THE USE AND EFFECTIVENESS OF COMMUNICATIONS CHANNELS FOR SCIENTISTS AND ENGINEERS IN A DEVELOPING COUNTRY - THE CONCEPT OF THE INTERNATIONAL TECHNOLOGICAL GATEKEEPER

by

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ABSTRACT

A questionnaire was developed and administered to the research personnel of An Foras Taluntais, the Irish agricultural research and development organization, to study the operation of communications channels for the international transfer of technological information. The techniques employed are consistent with those used in previous studies of the purely domestic flow of technological information into R & D labs.

Results of the study show that the international transfer, like domestic transfer, takes place in a two-step flow through certain intermediary agents called technological gatekeepers. These technological gatekeepers are well integrated into two information networks, an external network of information sources and an internal network of users to whom the information can be delivered.

Researchers of foreign nationality employed by An Foras Taluntais are poorly integrated into the internal network and therefore do not become technological gatekeepers. This remains the case even when they display all of the other qualifications of a technological gatekeeper, including the use of an extensive external information network.

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THE PROBLEM OF INTERNATIONAL TRANSFER OF TECHNOLOGY

A great deal of research has been devoted during the past decade both to the problems of economic development and to the implications of the so called "information explosion" in science and technology. Less attention, however, has been given specifically to the point at which these two areas intersect.

The problem posed by this intersection can be stated quite simply. A massive body of technical information exists in the world which, theoretically, the developing country should be able to tap and to apply in its development programs. The developing country must select and apply this technology efficiently, however, in order to reap the greatest benefits from it. But technology continues to multiply and accumulate at such a rapid pace that it is extremely difficult to keep track of it.

How then does the scientist or engineer working in a developing country with modest resources isolate and identify those pieces of the vast reservoir of the world's accumulated technical knowledge that are relevant to his current work? How, indeed, can he even discover whether his particular problem has already been solved by researchers in another country? Surely limited R & D budgets can be applied more efficiently if existing solutions to current technical problems and new advances in research techniques can be communicated to those abroad who need them, rather than having to "discover" them over and over again in each separate country.

Of course, as many authors have already pointed out, all R & D

suffers from this malady - however the symptoms are likely to be much more acute in a small country with limited resources. Such a country can ill afford duplication of research.

The question to be addressed, therefore, is - how do we improve the communications channels that carry information from research groups in one country and deliver it to research groups in another (particularly a developing) country? First we must identify the channels that are actually used to acquire information generated abroad and then we can suggest possible improvements in their performance.

This study will not address itself to theoretical questions about what channels people ought to use but will try to identify and to suggest improvements for those that they actually do use. The purpose of a "user study" is not to change man but to improve his tools.

DOMESTIC TRANSFER OF TECHNOLOGY

The R & D laboratory cannot function in an information vacuum. Scientists and engineers working in the lab must be informed of developments that occur outside the lab. Several channels can be used. Research personnel can consult technical literature and discuss technical matters with colleagues in other labs and with colleagues at professional conferences and society meetings. However, these channels which should serve the very useful function of funneling external information into the R & D lab have either a very small influence or even a significantly negative impact on performance.

Allen and others have presented strong evidence that the literature is infrequently used and poorly understood by most engineers. (Allen, 1966a, 1966b). In addition, the use of information sources external to the organization correlates negatively with performance (Allen, 1964, 1966b; Shilling and Bernard, 1964). This poor performance can be attributed to the lack of competence within the laboratory that necessitates the use of external consultants in the first place.

Hagstrom (1965), on the other hand, finds the reverse to be true for scientists in an academic department. External communication leads to better performance.

How can these seemingly contradictory results be resolved and how does external information penetrate the boundaries of the organization? Katz and Kahn (1966) resolve the contradiction by noting that persons inside each industrial or governmental R & D organization are likely to

have a "coding scheme" different from persons outside that organization. Each organization has its own way of approaching problems and setting priorities. Each demands primary loyalty from its employees.

