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Research and Technology Transfer Linkages in American Agriculture*

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I. Introduction

This is a buoyant time for the agricultural research community. Recent congressional action for the FY 1985 budget triples to $46 million the amount available for a competitive grant program and includes funds for biotechnology research. The Division of Agriculture of the National Association of State Universities and Land Grant Colleges (NASULGC), and the Experiment Station Committee on Organization and Policy (ESCOP) along with the Cooperative State Research Service (CSRS) have each issued reports, Emerging Biotechnologies in Agriculture: Issues and Policies, and Research 1984, respectively, that, in response to almost 15 years of criticism, assert the willingness of agricultural scientists to demonstrate their scientific mettle in the arenas of basic research and competitive award processes. USDA-Science and Education--Agricultural Research Service (ARS), long the target of repeated criticisms for its pork-barrel proclivities, the failure of its political leadership to defend the integrity of its research functions and to

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provide any coherent research policy,[1] has received praise for its new leadership and its initiatives under its six-year research plan.[2] ARS must now also find some solace in the growing criticism of political logrolling increasingly evident in the location of major research facilities by the Departments of Energy, Health and Human Services and elsewhere.[3]

The nature of the changes in the agricultural research system are the principal subject of this symposium, and thus are only alluded to in this presentation. Instead the focus of this paper is how these changes relate to the combined capability of public-sector organizations to generate, convert, adopt, and disseminate research findings in a manner that permits profit-oriented producers to incorporate them into firm-specific production functions.

The importance of linkages between research and technology transfer in agriculture is so widely demonstrated in empirical and historical studies that it is taken as the hallmark of the American agricultural

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[1]James Bonnen (1983), "Historical Sources of U.S. Agricultural Productivity: Implications for R&D Policy and Social Science Research," American Journal of Agricultural Economics (December), pp. 958-966.

[2]"After more than a decade of being on the receiving end of a barrage of criticism, the Department of Agriculture's (USDA's) sprawling research enterprise is in the midst of a shake-up. Many of the changes are aimed at pushing the department more firmly into biotechnology, an area that the critics claim has been relatively neglected. Other reforms include more centralized planning and directing of in-house research and eliminating layers of bureaucracy, resulting in savings that have been plowed into research at a time when overall budgets have seen little growth" (Jeffrey Fox (1984), "USDA Struggles to Reform Its Research," Science 22, pp. 1376-1378 (September 21)).

[3]Willis Shapley, Albert Teich, and Jill Pace (1985), Congressional Action on R&D in the FY 1985 Budget (Washington, D.C.: American Association for the Advancement of Science).

system. Indeed, agriculture is widely cited as the model for public-sector technology delivery systems.[4]

This concept of a technology delivery system, although couched and partitioned in different phrases by different authors, is integral to any treatment of the impacts of agricultural research.[5] The concept underpins findings of the high social rates of return to agricultural R&D. Numerous case histories also illustrate the way in which this system operates. Cooperative efforts among agricultural researchers, extension specialists, and county agents have often been required in order first to develop new scientifically-based approaches to agricultural production and then to educate producers as to how to incorporate them into a larger cultivation system.[6]

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[4]"The classic version of a technology transfer system is the agricultural extension programs . . . The agricultural extension system is perhaps the most 'complete' of any of the existing technology transfer programs" (National Science Foundation, Division of Industrial Science and Technological Innovation (1983), The Process of Technological Innovation: Reviewing the Literature (May), p. 162; see also Richard Nelson (ed.) (1984), Government and Technical Progress (New York: Pergamon Press).

[5]The technology delivery system includes activities (or stages) for (1) the delineation of research priorities, (2) the performance of various types--basic/applied--of research, (3) the conversion of research findings into economically useful production practices and technologies, (4) the development of ancillary information on the use of newly developed practices and technologies to accord with site-specific production settings, (5) the demonstration of new research findings and new technologies to an initial set of users, (6) the subsequent spread of the new practices to a larger set of users, and (7) the iterative feedback of changes in research activities, adaptive modifications, and consequent changes in use patterns that follow from use of the technology. See also A. A. Ezra (1975), "Technology Utilization: Incentives and Solar Energy," Science 187 (February 28), pp. 707-713.

