WORKING PAPER

ALFRED P. SLOAN SCHOOL OF MANAGEMENT

Research Program on the
Management of Science and Technology

# TECHNOLOGY TRANSFER TO DEVELOPING COUNTRIES: THE INTERNATIONAL TECHNOLOGICAL GATEKEEPER

T.J. Allen, J.M. Piepmeier, and S. Cooney

June 1970 #467-70

MASSACHUSETTS
INSTITUTE OF TECHNOLOGY
50 MEMORIAL DRIVE
CAMBRIDGE, MASSACHUSETTS 02139

Research Program on the
Management of Science and Technology

# TECHNOLOGY TRANSFER TO DEVELOPING COUNTRIES: THE INTERNATIONAL TECHNOLOGICAL GATEKEEPER

T.J. Allen, J.M. Piepmeier, and S. Cooney

June 1970 #467-70

The research was supported by An Foras Talúntais, the Irish Agricultural Institute. Raymond N. Seakan provided assistance in the data analysis. The authors gratefully acknowledge the cooperation of the management and employees of An Foras Talúntais.

## ABSTRACT

A questionnaire was developed and administered to the research personnel of An Foras Talúntais, 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 American research and development laboratories.

Results of the study show that the international transfer, like domestic transfer, takes place in a two-step process operating through certain intermediary agents called technological gatekeepers. These technological gatekeepers must be 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. Possible strategies for gatekeeper development are discussed.

# THE PROBLEM OF INTERNATIONAL TRANSFER OF TECHNOLOGY

A great deal of attention 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. Far less consideration, 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 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 researcher 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? A prerequisite for answering such a question must be a good understanding of the ways in which scientific and technological information flows between countries. An understanding of the way in which the existing system functions can often, by itself, suggest directions for improvement, and will lessen the likelihood of costly errors in policy formation or system design.

## THE PROBLEM OF INTER-ORGANIZATIONAL TRANSFER OF TECHNOLOGY

Before turning directly to an examination of channels used in international technology transfer, it will be useful to look first at an analogous situation. The large, technology-based firm faces a problem very similar to that confronted by the small country. No single organization can be technologically self-sufficient. There will always be relevant technology to be imported into the organization. The means by which large American corporations accomplish this feat has been the subject for much research in recent years. (1)

Most attempts at bringing new technology into the firm have assumed a straightforward model of information flow. According to this model, the interface between technical personnel in the firm and the external technical environment is a simple and direct one. Each and every member of the organization accomplishes this interface in exactly the same way. He both reads the literature and talks with people outside of the firm. To promote technology transfer under the terms of this model, all one must do is increase the degree and ease of contact between organization members and the two external information sources. Although in theory, this is very

simple, in practice it often becomes very costly and is frequently ineffective.

Research now shows that neither of these sources has been successful in providing information to the average industrial scientist or engineer. The literature is ineffective because it is not used (2). The average engineer makes very little use of his literature, particularly that contained in professional engineering and scientific journals. Furthermore, increasing the quantity of literature to which he is exposed will do little to alleviate this situation, since he already feels swamped by written material.

Direct contact with people outside of the organization is ineffective for different reasons. Such contact occurs quite a lot, but studies have shown a consistent negative correlation between the use of this information source and the user's performance (3). There are many reasons for this. Suffice it to say at this point that the channel is a "noisy" one, subject to misinterpretation, and is, therefore, an ineffective medium for technology transfer (4).

There is only one information source, in all of these studies, whose use has consistently shown a positive correlation with technical performance. It lies not outside the firm, but within. A colleague of the information seeker within his own organization proves to be the most effective direct source of information. This, however, begs the question of transferring information into the firm, and it isn't until one steps back and looks more carefully at the internal consultant that the most effective connection to the outside world appears. Those who were highly chosen as internal consultants also, on the average, made significantly greater use of the professional and scientific journals and maintained on going informal contact with many colleagues in other organizations,

particularly university and non-profit laboratories (5). They, thus serve as intermediaries between the average member of the firm and external sources of information. For this reason, they have been given the name "technological gatekeeper".