The scientist in an academic department, however, will probably identify himself first with his particular research specialty (his "invisible college"), a grouping that transcends organizational boundaries. His actual organization will come second.

The researcher in an industrial or governmental R & D organization is therefore much more likely to be constrained by the organization to adopt its coding scheme. The academic scientist, on the other hand, is likely to adopt a scheme that is compatible with his colleagues in the invisible college.

But this does not answer the second question, "How does external information penetrate the boundaries of an industrial or governmental R & D organization?"

The answer lies in the two-step flow of information with an information intermediary, the "technological gatekeeper", who is able to understand both external and internal coding schemes. These technological gatekeepers offer more efficient routes through which technical information can enter the organization.

The technological gatekeepers receive information from a wide variety of sources external to the laboratory and, in turn, act as information sources for the majority of their colleagues in the laboratory. Such a two-step flow seems to be significantly more effective in transferring technology than a simple one-step flow from source to receiver.

The two-step flow of information plays an important role in communications over a wide spectrum of human effort including: the adoption of hybrid seed corn by farmers (Rogers, 1965); the prescribing of new drugs by doctors (Coleman, et. al., 1966); and the spread of political opinions among the electorate (Lazarsfeld, Berelson, and Gaudet, 1948). It is not surprising therefore, that the same two-step process is important in technology transfer into R & D labs.

This study hypothesizes that communications channels for the international transfer of technical information will also demonstrate a two-step flow process and that "international technological gatekeepers" can be isolated and identified as key intermediaries through which information from abroad is channelled and distributed.

To facilitate comparison, the methods used to idenfity gatekeepers for the international transfer of technical information were tailored on the pattern of previous studies of domestic channels. (Allen, 1966a, 1966b; Allen and Cohen, 1969).

SAMPLE DESCRIPTION

The sample population comprised the personnel of An Foras Taluntais (AFT - the Agricultural Institute) including research personnel and first and second line supervisors but not technicians or the Headquarters (administrative) staff. Those who reported spending less than 25% of their time on R & D were also removed from the sample.

AFT is a fairly unusual R & D establishment in that it is impossible to categorize its members into classes such as scientists vs. engineers, basic vs. applied scientists, research vs. development personnel. To a very great extent the product of each man's labors is twofold, namely scientific publications and improved agricultural products. Although a substantial number of research personnel have published more than one scientific paper per annum during their careers with AFT (a respectable achievement) Michael Woods, Head of Glasshouse Crops and Mushrooms Division of AFT reports that "... the main outputs of An Foras Taluntais are technical innovations for immediate application at farm level...". (Woods, 1969, p. 34).

Thus we have a situation in which we cannot discriminate between scientists and engineers in the normal manner by looking at the results of their work (i.e. results physically encoded in a product for engineers, or results encoded in publications for scientists) (Allen, 1966a).

AFT is divided into six divisions. Each division is further subdivided into several departments (Glasshouse Crops and Mushrooms, Meat Research, Pig Husbandry, etc.). Each department may be spread over sev-

eral geographic areas and, furthermore, sections of several separate departments may be lumped into a single research center. Such a pattern tends to complicate intra-specialty communications but to facilitate inter-specialty information transfer.

The research personnel of AFT are overwhelmingly Irish by nationality (96% are citizens of the Republic of Ireland or Northern Ireland). Our sample population of 168 personnel contained 55 PhD's and most of the remaining held a degree or certification higher than the bachelors level.

METHOD OF INVESTIGATION

The Questionnaire

A five-page questionnaire containing 30 questions was devised and administered to all 237 members of An Foras Taluntais (The Agricultural Institute - "AFT") in the Republic of Ireland. The questionnaire was given in addition to a separate questionnaire issued annually by the Royal Irish Academy to every known member of the scientific and technological community in the country. Our questionnaire included both the demographic and biographic questions required by AFT and the more specific questions relating to communications which we desired. By this means we were able to employ an instrument with which the great majority of our population was already familiar and which carried the full blessing of both AFT and RIA. The questionnaire enjoyed an 83% response rate.

