research institutes, but the geographic position of Ireland would seem to make it easier for the staff of research institutes to establish and maintain contact with foreign colleagues. Nevertheless, the staff of the Swedish institute appear to be doing a far better job of keeping in touch with foreign technology.

Location of Foreign Contacts

One would certainly not expect Swedish and Irish organizations to establish their foreign contacts with the same parts of the world. Such contact is very strongly affected by both geography and history. Nevertheless, there are broad centers of technological activity in the world with which communication should be maintained. It is therefore interesting to examine similarities and differences in the location of foreign contact (Table XXVIII).

TABLE XXVIII

Location of Foreign Contacts by Sector

Location	Strength of Communication Bond					
	Sweden			Ireland		
	University	Research Institute	Industry	University	Research Institute	Industry
Scandinavia	0.07	1.22	0.17	---	---	---
Britain	---	---	---	0.38	0.21	0.29
Other Parts of Europe	0.29	0.28	0.95	0.20	0.09	0.12
North America	0.15	0.11	0.18	0.17	0.03	0.02
Other	0.15	0	0.20	0.06	0.03	0.02

$C_{fi} = \frac{Nfi}{Ni}$

The vast majority of foreign contacts in both countries is concentrated in Western Europe and North America. The only possible exception is with the two Swedish industrial firms which have begun to develop communication with Japan. History and geography are witnessed in the strength of the connection between Irish research institutes and organizations in the U.K. and between the Swedish research institute and organizations in other Scandinavian countries.

In general, the Swedish organizations appear better prepared to keep abreast of foreign technology. This is particularly true of the connection between the two Swedish firms and organizations in other European countries. The research institute has very strong foreign contact, but most of this is concentrated in Scandinavia. Perhaps some broadening of foreign contacts would be warranted, in this instance.

Ways in Which Foreign Contacts Were First Established

Swedish University scientists are most likely to have initially met foreign colleagues through professional society meetings or by approaching or being approached by the foreign scientist about their research work (Table XXIX). They are much less together, as was the case in Ireland. Committee membership, surprisingly, is the principal mechanism initiating foreign contact for research institute staff. Most of their foreign contacts are within Scandinavia, and it is not unusual for engineers and scientists from other Scandinavian countries to serve on Swedish committees. Over reliance on this means of establishing foreign contact may, however, prove too limiting for research institute staff. Since it would probably benefit their work to broaden their foreign exposure, it might be wise to encourage greater foreign

TABLE XXIX

Means by Which Foreign Contact was First Established as a Function of Sector

Mechanism	Country	Sector: University	Sector: Research Institute	Sector: Industry
previously worked together	Sweden	8.6%	0%	16.7%
	Ireland	38.3	26.4	8.1
professional society meeting or conference	Sweden	32.7	6.5	7.9
	Ireland	20.6	36.8	35.1
committee membership	Sweden	6.9	51.6	6.0
	Ireland	--	--	--
met in university	Sweden	5.2	0	0
	Ireland	10.3	26.4	6.8
introduced by mutual acquaintance	Sweden	12.1	3.2	9.8
	Ireland	5.6	5.2	6.8
met through work	Sweden	22.4	25.8	28.8
	Ireland	16.3	0	29.8
other	Sweden	12.1	12.9	30.7
	Ireland	16.3	0	13.5

conference attendance, or develop other means for bringing research institute staff into contact with a broader range of foreign technology.

Industry finds its foreign contact largely through work relationships. Some of this results from labor mobility, but more is due to ongoing contact, probably through customer/vendor relationships, subcontracts or joint ventures. Again it would appear wise to encourage other mechanisms to aid industry engineers in diversifying their foreign contact.

International gatekeepers differ significantly from their colleagues in the way in which they develop contact with foreign colleagues (X^2 = 32.9, p 0.001). They met foreign colleagues principally through work or conference attendance (Table XXX). Once again there is the example of the "rich getting richer and the poor getting poorer". The gatekeeper attending a conference already knows people who will be there. Through these individuals, he comes to know others as well. So he returns, not only with more information, but with an increased number of potential foreign sources as well. It is not difficult to see from this, who should be given priority for travel to foreign conferences.

TABLE XXX

Means by Which International Gatekeepers First Established Foreign Communication Contacts

Mechanism	Proportion of Instances
previously worked together	10.0%
professional society meeting or conference	23.8
committee membership	16.3
met in university	3.8
introduced by mutual acquaintance	13.8
met through work	25.0
other	7.5

CONCLUSION

First and foremost among the conclusions of this study is that the research method has proven appropriate and adaptable to the Swedish situation. The analyses of data reported in this document and in Hoglund and Persson (1981) indicate very clearly the power of the research technique.

By measuring the structure of the communication networks internal and external to organizations, and relating these structures to the demographic characteristics of the members and to institutional and environmental characteristics, much can be learned about the process of technology transfer. Such information can then be employed to develop policy to enhance the process. This pilot study provides numerous indications of that potential.