The technological gatekeeper receives information from a wide variety of sources external to the laboratory and, in turn, acts as an information source for his colleagues in the laboratory. Such a two-step flow seems to be significantly more effective in transferring technology than a simple direct connection from source to receiver. Gatekeepers, in at least some organizations, exist not as solitary intermediaries, but have actually developed a network among themselves (6). The gatekeeper network extends considerably the range of contact between organization members and sources of information in the world at large.

The two-step phenomenon has been show to play an important role in communications over a wide spectrum of human effort including: the adoption of hybrid seed corn by farmers (7); the prescribing of new drugs by doctors (8); and the spread of political opinions among the electorate (9). It is not surprising therefore that the same two-step process is important in technology transfer into R&D labs.

For some time now it has seemed possible to extend the methods used in the study of American R&D laboratories to the problem of the small nation. As a first step in this direction, an empirical analysis has been made of the way in which foreign agricultural information is acquired, by one small country, and then disseminated among its agricultural scientists. 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 identify international gatekeepers are tailored on the pattern of previous studies of American laboratories.

## SAMPLE DESCRIPTION

The sample population comprised the native-born personnel (10), of An Foras Talúntais (AFT - the Irish 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.

An Foras Talúntais operates under a charter similar to that of many other government supported research institutes. One of its primary goals is the acquisition of information to promote agricultural innovation as a means toward the economic and social development of the nation. It, therefore, acts in one sense as a gatekeeping institution, mediating between the Irish farmer and agricultural developments occurring both within and outside of the country. (11)

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 several geographic areas and, furthermore, sections of several separate departments may be lumped into a single research center. The research personnel of AFT are overwhelmingly Irish by nationality (95% are citizens of the Republic of Ireland or Northern Ireland). The sample population of 168 scientists contained 55 Ph.D.'s and most of the remaining held a degree or certification higher than the bachelors level.

## METHOD OF INVESTIGATION

### The Questionnaire

A brief questionnaire containing 30 questions was administered to all scientists in An Foras Taluntais. In addition to the usual demographic and biographic questions, the respondents were asked to name the people both within and outside of AFT with whom they most frequently communicated on scientific matters, and to estimate the intensity of their foreign correspondence over the past year. The questionnaire enjoyed an 85% response.

### Criteria for Choosing International Gatekeepers

To be an effective gatekeeper in an international sense 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.

### The Internal Network

The structure of the internal communication network can be approximated by examining the responses to the question in which "most frequent" scientific discussion partners are named. Each respondent is thus connected to those whom he names. This can be accomplished in either matrix or diagram format (Figure 1). This allows the computation of the number of entering branches can be used as an index of the number of people who turn to a given individual for information, or the number of people who can potentially be reached by information held by that person. A person with a large number of entering branches is likely to be a very important source of information for his colleagues in the organization. For purposes of the present study, this person will be called a "communication star" (12). Numbers 20 and 28 are communication stars in the figure.