Criteria for Choosing International Gatekeepers

To be an effective gatekeeper for international communication an individual must be well integrated into two networks: an external network of foreign information sources and an internal network of domestic users to whom the required information can be delivered.

Internal Network

We can easily identify those who have established an internal network by asking each individual in AFT the following question: "Please name those people in your present organization with whom you most frequently discuss technical matters (once a week or more often)." In totalling the number of times each individual is chosen by his associates we find that some are contacted by many individuals and some are never

contacted at all. Those who are chosen a number of times equal to or greater than a number that is one standard deviation above the mean number of choices for the sample are called "technical discussion stars".

Those labelled "technical discussion stars" by responses to question 12 are merely those who act as sources of information for their associates to a significantly greater extent than average. Not all technical discussion stars will be gatekeepers, but all gatekeepers must be technical discussion stars. If they were not technical discussion stars they would not be able to distribute information well and thus could not be effective agents of technology transfer.

External Network

For a technical discussion star to be an international technological gatekeeper he must also be well integrated into an external network of international information sources. In choosing a discriminator to identify those who have established and do employ an external network two factors are important. The discriminator must identify: (a) those who frequently and continually use the network, and (b) those whose network is broad enough to include many different international information sources.

Two criteria -- the frequency of foreign technical correspondence and the frequency of foreign scientific and professional society 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 was therefore judged to be a good measure of integration into the external network.

For the dual concepts of two-step information flow and "technological gatekeeper" to be meaningful, it must be demonstrated that the technical discussion stars described above actually do receive a greater amount of international information than do their colleagues. If each individual were to receive most of his international technical information directly from its source (one-step flow) then the two-step flow process would be of minor interest and the role of gatekeeper would be meaningless. In other words, good distributors must also be good receivers for the two-step process to work.

Table I demonstrates that the technical discussion stars actually do receive significantly more international technical information than non-stars as measured by frequency of foreign correspondence and attendance at foreign scientific and professional society conferences. These data support the two-step hypothesis.

TABLE I

THE USE OF EXTERNAL INFORMATION CHANNELS BY TECHNICAL DISCUSSION STARS AND NON-STARS

Criteria	Discussion Stars	Non-Stars	Level of Statistical Significance
Average number of times in the last year each has corresponded on technical matters with persons abroad	9.79	7.43	0.03*
Average foreign scientific and professional society conference attendance	9.42	5.05	0.0001*

* t-test (1 tail)

The "technical discussion star" who has either engaged in technical correspondence with foreign researchers or has attended foreign scientific

and professional society conferences a number of times greater than the mean number for all AFT research personnel was judged to be sufficiently integrated into and to be using the required internal and external networks and therefore were identified as gatekeepers.

Characteristics of Gatekeepers

AFT research personnel can now be dichotomised into two groups -- gatekeepers and non-gatekeepers -- and characteristics that distinguish each group identified.*

Characteristics which were considered potentially relevant to foreign communication are enumerated below.

Educational

1. highest educational level achieved

Organizational

1. number of years employed by AFT in a research capacity
2. organizational level (researcher, head of department, etc.)
3. percentage of time spent on R & D
4. number of years experience in present field of research

Biographical and Historical

1. employment in research outside of Ireland
2. special courses, sabbaticals, fellowships, internships, etc., taken outside of Ireland
3. university degrees taken at a foreign institution
4. nationality

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*Persons of nationality other than Irish were removed from the sample for separate consideration for reasons which will be described in the following chapter.

Professional

1. the number of published scientific or technical journal articles authored
2. the number of scientific or technical journals read regularly
3. the number of patents held
4. the number of contacts with overseas vendors of scientific and technical equipment
5. the level of overseas technical correspondence

Standard statistical techniques applied to the dichotomised population then allow us to determine in which of the above fourteen characteristics the gatekeepers differ significantly from the rest of the population. In addition AFT research personnel of foreign nationality can be compared with their Irish colleagues on these same fourteen characteristics to determine if they become gatekeepers to a greater or lesser extent than their Irish associates.