Data can be organized by sector, organization, technology or any combination of the three and analyzed accordingly. Strengths and weaknesses can be determined in terms of ability to keep abreast of technological developments both in Sweden and abroad. The effectiveness of communication between organizations or sectors can be determined. Analyses can be performed of the development of the social infra-structure in new technologies. Some indication of that potential can be seen in the present analysis, in which very different communication structures were observed for metals technology as compared with computer technology. Much more of this sort of analysis needs to be performed once a larger data base has been accumulated. Such analyses should instruct policy concerning the nurturing of new technologies as well as the rejuvenation of old ones.

For additional insights into what can potentially be learned the reader is referred to Höglund and Persson (1981).

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APPENDIX

The Survey Questionnaire

SVERIGES
CIVILINGENJÖRSFÖRBUND CF-STF

INFORSK
UMEÅ UNIVERSITET

KONTAKTMÖNSTER BLAND SVENSKA TEKNIKER FRÅGEFORMULÄR

Var god skriv tydligt(TEXTA) och svara så fullständigt som möjligt!

Kodkolumn

1 Namn: _____ 1-5

6 1

2 Vilken är Din ålder? _____år 7-8

3 Företagets(motsv) namn: _____ 9-12

4 Avdelning eller motsvarande: _____ 13-14

5 Arbetsplatsens ort: _____ 15-17

6 Anställningstid i nuvarande företag (motsv): _____år 18-19

7 Utbildning (ange Din högsta examen):

☐ Gymnasieingenjör
☐ Bergsskoleingenjör
☐ Civilingenjör
☐ Fil kand
☐ Licenciatexamen
☐ Doktorsexamen
☐ Annat, ange vad _____

20-21

8 Vid vilken skola avlade Du denna examen?

Skola/lärosäte: _____ 22-24

Skolans ort: _____ Land: _____ 25-27 28-29

9 Inom vilket tekniskt specialområde är Du huvudsakligen verksam?

☐ Metallurgi
☐ Bearbetning
☐ Manufakturering
☐ Råvaruförsörjning
☐ Energi- och värmeteknik
☐ Materialteknik, korrosion
☐ Ytteknik
☐ Metallografi
☐ Fototeknik
☐ Datateknik, programmering
☐ Annat, ange vilket: _____

30-32

10 Hur många års erfarenhet har Du av detta specialområde? _____år 33-34

11 Vilken är Din huvudsakliga arbetsuppgift?

☐ Produktion eller produktionsledande arbete
☐ Forsknings-, experiment eller utvecklingsarbete
☐ Konstruktions- eller formgivningsarbete
☐ Tekniskt underhållsarbete
☐ Administration
☐ Utredningsarbete
☐ Marknadsföring
☐ Informations- och dokumentationsarbete
☐ Undervisning
☐ Annat, ange vad _____

35-36

12 Vilken befattning/tjänst har Du? Beskriv Ditt arbete kort i klartext!

_____ 37-39

_____ 40-43

Ange ev. kod enligt befattningsnomenklatur för tjänstemän: _____

13 Vilka kommittéer eller grupper utom det egna företaget(motsv) som behandlar tekniska frågor är Du medlem i? Ange t ex grupp knuten till Jernkontoret, IM, IVF, IVA m fl.

Grupp/kommitté	Huvudorganisation(motsv)	
_____	_____	44-45
_____	_____	46-47
_____	_____	48-49
_____	_____	50-51
_____	_____	52-53
_____	_____	54-55
_____	_____	56-57
_____	_____	58-59

14 Vilka tidigare anställningar har Du haft i Sverige? (Om fler än 3, ange de 3 senaste före nuvarande anställning)

Företag (motsv)	Ort	fr o m	t o m	
_____	_____	19_ _	19_ _	1-5
_____	_____	19_ _	19_ _	6 2 Föret. 7-10
_____	_____	19_ _	19_ _	11-14
				15-18 Ort 19-21
				22-24
				25-27 Fr o m 28-29
				30-31
				32-33 T o m 34-35
				36-37
				38-39

15 Har Du haft anställning som tekniker utomlands? Inkludera även anställning för det egna företaget eller dess dotterbolag utomlands.

☐ Nej ⟶ Fråga 18
☐ Ja

OM JA, fyll i nedan (Om fler än 3 tillfällen, ange de 3 senaste) 40

Företag (motsv)	Ort	Land	fr o m	t o m	
_____	_____	_____	19_ _	19_ _	Föret. 41-44
_____	_____	_____	19_ _	19_ _	45-48
_____	_____	_____	19_ _	19_ _	49-52 Ort 53-55
					56-58
					59-61 Land 62-63
					64-65
					66-67 Fr o m 68-69
					70-71
					72-73 T o m 74-75
					76-77
					78-79

16 Uppskatta antalet gånger Du under den senaste 12-månadersperioden varit i kontakt med personer i utlandet som Du lärt känna under det senaste anställningstillfället enligt fråga 15 ovan.

Antal kontakt-tillfällen	Antal olika kontakt-personer	
_____ggr	_____st	1-5

I följande frågor ber vi Dig att namnge personer som Du har kontakt med. Detta är den enda metoden att få en bild av kontaktnätet bland personer inom Ditt specialområde. Resultaten kommer att slås samman och presenteras så att identifiering av enskilda personer omöjliggörs!