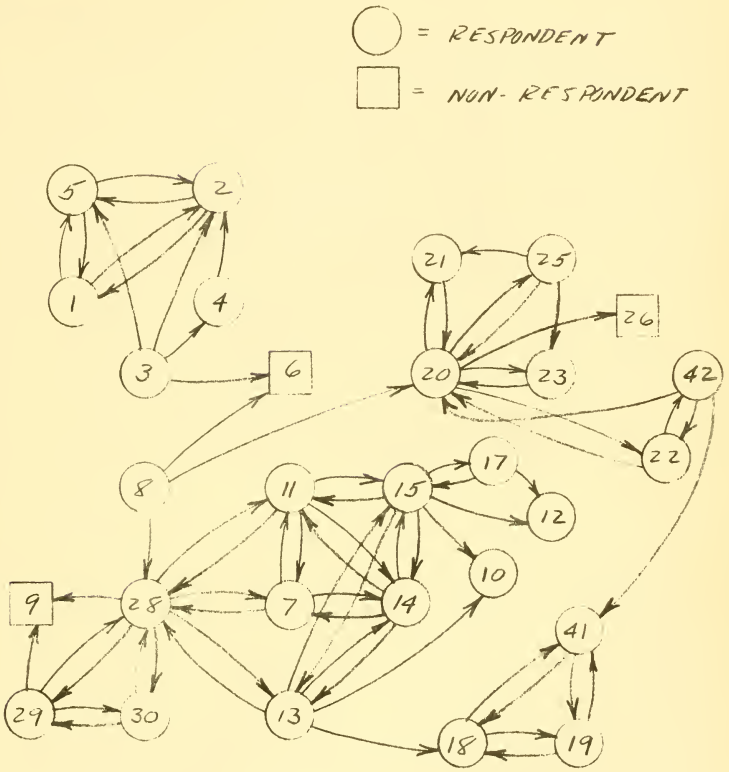



FIGURE 1. PARTIAL SCHEMATIC OF THE A.F.T. COMMUNICATION NETWORK

External Network

For a communication star to also be a technological gatekeeper he would have to be well integrated into an external network of foreign information sources. In choosing a discriminator to identify those who have established and do employ an enternal 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 diversity of foreign information sources.

Two criteria -- the frequency of foreign technical correspondence and the frequency of foreign scientific and professional society attendance -- are 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.

For the concept of the "technological gatekeeper" to be proved operative, it must be demonstrated that the communication stars described above actually do receive a greater amount of foreign information than do their colleagues. If each individual were to receive most of his foreign technical information directly from its source (direct flow) the role of gatekeeper would be meaningless. Similarly, if the high international communicators were isolates within the country, the gatekeepers would be non-existent. Simply stated, a single individual must be instrumental in both the acquisition and dissemination of foreign information.

In fact, the data show that technical discussion stars actually do receive significantly more international technical information than non-stars as measured by frequency of foreign correspondence and attendance

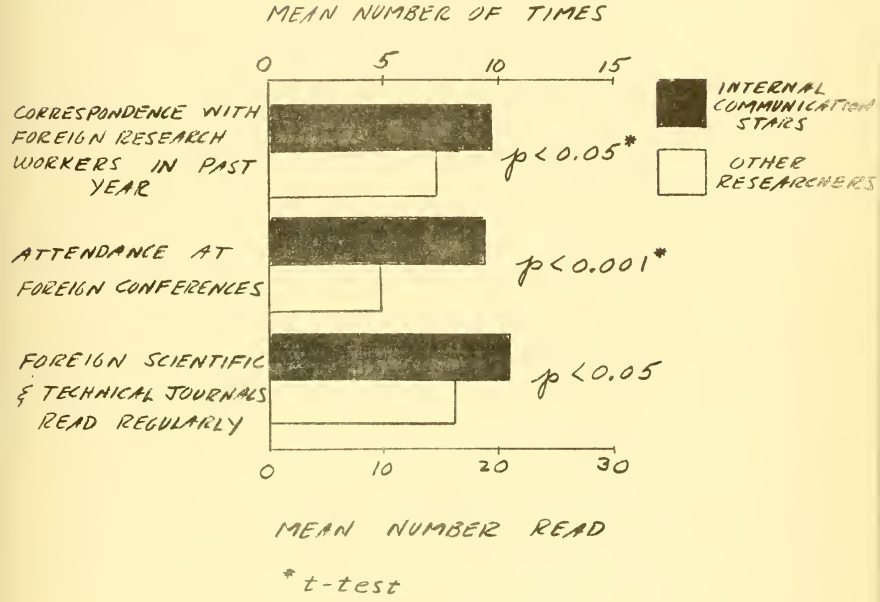



FIGURE 2. DEGREE OF FOREIGN COMMUNICATION BY INTERNAL COMMUNICATION STARS

at foreign scientific and professional society conferences (Figure 2). They also read a significantly greater number of foreign journals (13). The gatekeeper hypothesis is quite strongly supported.