[6]One recent technological innovation--the mechanical tomato harvester--provides a useful illustration of this linkage. Most attention in the development of the technology has focused on the work of G. C. "Jack" Hanna, a plant geneticist at the Department of Vegetable Crops at the University of California-Davis, who developed a tomato

The thesis of the paper is that strains are emerging between research and technology transfer activities within the public-sector agricultural technology delivery system. These strains are the product of three overlapping issues: (1) the portfolio of basic/applied research to be performed by agricultural scientists; (2) the responsibilities of extension specialists, including both the mix of applied research/in-service training and "program" activities that they perform and their organizational placement within colleges of agriculture; and (3) the functional relevance of the county-based cooperative extension system.

Central to this thesis is the view that recent changes moving agricultural scientists towards a more basic orientation are not themselves

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appropriate for mechanical harvesting, and Coby Lorenzen, an agricultural engineer, Department of Agricultural Engineering, who is credited with the creation of the first successful prototype. Successful operation of the mechanical tomato harvester, however, also required very specific conditions in the field. The soil could not be too wet; irrigation just prior to harvesting was forbidden. Growers were required to shape their seedbeds in specific ways to conform with the shape of the machine. Weeds had to be strictly controlled. Initially, flat areas at least 30 feet wide were required at each end of the field. Only the approved variety of tomato (in the early days, only VF-145) could be planted. Agricultural extension in California became involved in an educational program on how to use the harvester.

William Sims, extension specialist at the University of California, has observed that the university contributed to tomato harvesting technology in four areas: variety of tomatoes, harvesting machinery, cultural practices, and post-harvest technology. The University contributed to each of these four components, but more significantly, according to Sims, "The four components had to be put together and it had to be extended" (Personal interview with Patrick Madden, September 1983, in Irwin Feller, Lynne Kaltreider, Patrick Madden, Dan Moore, and Laura Sims (1984), "The Agricultural Technology Delivery System: A Study of the Transfer of Agricultural and Food-Related Technologies." 5 volumes. Report to USDA-Science and Education under Contract No. 53-32R6-1-55, Vol. 5, p. 101.

See also Moses Muskoe and Alan Olmstead (1982), "The Rise of the Cotton Industry in California: A Comparative Perspective," Journal of Economic History 42, pp. 385-412.

the first or indeed the primary cause of these strains, although they clearly intensify them. Agricultural researchers, extension administrators and personnel, private industry representatives, and observers of the organizational evolution of agricultural research and extension have identified many factors that have served to blur traditional lines of responsibility within a linked set of research-adoption-dissemination-education activities. Prominent among them are changes in the technical complexity and interdependency of agricultural production practices, the increased educational level of producers, the increased concentration of production into fewer units, the increased activity of the private sector in both research and technology transfer activities, and the reduction in the cost of transmitting information.

These centrifugal changes raise the question of whether the two principal holding companies for publicly conducted agricultural research and technology transfer activities--USDA-Science and Education and colleges of agriculture at land-grant universities--can conceptually and programmatically maintain and improve the functional integration of research and technology transfer activities.

The thesis applies both to the federal and state sectors. It includes, for example, the efforts by the ARS to simultaneously move to a more basic research orientation, as highlighted in its six-year plan, to take on a more active technology transfer role, and to forge closer functional linkages between ARS, FES, and the state extension services. This paper, though, focuses principally on land-grant universities. It raises several concerns about the long-term meshing of functional activities and organizational roles of agricultural researchers, extension specialists, and county extension agents. It also describes changes

underway in the land-grant university system that seek to maintain effective links between research and technology delivery.

Its documentation is a national study, funded by USDA-S&E of organizational relationships in agricultural research and technology transfer. The study was conducted between 1981-84 by my colleagues and myself at The Pennsylvania State University The study is unique among several contemporaneous inquiries in that it focuses on linkages among the component organizations. Thus it served to bring more sharply into analytical focus issues which are raised but generally treated as tangential to most of these studies.[7]

The study included field interviews with administrators, researchers, and extension personnel in land-grant universities in nine states (Alabama, California, Michigan, Nebraska, New York, South Carolina, Texas, Utah, and Vermont), with senior officials and program leaders in ARS, CSRS, and Extension Service (ES), Food and Nutrition Service, and other units within USDA, other federal agencies, including the National Science Foundation, National Institutes of Health, and Department of Energy, non-land-grant universities, chemical, seed and equipment manufacturers, equipment distributors, the agricultural press, and foundations. The study also entailed the development of case histories that focused on the (changing) roles of public- and private-sector organizations and of relationships among them in the development and diffusion of selected agricultural technologies.

