SUPPORT STRUCTURES FOR TECHNOLOGY TRANSFER

by

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"Be Prepared" is more than the Boy Scout marching song. It is a fundamental precept for managers in all fields. The more we capitalize on previous experience, the greater our chances for having sufficient resources, avoiding error and anticipating the competition. One of the ways in which people learn from previous experience is by building mental maps of situations we expect to encounter again. Maps which, for technology transfer, tell us things like:

- o what actions need to be directed toward which groups to obtain awareness, experimentation and adoption;
- o what skills are needed for communication, field trials and adaptative engineering;
- o what resources in time, capital and management support will be required; and
- o what are warning signals of conflict and wasted effort.

In short, our mental maps, expectations, or models of technology transfer (call them what you will); have much to do with our success as managers and policymakers on the introduction of new technology.

A Study of Technology Transfer Cases in Agriculture

Few of us are fortunate to have the personal experience to build valid maps of all the situations we will influence as policymakers. If we are especially lucky, we will have the opportunity to listen and learn from others with more experience. However, it is more likely that, like most of our brethren, we will be forced to generalize from limited situations seasoned generously with media reports. This is the way in which most models of technology transfer are born and this is the way we are easily led to expectations such as the famous proverb: Invent a better mousetrap and the world will beat a path to your door. If only it were that simple!

<u>Methodology</u>: The study on which this paper is based investigated the extent to which technology transfers from the U.S. Agricultural Research Service (ARS) to suppliers and farmers conformed to the principles of technology transfer appearing in the literature (e.g., from studies of transfer involving NASA, Energy and universities). In order to understand the full process of transfer, it was necessary to understand the experiences of both those who provided and those who accepted technologies. Therefore, equal numbers of ARS and industry sources were interviewed. The ARS sample focused on its larger laboratories (i.e., a number of professionals greater than 8) and

was a stratified selection representative of size, relative productivity and type of laboratory. All interviews with ARS personnel began with the Laboratory Director and proceeded to interviews with the scientists in charge of the nominated case.

The industry sample sought a match with the ARS laboratories studied and focused on trade associations active in agriculture. Wherever possible, the Chairman of the association's Research Committee was interviewed (typically a farmer or industry executive). In a few cases, it was necessary to interview either the association's Director of Technical Affairs (e.g., the Chairman was relatively new and inexperienced) or industrial executives from firms with a strong reputation for innovation in agriculture (e.g., there was no comparable association).

Each interview began by asking respondents to: "Please nominate an actual project, preferably one ARS would be proud of, whose results have been transferred from ARS to industry within the last 3-5 years." In other words, rather than seeking a random or representative sample of ARS transfers; we purposely biased our sample toward recent cases and cases which represent the best of ARS practice [see Wolek for further detail] .

Purpose of the Present Paper: This paper discusses a subset of case histories which illustrate several characteristics of the social system which supports and structures innovation in agriculture. Despite the fact that most of the cases discussed were successful, the arguments presented here are based on a limited number of anecdotes from the larger study. Therefore, further study is necessary and encouraged to provide adequate sample sizes and measures to assure the validity of these exploratory ideas.

Screening Mechanisms for Agricultural Innovation

Technology transfer is a time and energy consuming process for all involved. Scientists must communicate results to many people, technologists must adapt findings and technologies to fit existing markets, companies must promote products in the market, innovative farmers must conduct realistic field trials and policymakers must support an often long and trying process is to be successful. Such energy cannot be committed without some mechanism for evaluating the merits of a project compared with other opportunities.

The Task of Screening Inventions: Innovators in all sectors of agriculture need some mechanism for evaluating ideas and technologies and narrowing down to the very few which fit available resources. That is, they must be able to assess:

- o *technological feasibility* of an invention (does it violate laws of nature, will it work, are materials and components available, etc.?);
- o *commercial feasibility* of the products based on the invention (is there sufficient advantage over competitive products, are producers available with the requisite resources, do potential buyers possess the resources and talent needed, etc.?); and
- o *investment priority* for programs to promote innovations (how much resources are available, is necessary expertise at hand and will this invention contribute to a cumulative growth of expertise, how much risk is entailed in defending proprietary position, etc.?).

The magnitude of this task of evaluating innovations is illustrated by two programs seeking to screen inventions for possible government awards. In one, the government of Sweden used a panel of technologists and industrialists to screen inventions responding to an announcement of a prize for inventions utilizing Sweden's natural resources [Ottosson]. Out of 2710 submitted inventions, only 54 (2%) were selected as patentable and only 10 (.4%) have been accepted for commercialization by Swedish companies.