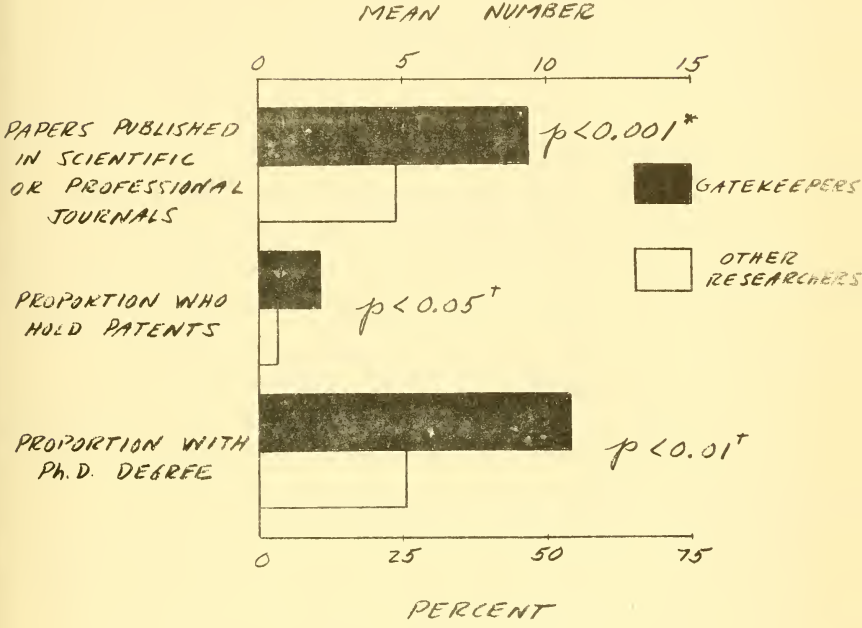
## CHARACTERISTICS OF THE INTERNATIONAL GATEKEEPER

Recent studies (14) have found that gatekeepers in American laboratories are better educated and higher in performance than their non-gatekeeper colleagues. They are, on the average, more likely to have a Ph.D. degree, are more frequently published, and are more likely to be named by their organizations as the most important contributors to its technical goals.

The gatekeeper (15) on an international scale also displays greater technical competence than his non-gatekeeper colleagues. Technical performance is of course, extremely difficult to measure, but to the extent that publication of scientific and professional papers and the acquisition of patents serves as an indicator, the international gatekeeper is a high performer, indeed. The technological gatekeeprs in AFT are, on the average, significantly superior to their colleagues in both publications and patents and a higher proportion have a Ph.D. degree (Figure 3).

## THE DEVELOPMENT OF INTERNATIONAL GATEKEEPERS

Given the existence of gatekeepers at an international level and their importance in coupling the country to foreign technology, the important problem now becomes how to develop people into this role. There are of course many possibilities, but two would appear most likely. First of all, a scientist might develop contacts through foreign education and maintain these after returning home. If this were the case, a government desiring to stimulate the importation of foreign technical information could do so by supporting the education of its citizens in those countries




* t-test
† proportionality test (15)

FIGURE 3. PERFORMANCE AND EDUCATIONAL LEVEL OF GATEKEEPERS

with which it hoped to promote communication. On the other hand, a more direct attack upon the problem might be to encourage the employment of foreign nationals. The foreigners would presumably retain contacts in their home countries, thereby establishing themselves as potential gatekeepers for the host country.

In fact, neither of these potential solutions appears worthy of support. The people who are functioning as gatekeepers for the agricultural institute were not predominantly foreign-educated (Figure 4). Proportionately, gatekeepers have fewer foreign degrees than do non-gatekeepers. Foreign education does not appear to be an effective strategy for creating gatekeepers. Employment in research in another country is, however, quite effective in this regard. A very high proportion of the gatekeepers (89.3 percent) were either employed by a foreign agency or firm or visited another country to work on a sabbatical or research fellowship. This finding seems quite reasonable. Far more enduring relationships can be established during post-graduate research than during the educational process. A government wishing to establish foreign communication channels would, therefore, be well advised to support the graduates of its own universities for short periods of work abroad, rather than to support foreign education.

The effectiveness of foreign visits in promoting communication is, naturally, a decaying function of the time since the last visit (Figure 5). Unless given an opportunity to renew acquaintanceships, a person's level of foreign communication will steadily decline with time. Judging from the present data, scientists, who are to function as gatekeepers, should be encouraged to participate in foreign sabbaticals every five to ten years. International conferences certainly have a potential for offsetting this decline. Just how effective they are in maintaining these