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[7] Irwin Feller, Lynne Kaltreider, Patrick Madden, Dan Moore, and Laura Sims, (1984) "The Agricultural Technology Delivery System: A Study of the Transfer of Agricultural and Food-Related Technologies." 5 volumes. Report to USDA-Science and Education under Contract No. 53-32R6-1-55.

The term thesis is used to frame this presentation in order to emphasize its problematic and future-oriented tone. It represents neither a summative evaluation of current organizational functions nor of relationships. Even less so is the presentation prescriptive, in the sense of postulating a fixed correspondence between functional activities and organizational arrangements. Indeed, if anything, the thrust of this presentation is that the future effectiveness of the agricultural technology delivery system may likely rest on (or require) a fundamental redefinition of roles and relationships among its current constituent parts as it is on the array of modifications now being taken or likely to be taken to strengthen the integration of research and technology transfer activities.

II. Inter-Organizational Linkages as a Policy Issue

Although widely referred to in studies on the rate of return to publicly supported agricultural R&D and extension, little current descriptive information exists on the character of the functional linkages between research and technology transfer or of the organizational linkages between and among agricultural scientists, extension specialists, and county extension agents. The subject, for example, falls between the major studies by Busch and Lacy on the research priorities of agricultural scientists and the assessment of cooperative extension by Warner and Christenson.[8] Nor is it directly treated in

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[8] Lawrence Busch and William Lacy (1983), Science, Agriculture and the Politics of Research (Boulder, Colorado: Westview Press); Paul Warner and James Christenson (1984), The Cooperative Extension Service: A National Assessment (Boulder and London: Westview Press).

several other recent careful examinations of agricultural research.[9]

The "policy" literature that has so affected discussions of agricultural research also pays little attention to the subject of linkages between research and technology transfer. The principal documents in the decade-long critique of agricultural research--the 1972 National Academy of Science (Pound) report, Report of the Committee on Research Advisory to the U.S. Department of Agriculture, the 1981 Office of Technology Assessment report, An Assessment of the United States Food and Agricultural Research System, and the 1982 Winrock report, Science for Agriculture, are primarily concerned with the "quality" and "direction" (basic/ applied) of agricultural research--the issue of "science in agriculture." The reports are largely silent about functional or organizational linkages between (a more) science-based agriculture and technology transfer.

The 1984 oversight hearings by the House Committee on Agriculture's Subcommittee on Department Operations, Research and Foreign Agriculture, on agricultural research and extension focused on many issues. Only in a passing inquiry into ties between ARS and the Federal Extension Service, however, did the question of linkage between research and technology transfer surface.[10]

NASULGC, ESCOP, ECOP, and USDA documents and reports are similarly not informative about current relationships between research and

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[9]Don Paarlberg (1981), "The Land-Grant Colleges and the Structure Issue," American Journal of Agricultural Economics 63 (February), pp. 129-134; Don Hadwiger (1982), The Politics of Agricultural Research (Lincoln, Nebraska: University of Nebraska Press).

[10]A. Barry Carr (1984), Critical Issues in Agricultural Research, Extension and Teaching Problems (Library of Congress, Congressional Research Service) (October).

technology transfer activities within the land-grant system. They assert the existence of the linkage, but in fact give little attention to the strength of existing linkages or the possible effects that the paths each is preparing to follow have on these linkages. NASULGC's report, Emerging Biotechnology, for example, sets forth major initiatives to strengthen the basic research capabilities of ARS and the state agricultural experiment stations. The report, again, is largely silent on the question of the land-grant university's activities in transferring this technology. It notes that Cooperative Extension would have to move forward, but basically asserts:

> Cooperative Extension, the education and technology transfer component of the land-grant system, is the delivery system which ensures that new knowledge and technology will be placed in the hands of users as quickly as possible and also provides the feedback mechanisms which bring new problems back to the researcher.[11]

The ESCOP-CSRS report, Research 1984, similarly makes only passing reference to extension and then only in the context of using new communication technologies to facilitate/improve communications.[12]

Similarly, reports emanating from Cooperative Extension, such as Extension in the 80s, tend to assert the historic contribution of cooperative extension, to identify several factors prompting a reevaluation of extension's operations, and to emphasize the research base of extension programming. The reports do not address how effective ties between research and technology transfer activities are to be maintained, tending at most to focus mainly on program initiatives for new

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[11] NASULGC, op. cit., p. 5.

[12] ESCOP, op. cit., p. 15.

clientele or on the users of computer and other information technologies for disseminating research results.[13]

The unquestioned acceptance of the existence of an integrated system, of a smooth hand-off of responsibilities and functions, would be appropriate if in fact the system continued to work that way. But it does not, at least in a sufficient number of settings, appear to be cause for concern. There is, for example, evidence that the ties between research activities and extension activities are far looser than expected. Busch and Lacy's findings suggest that extension personnel are relatively unimportant as a source of research priorities for agricultural scientists. Frances Wolek's study of technology transfer in ARS suggests that extension personnel are seldom involved in the transfer of ARS research.[14] Along similar lines, Lipman-Blumen and Schram, in their study, Paradox of Success, write:

> Many interviewees report that while the theoretical relationships between research and extension is clear (i.e., Extension translates and demonstrates new research findings for users and simultaneously reports users' research needs to scientists), in reality, the relationship is not well articulated. Some Extension personnel worry about a growing separation of researchers and Extension workers.[15]

More broadly, Ruttan has observed,

> Although the evidence is not yet conclusive, it is hard for me to escape the conclusion that the institutional changes introduced to

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[13]The issue does surface indirectly in recent General Accounting Office reports on Cooperative Extension's Missions. See General Accounting Office (1981), Cooperative Extension Service's Mission and Federal Role Need Congressional Clarification (Washington, DC), CED-81-119, p. 21.

[14]Frances Wolek (1984), Technology Transfer and ARS (Villanova, PA: Villanova University).

[15]Jean Lipman-Blumen and Susan Schram (1984), The Paradox of Success (Washington, D.C.: USDA-Science and Education), p. 3.

> implement national science policy after World War II have contributed to the disarticulation rather than to the strengthening of the linkages between advances in knowledge and technology development. There is a critical need for the architects of national science policy to give attention to the problem of how to institutionalize more effective articulation between advances in knowledge and advances in technology. And we must be particularly careful, in those areas where articulation is effectively institutionalized, that the reforms that are introduced do not lead to further disarticulation.[16]

Overall, many recent statements from both the research and extension communities involve declamation as much as documentation. This shared declamation provides a common front to the external world. One interpretation of these statements is that the linkages are so strong as to be self-evident. Another is that each sector although aware of the difficulties of maintaining effective linkages to the other, is preoccupied with responding to the set of pressures unique to it, with issues of linkages being relegated to lesser importance.

III. An Historical Perspective

The context and point of this thesis should be noted. First, on the occasion of an examination of the 100-year history of the Kentucky State Experiment Station, it is appropriate to move beyond a focus on annual budgets for multi-year reauthorizations of Title XIV, to consider the evolutionary character of the correspondence between functions and organizations, both within the public sector and between the public and private sectors. What is fundamentally at issue here is the recurrent need to integrate two different frameworks, one, a functionally

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[16] Vernon Ruttan (1983), "Agricultural Research Policy Issues," The B.Y. Morrison Memorial Lecture, HortScience 18(6), pp. 809-818; pp. 811-812.

derived framework relating to the stages of technological change, the other an organizational framework that links the individuals who perform these functions. For as Lambright and Teich have argued, "technology transfer is best understood as fundamentally a problem in interorganizational relationships."[17]

Second, the issues raised here are not new ones; they are part of the early history of the state experiment station and of the inherent contradictory pulls on publicly-supported agricultural research in America. Debates over the mix between "basic" and "applied" research are found in the early history of many experiment stations, and of conflicts between the stations and of the U.S.D.A. Office of Experimental Studies. So too are found conflicts between the role of the experiment station scientists as a "researcher" and as a source of expertise and information to state farmers.[18]

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[17] H. Lambright and A. Teich (1976), "Technology Transfer as a Problem in Interorganizational Relationships," Administration and Society 8, pp. 29-54; p. 30.