The second program is one used by the U.S. government (The Office of Energy Related Inventions --OERIP-- of the National Bureau of Standards) to screen energy inventions (conservation , power generating technologies, etc.). Over the 10 years of OERIP's existence, 22,000 inventions and ideas have been submitted, 320 (1.5%) have been evaluated as warranting investigation by funding authorities (e.g., Department of Energy). George Lewett [198x], the Director of the OERIP, summarizes his experience by noting that for every 1000 inventions submitted only 3 (.3%) will "end up as being, to some extent or the other, 'successful'" in yielding profits and energy savings.

The difficulty and complexity of the screening process is evident in the present study. In total, sufficient data was available to judge the value of the 47 technologies. The simplest test of value was used: was the technology actually put into practice and did it have an impact in use? Despite the fact that all the technologies included were ones which some authority felt were a matter of pride, 30 (64% of the total) passed this minimum test of value.

The Informal Screens of Agriculture: People familiar with industrial innovation might be led to believe that the screening mechanisms encountered were ones which *formally* involved top management in ARS and the companies involved. That is, that a laboratory director saw that a project had potential and gave it the needed backing and/or that a company president recognized an opportunity and encouraged aggressive action. In contrast to this expectation, the most impressive characteristic of the successful transfers was that the screening mechanisms were quite *informal*.

Probably the best examples of these informal mechanisms concern the technologies of new plant varieties. For example, NC82 is a new variety of tobacco which resists bruising and bacterial wilt. Developed at ARS's Tobacco Research Laboratory, NC82's value is attested by the fact that it constitutes 18% of North Carolina's crop. In its clearest form, the informal nature of the screening process for NC82 is illustrated by the work of the New Variety Advisory Group of the "Tobacco Workers Conference". The Group and the Conference which it advises take great pains to retain their informal status. The Conference has no charter, central administration or formally recognized authority. However, the state agencies which do have authority will not promote (e.g., formally register, stock breeding seed, disseminate information, etc.) a variety of tobacco which has not been "approved" by the Advisory Group.

The mechanism by which the Advisory Group gives its approval is a model of informal collegiality. The Group meets annually for a convention which includes discussion of new varieties. While a vote is taken, it is delayed until a consensus is evident. This primary criterion of consensus depends on successful consideration of such issues as:

- Do field and laboratory tests of the variety show it to have the characteristics (nicotine, sugar content, appearance, etc.) to pass standards which document the minimums needed for interest in a variety?
- Have experimental plantings generated sufficient interest among farmers and buyers?
- Have sufficient data been obtained to understand its advantages, possible problems and management requirements (e.g., sucker control and early flowering in cold weather)?
- Is the variety necessary given others available and the pressures upon farmers for other investments?

Sometimes the consensus is to wait, sometimes to drop further work (something ARS takes seriously) and sometimes to release. However, the emphasis is on a consensus that the variety serves the needs of the market and producers, not on criteria common in formal organizations such as formal objectives, deadlines and management pressure.

Certainly the activities of the Tobacco Workers Conference are interesting and, equally certain, it is good to hear of a field which has developed an effective means for assuring the widespread input and action necessary to achieve a market presence of sufficient scope to assure adequate prices. However, the case is introduced, not as a unique example, but as an especially clear illustration of informal mechanism encountered in many of the successful cases in our survey. These characteristics are summarized in Exhibit 1 together with examples from other cases concerning technologies other than new plant varieties .

In summary, many of the successful cases of technology transfer showed reliance on informal groups which had shifting membership and leadership, reliance on both empirical data and social networks, willingness to back a technology with the group's status and practiced means for disseminating information. When the field was well established and the importance of consensus reflected in the market for all farmers (tobacco), informal mechanisms were as well established as the Workers Conference. When the field was less structured around one commodity or when concerted action was not necessary (aflatoxin testing for grain elevators), the informal mechanisms were likely to be *ad hoc* and emergent as crises or common problems arose.

Support Services and Innovation

The previous section began by noting that technology transfer requires careful screening by all concerned. Investments of time and energy are best made when we are united with others in appreciating the opportunities of a new technology and being committed to favorable action. This section presents a further extension of the idea that innovation requires concerted action. However, given the fact that this discussion will be breaking new ground for the generic subject of technology transfer as well as for agriculture, it will be introduced via two case examples.