CHARACTERISTICS OF THE GATEKEEPER FOR INTERNATIONAL TRANSFER OF TECHNOLOGY

Recent studies have found that gatekeepers for domestic transfer of technology are technically more competent and productive than their non-gatekeeper colleagues (Allen, 1966a, 1966b). They are, on the average, more frequently published, they read a larger number and a wider range of technical and scientific publications, and they are more frequently sought by their colleagues for assistance on particularly difficult problems.

Our gatekeeper for international transfer of technology also displays greater technical competence than his non-gatekeeper colleagues. Although technical competence is a difficult attribute to define precisely, three measures are herein employed (number of scientific and professional papers published, educational level, and patents held) which, when taken together, should give a reasonably good evaluation of competency. They have the added advantage of being consistent with measures used in previous studies.

Technological gatekeepers that were identified in AFT are, on the average, significantly superior to their colleagues on all three of the above measures. As Table II demonstrates, they have published a greater number of papers and are more likely to hold Ph.D.'s and patents than their associates.

TABLE II

A COMPARISON OF GATEKEEPERS WITH NON-GATEKEEPERS
ON THREE MEASURES OF TECHNICAL COMPETENCE

Criteria	Gatekeepers	Non-Gatekeepers	Level of Statistical Significance
Average number of papers published in scientific or professional society journals	9.3	4.8	0.0001*
Percentage holding a Ph.D.	53.6	25.4	0.002+
Percentage holding patents	10.7	3.3	0.05+

* t-test (1 tail) +proportionality test

The Internal Information Network

To fulfill the role of gatekeeper for international transfer of technology a researcher must establish two information networks -- an external network of information sources and an internal network for information distribution. Those who have established an extensive internal network (the technical discussion stars) were identified using the procedure described in the previous section.

The External Information Network

The level of his foreign technical correspondence and the frequency of his foreign scientific and professional conference attendance are the criteria employed as measures of the researcher's use of an external information source network. When combined with a measure of his internal information distribution network, they distinguish the gatekeepers from the non-gatekeepers in AFT. We must, of course, determine whether the gatekeepers identified by using these external network criteria actually employ the other available external channels significantly more often as

well. If they do then there is good reason to believe that the gatekeepers chosen have actually established and do regularly use an extensive external network (rather than only the two channels used above as measures). If they do not, however, we must question the validity of our two criteria as measures of the researcher's overall external network.

The results of an investigation of other external channels vindicate the choice of criteria. Table III demonstrates that gatekeepers use two other external channels (scientific journal readership and contacts with foreign vendors of scientific and technical equipment) significantly more often than their non-gatekeeper colleagues.

TABLE III

THE USE OF TWO EXTERNAL INFORMATION CHANNELS
BY GATEKEEPERS AND NON-GATEKEEPERS

Channel	Gatekeepers	Non-Gatekeepers	Level of Statistical Significance
Average number of face-to-face contacts with foreign vendors of scientific or technical equipment in the last year	2.8	1.6	0.01*
Average number of foreign scientific and technical periodicals read regularly	24.6	16.1	0.0007*

* t-test (1 tail)

Contacts with Foreign vendors

Allen (1966a) notes that contacts with vendors can transfer information into the R & D laboratory. This information channel, however, does not seem to be an exceptionally strong one for American engineering. The vendor generally gives copious advice, but most of it understandably involves the use of one of his products. In an international setting,

however, the vendor can serve the function of keeping the researcher informed of new techniques and hardware developed abroad and presumably identify those research establishments which use them.