[18] "No problem was more exasperating to station scientists than the assumption that they should be responsible for answering any and all questions which might be addressed to them. Indeed, a number of directors were proud to list among their accomplishments the fact that their stations had become 'general bureaus of information.' This achievement seemed far less positive to staff members increasingly occupied in answering a bewilderingly varied correspondance" (Charles E. Rosenberg (1971), "Science, Technology, and Economic Growth: The Case of the Agricultural Experiment Stations Scientist, 1875-1914," Agricultural History 45, pp. 1-20; p. 5). Yet Rosenberg also notes that in addition to general values associated with the professionalization of agricultural research, "agricultural scientists of all disciplines tended to accept service as an absolute value. In an era before the Smith-Lever Act, this ethic of Service helped (with the institutions' own need for creating public support) create an extension program in function if not in name, bringing and adapting agricultural innovation to an industry normally resistant to change" (p. 17).

Third, this focus on induced changes in relationships among the component organizations is itself not a judgment on the capabilities of the organizations to change. If anything, the ability of the traditional system to adapt effectively to changing conditions has been identified as one of the reasons why research and extension activities have been found to have contributed to agricultural productivity over long periods of time and to have yielded high rates of social return.[19]

Adaptability is one desired characteristic. But another is that the organizations move in an articulated manner. If, or as, each of the principal organizations involved in the public-sector system responds to the criticisms raised about its respective performance, and does so in a manner that is responsive to that set of criticisms alone (e.g., "better science" in agricultural research; a more diversified clientele in cooperative extension), the risk increases that the integrated linkages between research and technology transfer may be attenuated.

Fourth, there is a fundamental difficulty in developing a "tight" analytical framework involving linkages between functions and

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[19] As Robert Evanson has noted:

> . . . these research institutions have been productive over a long period of time. They have had the capacity to be oriented to clientele groups to produce research findings of value, and, at the same time by investing in related scientific research in the institutional framework of the experiment station, they have managed to replenish invention and discovery potential.
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> . . . these research and extension institutions were productive over the whole of the past century. This sustained productivity was attributed to a capacity for institutional change which in turn was associated with a capacity to respond to clientele interests. (Robert Evenson, "Agriculture," in Nelson, op. cit., pp. 233-282; p. 268.)

organizational roles in a technology delivery process and the "looseness" of the functions performed in part by agricultural researchers but especially extension personnel. The span of activities of Cooperative Extension, the conflicting pressures on it concerning its program priorities, and the inherently formidable task it confronts as it seeks to introduce directed changes into a "grass-roots" system are subjects beyond the scope of this presentation. Still, it is necessary to recognize that Cooperative Extension is more than a component of the technology delivery system. Even if one omits its other program areas (e.g., home economics, 4-H) and focuses only on agricultural production and soil conservation, the range of services offered by Cooperative Extension to its traditional agricultural clientele extends beyond the activities that are contained within the technology delivery model.[20]

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[20]For example, a recent description printed in the Centre Daily Times of the services offered by the Cooperative Extension agricultural agent in Centre County, Pennsylvania (the home of The Pennsylvania State University) reads as follows:

> Agricultural services provided for most of the farmers in Centre County include meetings such as: forage, small grain and soybean production, corn production and soil fertility, sprayer callibration, pesticide re-certification, no-till sod seeding, farm income tax, farm business analysis, farm safety, dairy day, Dairy Herd Improvement Association records workshops, mastitis prevention and maintenance of milk equipment.
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> Demonstrations were done last year on alfalfa variety plots, manure management plots and NIR mobile van forage analysis.
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> Data collection programs provided are the five-acre alfalfa growing program and the five-acre corn club.
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> The county agent also provides support to the Centre County Crop Improvement Association and the two crop technicians . . . This is an agronomic crop consulting service owned and directed by farmers who use the service to collect data that can be used to make more precise crop production decisions. (Centre Daily Times, Sunday, November 25, 1984, p. D-7)