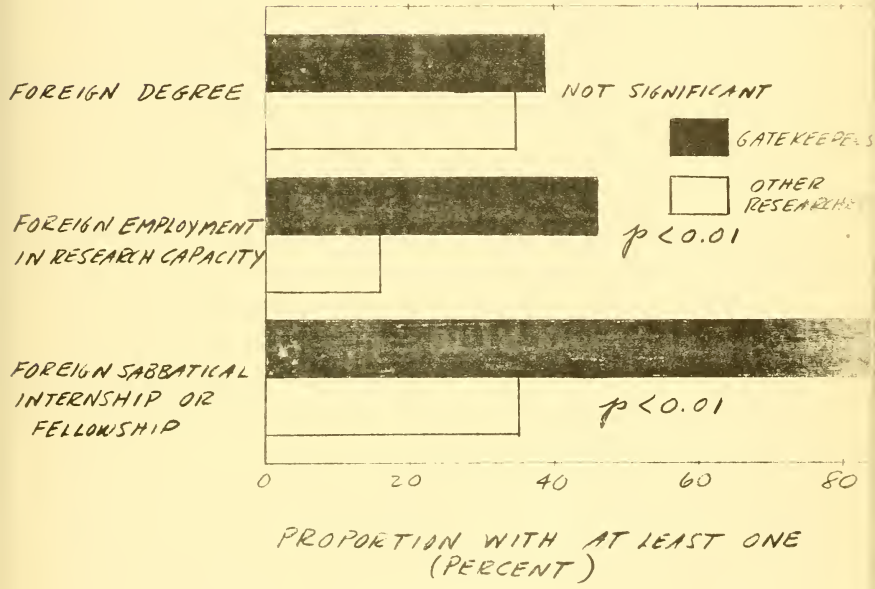



FIGURE 4. FOREIGN EXPERIENCE OF GATEKEEPERS

communication channels remains to be determined.

When it comes to the question of employing foreign nationals in the recipient country, the situation is somewhat different. While international transfer of technology is fostered by enabling talented researchers to undertake periods of foreign research employment, the reverse process seems to work poorly. That is, foreign nationals employed by the recipient country in a research capacity have not become gatekeepers for international transfer of technology (16). Even the many foreign personnel who display all the other qualities applicable to the gatekeeper (authorship of many papers, Ph.D., foreign employment, substantial foreign correspondence, and frequent attendance at foreign scientific conferences) do not communicate with a sufficient number of colleagues within the country to qualify themselves as gatekeepers. Although they have successfully established the requisite network of external contacts, they seem unable to construct the internal network and therefore fail to function effectively as gatekeepers.

This most certainly does not imply that their direct contribution to the nation is at all small. The foreigners in the sample are very productive scientists, and are undoubtedly making a very large direct contribution to the Irish economy. They are merely not functioning in a gatekeeper capacity. That role, it appears, is reserved for the native-born scientists.

The reasons for this failure to develop an internal network even when an extensive external network has been put together are not entirely clear. The ten researchers of other nationality in our sample have been employed by the agricultural institute a fewer number of years on the average than the gatekeepers or the other Irish researchers. Gatekeepers, on the other hand, have been employed slightly longer than their colleagues.

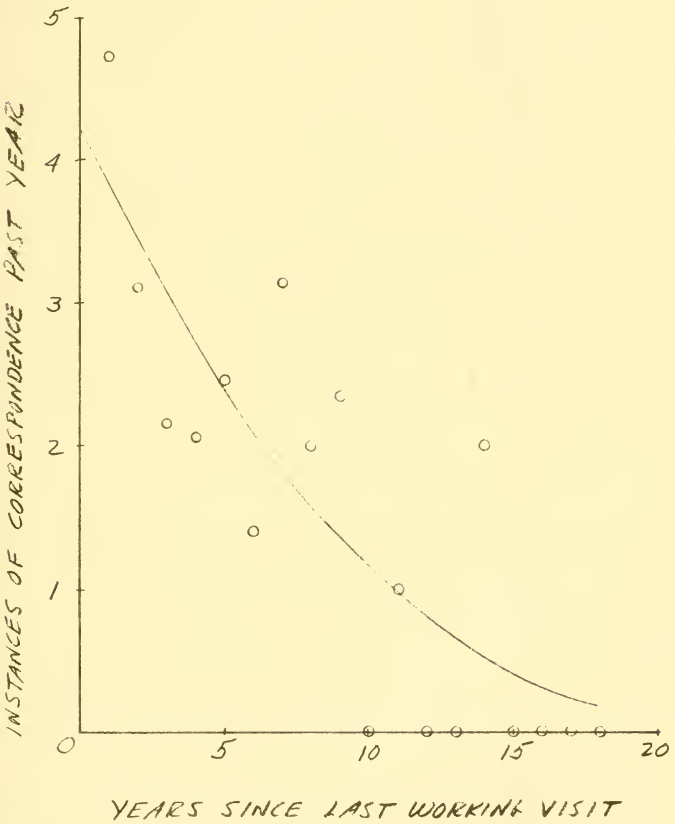



FIGURE 5. CORRESPONDENCE WITH RESEARCH WORKERS MET DURING EMPLOYMENT, OR SABBATICAL, ETC. AS A FUNCTION OF TIME SINCE RETURN HOME

The shorter average duration of employment might well explain the fact that no foreigners appear among the communication stars.