EXHIBIT 1

GENERIC CHARACTERISTICS OF INFORMAL SCREENING IN AGRICULTURE

Characteristic	Function	Example
Flexible Leadership develops and changes as the situation requires. (e.g., test genetic stability *vs.* assess buyer reactions).	Innovations require a long time, have high uncertainty and require shifting expertise as new problems and opportunities arise.	Afla Toxin Procedures resulted from an informal network of elevator operators, food companies, regulators and scientists who found the problem, developed and tested a new method.
Results Based Decisions rely on empirical proof of the technology's performance relative to the group's goal (e.g., assure sufficient supply of quality product to obtain a fair price).	There is no authority over the actions of independent growers and companies and voting plans of one farm, one vote or number acres = votes would not test commitment	Cherry Fumigation Methods were refined and tested until Japanese officials relaxed bans on American imports.
Managed Risk in that no individual risks status or capital until a consensus on action is reached (e.g., field data motivate commitments to plant and buy).	The status of the group is behind the technology and lends confidence to adoptees.	Hybrid Sunflowers were pioneered by farmers and breeders working as a group to develop the approach before establishing farms, seed companies and associations.
Network Dissemination results from group member status as opinion leaders in their constituencies (e.g., approved varieties are listed in the growing reports of experiment stations).	An established reputation with media, agencies and associations places news and reports on meeting agendas and in publications.	Brucellosis Testing was improved only after a consensus of farmers and animal health officials created pressure for companies to modify existing products.

A Services Infrastructure for Irrigation Equipment: The previous section pointed out how the agricultural community organizes to obtain widespread action when the market requires a significant consensus. In this case organization also evolved, but around another motivation: a common crisis and threat of widespread loss.

Only a few accidents were needed to make the writing on the wall clear: suppliers and users of irrigation equipment faced the possibility of expensive legal actions concerning liability for electrocution of workers handling irrigation equipment. The fact that people were making dumb mistakes did not alleviate the need for clear standards and a way of getting information on how to wire irrigation systems to the field.

The response was a diverse group of scientists, equipment producers and farmers (organized as a new committee of the Irrigation Equipment Manufacturers Association) who developed a system of standards and information dissemination to manufacturers, equipment contractors and farm organizations. The success of the response was attested by an industry award to the ARS scientist who led the effort and a decrease in the number of reported accidents.

This case of wiring standards highlights the need for supporting services when new technologies are introduced into the field. It is not enough to sell a wonderful black box and leave the users to their own resources. Safe and successful use requires standards, contractors who know how to install and service equipment and consultants who can respond to special problems and inspect system installations. In short, a whole host of support services is needed.

A Political and Services Infrastructure for Boll Weevil Eradication: The ambitious ARS program to eradicate the boll weevil is a total systems effort which involves the use of multiple technologies and modern field management in a carefully monitored approach to eliminating boll weevil populations. The approach is especially demanding of consensus, for all farmers in a targeted area must be bound to conformance, or the project has no hope of success (i.e., the weevil must have sanctuaries from which it can easily invade cleared territory).

When the project was first conceived, it was approached as a task of educating farmers and public organizations. If they could be shown the advantages of an integrated attack (controlled sprayings, monitoring populations, use of parasitic organisms, etc.), they could be convinced to give the area-wide cooperation necessary. A program of education on areas naturally bounded by barriers to weevil migration (e.g., mountains) is a massive task, but one which federal and state agencies undertook. Technical publications, field days, news and farm media, seminars and presentations at fairs; all are used to educate farmers, local agencies and the public.

The extent and organization of this massive effort is an admirable exercise in technology utilization and undoubtedly has many lessons for those interested in technology transfer. However, the point made here concerns a problem which the program encountered. The eradication program was strongly and, for a time successfully, resisted by insecticide service firms (contractors and consultants). The eradication program would be specifying the nature, timing and location of insecticide applications as well as promoting non-insecticide methods. The program's ultimate goal was the eradication of a pest whose existence was the justification of service companies.

Service Firms and Innovations in Agricultural Methods: The primary message of this section is that the success of many technologies in agriculture requires the existence of an active support of service firms which provide aid in critical activities (Exhibit 2). These activities include:

- designing technology applications for the specific conditions found at farms and regions (consulting);
- installing and /or applying the technology so that it is managed to minimize problems not evident before application and to maximize the technology's effectiveness considering its synergy with the farm's characteristics (contracting and training);
- testing for stability, effectiveness and side-effects and participating in programs to generalize the lessons learned into standards and principles of good practice (standards and testing); and
- documenting practice, underlying principles and field data and disseminating these for use by farmers, local agencies, and industry (information and data base publishing).