Journal Readership

Journals and journal pre-prints constitute one of the most important communications channels for scientists (Allen 1966a). They play a more minor role for engineers, except for engineer-gatekeepers who use them much more frequently and effectively than their associates (Allen, 1966a). As every researcher knows, it is nearly impossible to "keep up with the literature", even the literature of a small sub-specialty. Those who are able to consume and digest a larger amount and a wider variety of publications are obviously in a better position to disseminate information to their colleagues

Foreign Technical Experience

Other external links that facilitate the inflow of foreign information also exist. Educational degrees taken at foreign universities, employment in a research capacity in foreign laboratories, and other foreign technical experience (special courses, sabbaticals, visiting fellowships, internship, etc., taken in a foreign country) are three such links. Each of these three links can help the participant to foster technology transfer in two ways, directly and indirectly.

Direct - by helping him learn of new techniques or areas of research not currently in use or under study in his home country.

Indirect - by establishing a network of contacts (or contributing to a network already begun) with researchers overseas in the participant's own or a related field.

The importance of the direct benefit should decay with time. The research front creeps on and older techniques and ideas become less relevant. The indirect benefit, however, should decay more slowly and continue to yield rewards after all direct benefits have ceased. Correspondence on technical matters with foreign colleagues met during periods of foreign study, employment, or other technical experience permits such a continuing transfer of information. The indirect benefit, over the long run, probably outweighs the direct benefit appreciably.

Of the three forms of foreign technical experience investigated by our questionnaire, the gatekeepers differed from their fellow researchers on two but did not differ on the third. As Table IV demonstrates gatekeepers, on the average, have undertaken foreign research employment and other foreign technical experience significantly more often but have not taken more foreign degrees.

TABLE IV

FOREIGN TECHNICAL EXPERIENCE OF
GATEKEEPERS AND NON-GATEKEEPERS

Criteria	Gatekeepers	Non-Gatekeepers	Level of Statistical Significance
Percentage with at least one foreign sabbatical, internship or visiting fellowship, etc.	82.1	51.6	0.002+
Percentage with at least one incidence of foreign employment in a research capacity	42.9	18.0	0.003+
Percentage with at least one foreign degree	39.3	37.7	N.S.+

+proportionality test

These data suggest that, although study in a foreign university may well aid the international transfer of technical information directly, it does not contribute significantly to the development of superior transfer agents (i.e., gatekeepers). Foreign "visits" and foreign research employment do.

A further test of the effectiveness of the three forms of foreign technical experience in establishing external links for technology transfer was made. All researchers who had taken a foreign degree but had not undertaken foreign research employment or other foreign technical experience were identified. This segment of the population was then compared to a second segment consisting of those who had undertaken foreign research employment or other foreign technical experience but not a foreign degree. Table V shows that the group with foreign employment and/or other foreign technical experience corresponds on technical matters with overseas colleagues a significantly greater number of times than the group with foreign degree only.

TABLE V

AVERAGE LEVEL OF FOREIGN TECHNICAL CORRESPONDENCE OF RESEARCHERS WITH FOREIGN RESEARCH EXPERIENCE AND/OR OTHER FOREIGN TECHNICAL EXPERIENCE vs RESEARCHERS WITH FOREIGN DEGREE ONLY

	FV and/or FE but no FD*	FD but no FV or FE*	Level of Statistical Significance
Average number of times in the last year the researcher has corresponded with persons overseas on technical matters	8.9	5.6	0.02+

*FV = other foreign technical experience
FE = foreign research employment
FD = foreign degree

+ t-test (1 tail)

TRANSFER OF TECHNOLOGY BY EMPLOYING RESEARCHERS OF OTHER NATIONALITIES

While international transfer of technology is fostered by enabling talented AFT researchers to undertake periods of foreign research employment, the reverse process seems to work poorly. That is, foreign nationals employed by AFT in a research capacity have not become gatekeepers for international transfer of technology.* Even the many foreign personnel who display all the other qualities applicable to the gatekeeper (authorship of many papers, PhD, foreign employment, substantial foreign correspondence, and frequent attendance at foreign scientific conferences) are only infrequently picked by their Irish colleagues as technical discussion choices. These researchers of other nationality have successfully established the requisite external network of contacts but seem unable to construct the internal network and therefore cannot function as gatekeepers.