In fact we suspect that a more general mechanism is operating. On the average, the longer an Irishman has been employed by An Foras Talúntais the greater is the number of colleagues who choose him for communication and, therefore, the wider his internal network becomes. The foreigner, on the other hand, does not seem to be able to increase his range of contacts with time (Figure 6). The foreigner requires much longer to become integrated into the nation's technical communication network. Foreigners have been employed by the institute up to six years, but still do not show a degree of integration comparable with that of the natives. Anyone hoping to rely upon foreign nationals for the gatekeeping function should be blessed with great patience.

## CONCLUSIONS AND IMPLICATIONS

The existence of international technological gatekeepers as intermediaries in the technology transfer process has now been clearly demonstrated. The international gatekeepers display characteristics which are very similar to those found in American R&D laboratories. They are, on the average, technically more competent and more productive. They regularly read a large number of technical publications and hold a Ph.D. degree significantly more frequently than their colleagues.

The international gatekeeper's ability to keep abreast of foreign technological developments is an important asset for every small country. The gatekeeper mechanism is not only an effective way for a country to import technological information, but it would appear to be a relatively inexpensive way as well. The cost of allowing a gatekeeper to maintain

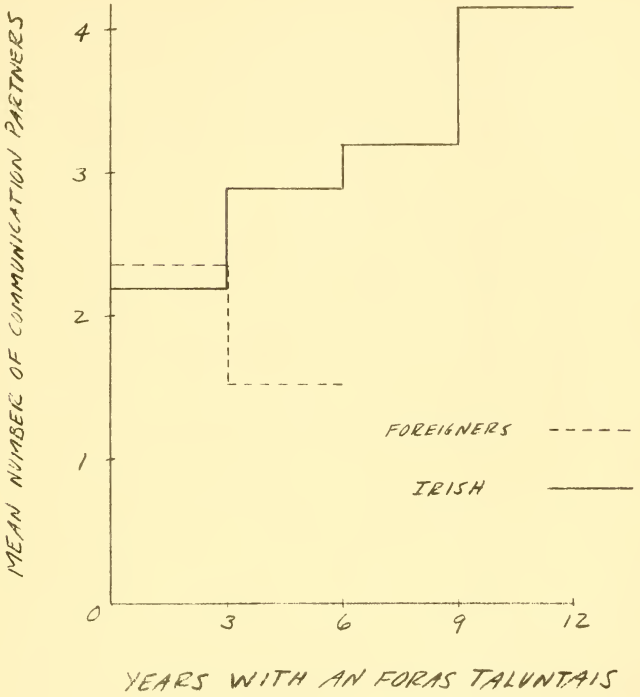



FIGURE 6. INTEGRATION INTO THE COMMUNICATION NETWORK AS A FUNCTION OF LENGTH OF EMPLOYMENT

his foreign contacts through periodic travel is quite small, when viewed in light of the benefits to be derived. The gatekeeper phenomenon is certainly not the complete answer to all of the small nation's problems. But an understanding of this process coupled with a willingness to capitalize upon it will certainly be a long step in this direction, with little costs to the nation.

The present evidence indicates that the gatekeeper develops his external contacts most effectively through active research experience in a foreign country. Doing research in another country is more effective in establishing communication with foreign scientists than is university attendance. Much more enduring relationships seem to be established during a year of postgraduate research than are established during several years of education.

The implications of these results are unambiguous. If international transfer of technology is to be fostered, the small nation should seek to open those channels through which information flows most effectively. In order to foster increased information flow a country 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.