Support of service industries was especially important in those cases in our survey where a technology entailed innovation in the methods or processes used by farmers and agricultural firms. Such process innovation is contrasted with the adoption of new products which are substituted in existing methods (e.g., an improved vaccine, a new chicken cage, a forage protein tester, etc.).

Exhibit 2

SERVICE ORGANIZATIONS IN AGRICULTURE

TESTING

(Testing for Adulteration in Syrup)

INFORMATION

(Data Base on Cross Breeded Cattle)

STANDARDS

(Aflatoxin in Grain Elevators)

CONTRACTING

(Design of Flow-Control Weirs)

The Inventive Community

The reason why the above anecdotes about technology transfer excited our interest is that they suggest important modifications to our mental maps about the process of innovation in agriculture. That is, they emphasize the need for concerted action by many people. When a support system exists and when consensus is built, more than transfer is obtained. Consensus and service support build markets, expertise and improvements in technology and its use.

The dominant model of technology transfer already emphasizes action by several people: scientists, agents and early users (see Exhibit 3). The cases discussed here modify this posture by emphasizing the contributions of other parties to transfer (screening networks and service systems). In addition, and maybe more important, these cases highlight the interactions between these parties, thus implying that the structure is a *social system for innovation* in agriculture (see Exhibit 4). A system which works best when all parties appreciate the contributions of others and when they are personally linked to each other. Scientists cannot develop practical findings without input on realistic field conditions. Agents cannot substitute for service organizations who provide routine work in installing, testing and maintaining field systems. Service organizations cannot be assured that a technology has sufficient commitment to justify start-up costs without a consensus of farmers and industry. In short, the system provides inputs in information, confidence and support to each party.

The targets of this system are twofold: the established producers of both agricultural technology (industrial firms) and of commodities (farmers). Established organizations are often thought to possess an NIH (Not Invented Here) mentality which explains their "resistance" to innovation. However, the cases studied in the present survey identified many practical concerns which cause executives and farmers to take the time to be sure of a new technology, before making expensive commitments which take resources from other opportunities. Such practical considerations include determining:

EXHIBIT 3

THE EXTENSION PROCESS OF TRANSFER

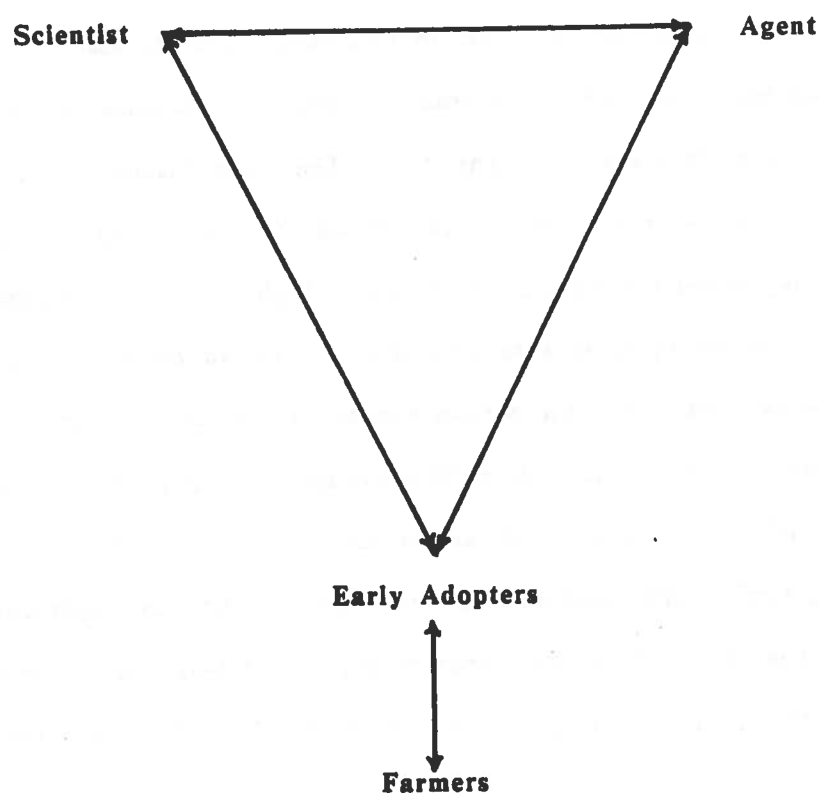
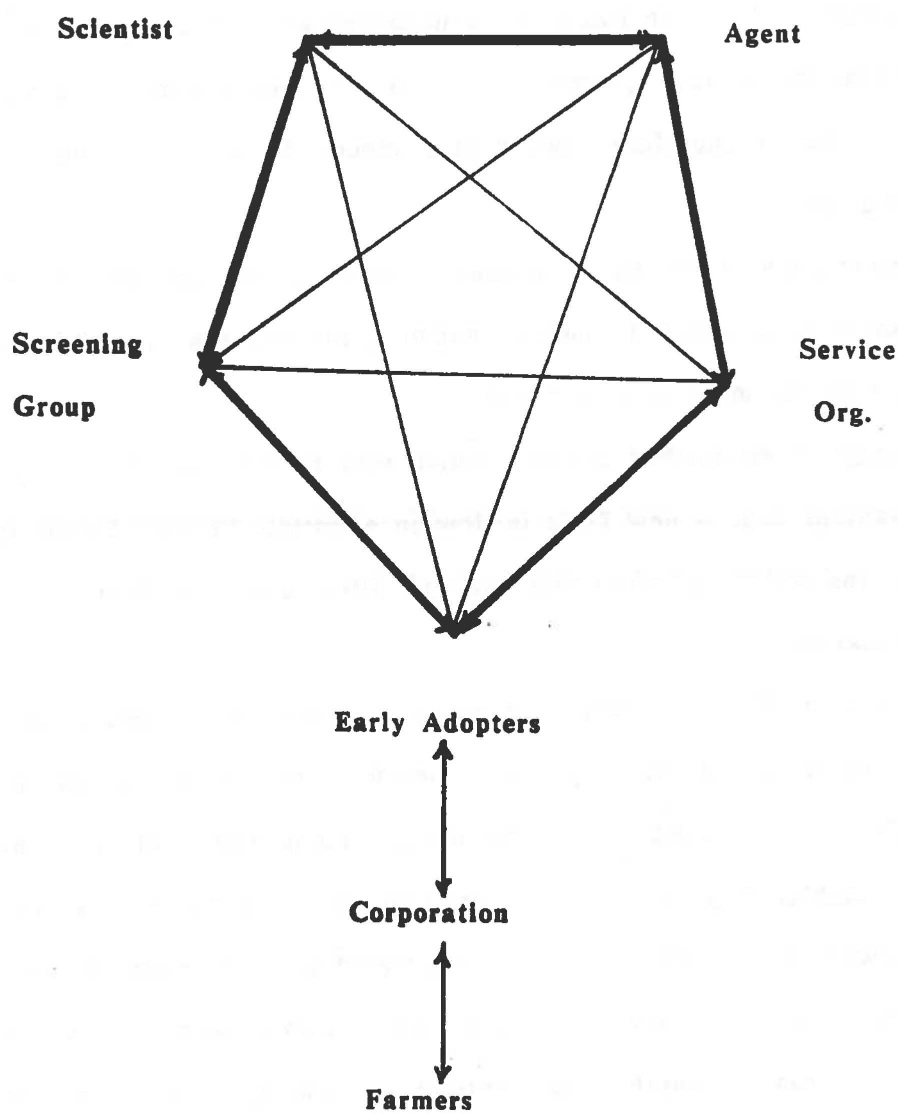


EXHIBIT 4

THE INVENTIVE COMMUNITY AND TRANSFER



- o problems which may arise in full use and which are not now evident (e.g., an attractive potatoe variety was found to suffer from hollow heart);
- o competition from other technologies and how robust the technology may be to such threat (e.g., industry officials judged a new process for anerobic fermentation of wastes to be inferior to competitive technologies);
- o quantities which are likely to be produced and whether they provide the market presence to interest buyers (e.g., processors saw no competitive need for a high-tech method of processing vegetable oil, therefore equipment producers have not responded to a scientifically exciting technology);
- o suppliers which are strong enough to perfect, produce and market a technology (e.g., an innovative approach to sucker control is not being addressed because equipment firms are fighting for mere survival); and
- o changes in established practice which may be necessary for a technology to realize its full advantage (e.g., a new fruit is slow in adoption, because buyers taste products before they are ripe which is before this variety's advantage is evident).

Policy Implications

The concept of an Inventive Community has important implications for policymakers on agricultural research. Specifically the framework relates to the issues of resource allocation, the role of the public sector in R&D and to the design and management of Technology Transfer programs.