The reasons for this failure to develop an internal network even when an extensive external network has been put together are not entirely clear. Two factors seem to be involved. The first concerns the number of years the "foreigner" has been employed by AFT and the second concerns the goals toward which his research is aimed.

Duration of Employment in AFT

The 10 researchers of other nationality in our sample have been employed by AFT a fewer number of years on the average than the gate-

*This most emphatically does not mean that they are poor researchers, only that they do not fill the particular role of transfer agent.

keepers or the other Irish researchers as Table VI demonstrates. Gatekeepers, on the other hand, have been employed slightly longer than their colleagues.

TABLE VI

AVERAGE DURATION OF EMPLOYMENT IN AFT BY GATEKEEPERS, IRISH RESEARCHERS OTHER THAN GATEKEEPERS, AND FOREIGNERS

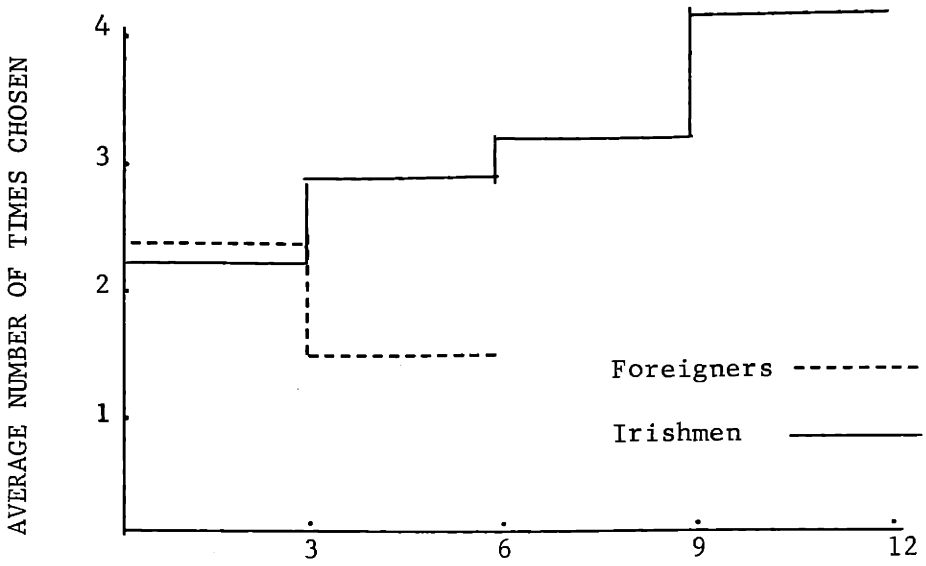
	Average Number of Years Employed by AFT	Level of Statistical Significance
Gatekeepers	7.9	
		0.02^{+}
Irish researchers other than gatekeepers	6.3	
		0.002^{+}
Researchers of nationality other than Irish	2.9	

+ t-test (1 tail)

In fact a more general mechanism seems to be operating. Graph 1 shows that, on the average, the longer an Irishman has been employed by AFT the more frequently he is picked by his colleagues as a technical discussion choice and, therefore, the wider his internal network becomes. The foreigner, however, does not seem to be chosen more often the longer he is employed, in fact he seems to be chosen fewer times. (The sample of foreigners was too small to determine the significance level of this difference. The data suggest, however, that a difference does exist).

GRAPH I

AVERAGE FREQUENCY OF CHOICE vs
NUMBER OF YEARS EMPLOYED BY AFT



Although it is tempting to ascribe the foreigner's lack of an internal network solely to the short span of his employment, to do so implies that number of years in the organization rather than technical competence or research experience is the basis for being picked as a technical discussion choice. One normally considers that technical skill or at least research experience, on the average, increases with the number of years employed in research -- years employed therefore becomes something of an overall indicator of experience. In this case, however, the foreigners demonstrate a high level of competency even though years of employment in AFT* are less than average. Table VII shows that foreigners have published more papers, hold a PhD degree more often, and have had a

*Most researchers of foreign nationality have also had research experience abroad.

greater level of foreign research experience than their Irish colleagues.