In addition, the nation should recognize that gatekeepers are an efficient mechanism for transfer and it should help them to perform their role. This can be done first of all by helping them to maintain

existing contacts through foreign travel. A second possibility is suggested from observation of gatekeeper functioning in American research laboratories (20). Analysis has shown that in some U.S. laboratories there has developed, quite spontaneously, a rather extensive and very cohesive networks of gatekeepers. These networks are generally confined to a single technical specialty, but often overlap and can include members of several specialties in a single network, depending upon circumstances. This clustering of gatekeepers into a network enhances their functioning considerably. Information can now enter through a single gatekeeper, and eventually reach almost any person needing it after being transmitted along the gatekeeper network. The average scientist or technologist now has not a single intermediary functioning between himself and the world-at-large, but an entire network of intermediaries. The probability of closing the path between information source and user is thereby increased by a considerable amount. A small country could, with little effort, emulate this example and attempt to establish internal networks among its gatekeepers. This would most certainly enhance its ability to import the needed technology for economic development.

## REFERENCES


1. For reviews of such studies over the past ten years see the chapters on "Information Needs and Uses in C. Cuadra (ed.) Annual Review of Inforamtion Science and Technology, Vols. I through IV. For a theoretical model describing just how the process occurs, see T.J. Allen Managing the Flow of Scientific and Technological Information, report to the Office of Science Information Service, National Science Foundation, 1966.

2. T.J. Allen, The performance of information channels in the transfer of technology. Industrial Management Review, 8, 1966; L.H. Berul, M.E. Elling, A. Karson, A.B. Shafrity and H. Sieber, Department of Defense User Needs Study, Anerbach Corp. 1965; A.F. Goodman, J.D. Hodges, Jr., B.W. Angalet and R.B. McCord, DOD User Needs Study, Phase II, North American Aviation, Inc. Autonetics Division, 1966.

3. T.J. Allen, Performance of information channels in the transfer of technology. Industrial Management Review, 8, 1966; C.W. Shilling and J. Bernard, Informal Communication Among Bio-scientists (Report No. 16A) Washington D.C.: George Washington University Biological Communications Project, 1964; T.J. Allen, The Use of Information Channels in R&D Proposal Preparation (Working Paper No. 97) Cambridge M.I.T. Sloan School of Management, 1964; N.R. Baker, J. Siegmann and A.H. Rubenstein, The effects of perceived needs and means on the generation of ideas for industrial research and development projects. IEEE Transactions on Engineering Management 14, 1968.

4. For an extensive theoretical discussion of this problem see, D. Katz and R.L. Kahn, The Social Psychology of Organizations New York: Wiley 1966, Chapter 9.

5. T.J. Allen and S.I. Cohen, Information flow in R&D laboratories, Administrative Science Quarterly, 14, 1969.

6. T.J. Allen, Network analysis in R&D laboratories, R&D Management, 1, 1970 (in press).

7. E.M. Rogers, Diffusion of Innovations, New York: The Free Press, 1965.

8. J.S. Coleman, E. Katz, and H. Menzel, Medical Innovation: A Diffusion Process, New York: Bobbs Merrill, 1966.

9. P.F. Lazarsfeld, B. Berelson, and H. Gaudet, The People's Choice, New York: Duell, Sloan, and Pierce, 1948. Katz, E. "The Two-Step Flow of Communication", in W. Schramm (Ed.), Mass Communication, 2nd ed. Urbana, Illinois: University of Illinois, 1960.

10. Foreign born scientists are considered specially and treated in a later part of the paper.

11. M. Woods, Research in Ireland, Dublin: Institute of Public Administration, 1969.

12. Communication stars are operationally defined as individuals with a number of branches entering their nodes (communication choices by

colleagues) equal to or greater than one standard deviation above the mean number of entering nodes for the sample.

13. They regularly read a greater number of domestic journals as well.

14. T.J. Allen, Roles in technical communication networks. D.K. Pollock and C. Nelson (eds.) Communication Among Scientists and Technologists Lexington: Heath (in press.)

15. Gatekeepers are operationally defined as communication stars who also have either engaged in correspondence with research workers in other countries or have attended foreign conferences to a degree greater than the mean for the sample.

16. H.M. Blalock, Social Statistics, New York: McGraw-Hill, 1960.

466-70

467-70

468-70

469-70

470-70

471-70

472-70

473-70

474-70

475-70