Target to Market Planning: The last thing which a policymaker needs to be told is that the process of technology transfer is more complicated than is commonly thought. To be told, in addition, that effective policy encourages long-time commitment to the activities of invisible networks which have intangible contributions is rubbing salt in an already open wound. Policymakers already know the process is complicated and that cooperation with private organizations is necessary. The problems are that resources are not available for any but the most tangible actions and that pressure exists for clear results in technologies transferred and producing visible results.

The point of this paper is not an intellectual nicety which has no practical significance to resource constrained agencies. Not at all! While it is true that policymakers must encourage reliance on the limited technology transfer mechanisms which budgets and constraints allow, there are also times when agencies are committed to the full process of transfer in all its complexity. Clearly there are missions of national importance in which top policy and/or emergencies call for timely application of research from national laboratories (e.g., crises concerned with epidemic diseases). In such cases, policymakers will need to promote the cooperation of screening networks and the growth of supporting services outlined here. In short, there are times when national program managers must plan from initiation to use (i.e., must *target programs to market*).

It is also important for policymakers to remind themselves that they are not the only arbiters of which programs are top priority. An agency's scientists have there own sense of when history demands rapid and full use of research. In other words, agency's do find their best people leaving the bench and spending all the resources appropriated to them (and which they can bootleg) to work with informal networks in active field tests and to promote private service businesses as needed. The message to policymakers is: your best people will target programs to market with or without your active support.

The framework presented in this paper offers the kind of mental map needed for policymakers to understand when their staffs are targeting markets so that they can make decisions to provide the necessary support when a national priority is involved or take the needed actions to deflect energies back to the bench. In short, in today's resource constrained agencies, targeting to market can be a valid goal for only a small minority of programs, all others must be maintained as providing the infrastructure of knowledge which will be necessary if and when the private sector commits to the investments indicating the resolve necessary for commercial innovation.

The Obstreperous Community: The material presented to this point is strongly colored by the fact that the cases investigated were successful transfers which made people proud. Thus, the cases present the screening by informal groups and building of service infrastructure as desirable activities for government agencies seeking to maximize the public good. This is not always the case!

While informal screens and service structures are necessary for full transfer, these structures can also become resistant to innovations which threaten their present status and welfare. The fact that they are loosely structured and informal may make them even more difficult to modify and change. This issue was at the heart of the case on boll weevil eradication: the ARS program was inadvertently threatening the livelihood of existing service industries. However, the service industries had to change if the promising ARS program was to be given a fair trial. It might have been helpful if ARS understood this potential threat and planned an approach which offered advantages to existing services, but it might also have been unable to avoid a fight with those who insisted on being entrenched.

The fact that much of the structures described for the inventive community are informal is both a strength and potential weakness. The strength of informal arrangements is the force of socially sanctioned agreement and the peer pressure which supports action once consensus is reached. The weakness of such agreement is that once made, it is hard to change and evolves into social tradition. For example, one of the screening groups studied essentially controlled the release of new plant varieties to the market. Over the years, the group had learned that farmers and buyers would be unlikely to respond unless a plant tested out on specific characteristics. So strong was this conviction that despite all desire to remain informal, these characteristics were documented as "*required standards*" for approval. The ARS scientists who had worked carefully with this group over many years noted that the standards had become "very strict" to the point of retarding important new introductions. However, these same scientists confessed to being impotent in the face of the tradition which had emerged.

Federal Leadership of Agricultural Innovation: What makes obstreperousness particularly dangerous from the perspective of public policy is that the impotency of federal officials can extend beyond specific cases to more general positions about agricultural policy. That is, in building relationships of trust and mutual understanding in an informal structure, federal scientists may all too easily become preempted. Instead of representing the broad public welfare, scientists may find themselves siding with parochial interests in order to retain their positions in the networks and their rights to be heard on other projects of importance. The quandry is that without informal interaction, the infrastructure of network commitment and service support necessary for innovation will not be built.

In resolving this quandry, it is important to emphasize that the public does not have the right to ask federal scientists and managers to avoid contact with private users of technology. This is the path of sterile research, frustrated professionals and ultimate competition with private organizations. What the public does have a right to is dedication to *managing* the interaction. In particular, that federal professionals take leadership positions in targeting technologies to market which are in the broad public interest and that they assure the presence of voices representing the public interest in network deliberations (e.g., university faculty appeared to play this role in several of our cases). The ability to assume such leadership will not develop from passive management of federal programs, it must be actively promoted and nurtured through such steps as recruitment, sponsorship of high-visibility conferences, training of program directors and incentive systems to reward professionals whose projects provide role models for others.

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