TABLE VII

A COMPARISON OF NON-GATEKEEPER IRISHMEN WITH FOREIGNERS ON THREE MEASURES OF TECHNICAL COMPETENCE

Criteria	Foreigners	Non-Gatekeeper Irishmen	Level of Statistical Significance
Average number of papers published	7.3	4.8	0.05*
Percentage with Ph.D. degree	80.0	25.4	0.0001+
Percentage with foreign research experience	80.0	18.0	0.0001+

* t-test (1 tail) + proportionality test

Since a period of three years does seem long enough to enable a foreigner to become sufficiently socialized into the organization and since the foreigners are certainly no less competent than their Irish colleagues we are left with doubts that fewer years of employment in AFT is the sole cause of the foreigner's lack of an internal network.

Foreigners' Research Goals

An important distinction probably exists between the ways in which Irish researchers and foreign-born researchers see the role of an AFT scientist. Michael Woods in a discussion of AFT's role in Irish research (1969, p. 34) states most explicitly that AFT exists to improve Irish agriculture, "...the main outputs are technical innovations for immediate application at farm level." Dr. Woods, for instance, describes in detail the substantial benefits accruing to the Irish balance of payments from

AFT's development of a late-ripening tomato. Such close attention and concern that its products be immediately useful to the nation is somewhat uncommon for a research establishment of a highly science-oriented nature. It is this concern perhaps that distinguishes the Irish researcher from his colleagues of foreign nationality. Researchers of foreign nationality, like most scientists around the world, would tend to value the production of published journal articles as the most important outcome of their research.

The discrepancy in research goals may combine with the shorter period of employment in AFT to make the foreigner a less attractive choice for technical discussion and therefore to reduce his internal information network.

CONCLUSIONS AND IMPLICATIONS

The existence of international technological gatekeepers as information intermediaries in a two-step flow communication process has been demonstrated. These international technological gatekeepers display characteristics which are very similar to the domestic technological gatekeepers identified by Allen and others in American R & D labs. They are, on the average, technically more competent and more productive. They regularly read a larger number of technical publications and hold a PhD degree significantly more frequently than their non-gatekeeper colleagues.

International technological gatekeepers employ many external information channels more effectively than their colleagues. These channels include: Correspondence with foreign colleagues on technical matters,

Attendance at foreign scientific or professional society conferences,

Contacts with overseas vendors of scientific and technical equipment,

Reading of foreign scientific and technical publications.

Periods of foreign research employment and other foreign technical experience help an able researcher to develop an external information network and thus help him to become an international technological gatekeeper. Foreign university degrees, however, do not.

The implications of these results are unambiguous. If international transfer of technology is to be fostered the research organization should seek to open those channels through which the information flows. It

should recognize that two-step flow is an efficient vehicle for transfer and it should help the international technological gatekeeper to perform his role. Such help could take the form of a reward structure that recognizes the benefits to the organization deriving from the gatekeeper's role as information transfer agent. The quality and the efficiency of its research are measures of the success of an R & D lab. Technological gatekeepers improve both quality and efficiency by continually infusing the organization with fresh information. Such information helps to prevent both research duplication and the pursuit of blind alleys. Such information helps to improve the work of many researchers and the information agent should receive credit for his assistance.

In order to foster increased information flow the R & D organization should assist able, domestically educated research personnel in getting grants to do research abroad. It should encourage researchers to take foreign sabbaticals, fellowships and other forms of extended foreign technical experience. It should not however, spend money directly on foreign education for its personnel. Foreign research employment and other forms of foreign technical experience greatly increase an individual's ability to fill the role of international technological gatekeeper and thus improve channels for international communications. Foreign education, per se, does not.

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