17 Om Du stöter på ett speciellt svårt problem inom ditt tekniska specialområde, vem/vilka skulle Du då troligast vända Dig till?

Namn	Företag (motsv)

18 Vilka personer i Ditt nuvarande företag(motsv) diskuterar Du oftast tekniska problem med? Utelämna rent administrativa spörsmål! (Om fler än 8 personer, ange de 8 vanligaste)

Namn	Kontaktfrekvens Ung antal kontakter/månad

19 Vilka personer i Sverige utom Ditt eget företag(motsv) diskuterar Du oftast tekniska problem med? (Om fler än 5 ange de 5 vanligaste)

Namn	Företag(motsv)	Antal kontakter/år	Möttes genom*

* Markera i kolumnen till höger ovan HUR Du först kom i kontakt med respektive person. Använd följande koder:

1 Vi arbetade tillsammans	5 Vi studerade tillsammans
2 Vi möttes på en konferens	6 Vi träffades via annan person
3 Jag blev kontaktad i arbetet	7 Jag tog själv kontakt i arb
4 Vi satt i samma kommitté	8 Annat sätt: _____

Namn
11-15
16-20
Föret.
21-24
25-28
Namn
29-33
34-38
39-43
44-48
49-53
54-58
59-63
64-68
K.frek.
69-70
71-72
73-74
75-76
77-78
79-80
1-5
6
7-8
9-10
Namn
11-15
16-20
21-25
26-30
31-35
Föret.
36-39
40-43
44-47
48-51
52-55
K.frek.
56-57
58-59
60-61
62-63
64-65
Möttes
66
67
68
69
70
71

20 Vilka personer utomlands diskuterar Du oftast tekniska problem med? (Om fler än 5 ange de 5 vanligaste)

Namn	Företag (motsv)	Land	Antal kontakter/år	Möttes genom*

* Markera i kolumnen längst till höger HUR Du först kom i kontakt med respektive person. Använd koder som i fråga 19.

21 Uppskatta totala antalet gånger Du under de senaste 12 månaderna varit i kontakt med personer i utlandet angående tekniska frågor.

_____antal gånger

22 Hur många gånger under de 3 senaste åren har Du varit med om följande:

Deltagit i konferens/kongress i Sverige: _____ggr

Deltagit i konferens/kongress utomlands: _____ggr

Studie- eller tjänsteresa till utlandet: _____ggr

23 Brukar Du använda följande informationskällor? (Uppskatta frekvensen med hjälp av vidstående skala)

	Aldrig	Någon gång/år	Någon gång/månad	1-2 ggr vecka	3-4 ggr/vecka	Dagligen
Fackböcker	☐	☐	☐	☐	☐	☐
Referatorgan, index mm (t ex Engineering index, Current contents)	☐	☐	☐	☐	☐	☐
Patentskrifter	☐	☐	☐	☐	☐	☐
Leverantörstryck	☐	☐	☐	☐	☐	☐
Information fr branschsammanslutning	☐	☐	☐	☐	☐	☐
Datorbaserad litteratursökning	☐	☐	☐	☐	☐	☐

24 Brukar Du regelbundet läsa vetenskapliga eller tekniska facktidskrifter?

☐ Nej
☐ Ja, jag läser ca _____st tidskrifter

1-5
6 5
Namn
7-11
12-16
17-21
22-26
27-31
Föret.
32-35
36-39
40-43
44-47
48-51
K.frek.
52-53
54-55
56-57
58-59
60-61
Möttes
62
63
64
65
66
67
68-69
1-5
6 6
7-8
9-10
11-12
13
14
15
16
17
18
19
20-21

25 Vilka av följande språk kan Du tala?

	Obehindrat	Med viss svårighet	Med stor svårighet	
Engelska	☐	☐	☐	22
Franska	☐	☐	☐	23
Tyska	☐	☐	☐	24
Andra _____	☐	☐	☐	25

26 Anser Du det som angeläget eller mindre angeläget att utöka Dina kontakter med följande typer av organisationer?

	Mycket angeläget	Angeläget	Mindre angeläget	Oangeläget	
Svenska:					
universitet/högskolor	☐	☐	☐	☐	26
forskningsinstitut	☐	☐	☐	☐	27
industriföretag	☐	☐	☐	☐	28
Utländska:					
universitet/högskolor	☐	☐	☐	☐	29
forskningsinstitut	☐	☐	☐	☐	30
industriföretag	☐	☐	☐	☐	31

27 Skulle Du kunna tänka Dig att vara anställd som tekniker i utlandet under mer än ett halvår?

☐ Ja, utan tvekan ☐ Ja, med viss tvekan ☐ Nej, troligen inte ☐ Nej, helt otänkbart 32

28 Upplever Du att det finns hinder som gör det svårt att ta kontakt med tekniker och specialister inom eller utom landet?

Inom landet: _____ 33-34

_____

Utom landet: _____ 35-36

_____

29 Övriga synpunkter: _____

_____ 37-38

_____

_____

_____

TACK FÖR DIN MEDVERKAN!