Fifth, the complexity and diversity of American agriculture produces a wide range of functional activities and organizational arrangements. Interactions among the changing characteristics of producers, the technical orientation of research and extension personnel, the nature of the technologies being developed, the R&D intensity of agriculture in a particular region, and the changing role that organizations play over the life cycle of a technology are numerous. So, too, are the services being performed by agents, specialists, or researchers across the country.[21]

Sixth, there are many organizational changes currently being implemented at land-grant universities that seek to improve the integration of research and extension activities. These changes include formal modifications such as greater use of joint research-extension appointments for extension specialists, establishment of regional centers staffed by both researchers and extension specialists, increased attention in recruiting both researchers and specialists for individuals who can "crosswalk" between the two functions, establishment of institutes of agriculture which organizationally place experiment station and extension activities under a more coordinated administrative structure,

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[21]For example, extension specialists in those university systems that pride themselves on basic research were found to emphasize roles as applied researchers, responsive in varying degrees to county agents and growers. These specialists were heavily influenced by academic standards including publication of research results in refereed journals. The specialists and their administrators viewed such publications as important for promotion and tenure decisions. In other states, extension specialists serve essentially as technical consultants to both agents and producers, taking on heavily service roles, e.g., drafting drawings of irrigation systems. They transmitted already known state-of-the-art knowledge; they are only marginally involved in either their own research problems or in disseminating emerging findings.

and the move towards functionally integrated budget submissions for state support. Informal modifications include a greater recognition of the interdependence of the activities of the experiment station and cooperative extension, including improved lines of internal communication, and the de facto repositioning of the activities of researchers, specialists, and agents such that as researchers move towards a more basic research orientation specialists increase their commitment to applied research, and agents take on enlarged "problem-solving" research activities.

It is thus not possible to generalize as to the strengths of linkages between research and technology transfer activities across all the states or even necessarily across commodity or scientific areas within a state. Even less so is it possible to prescribe remedies, particularly of an organizational form, that are uniformly or indeed even widely applicable across the varigated settings of land-grant universities.

IV. Research-Extension Linkages in Land-Grant Universities

In the prototypical public-sector agricultural technology delivery system, the various functions of basic research, applied research, demonstrations, etc. are performed by individuals located in different organizations: researchers at federal and land-grant universities, extension specialists located at the land-grant university, and extension agents located in counties.

As is well known, the decentralized, flexible, and iterative character of roles and relationships has been the hallmark of the combined contribution of public- and private-sector organizations to sustained

increases in agricultural productivity.[22] The functioning of the system has involved both the "mixing of functions" by individuals, i.e., performing research and transfer activities, and the linkage of activities among these individuals, both formally in project teams or informally through working networks.

The degree of separation or its opposite, integration--functional as well as organizational--between research and extension is difficult to measure. Still, in the Penn State study as well as in earlier statements the emphasis accorded by numerous respondents from both research and extension communities to improved relationships in recent years suggests that if the relationship was not rigid, it was at least difficult to penetrate.[23]

The strains in relationships occur at all levels of the land-grant university, affecting at the "macro-level" its commitment to a mission orientation, and at its micro-level, the activities and functional relevance of county extension agents.

One of the historic themes that permeates colleges of agriculture in land-grant universities is that of a mission orientation. This theme is voiced in the statements of both academic and research administrators

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[22] D. Gale Johnson (1981), "Agricultural Productivity in the United States: Some Sources of Remarkable Achievement," 1981 Seaman Knapp Lecture, National Association of State Universities and Land-Grant Colleges Annual Meeting, Washington, D.C.

[23] Writing of the early history of experiment stations in the south, Jane Porter, Historian, U.S. Department of Agriculture, observed as recently as 1979: "Although a rigid separation between research, regulatory, and extension functions has become a cardinal principle in the American system of services to agriculture, this was not true in the early days when neither funds nor personnel were available for such a structure" (Jane Porter (1979) "Experiment Stations in the South, 1877-1940," Agricultural History 53, (January) pp. 84-101; p. 85.)

who see their institution as "world class" research universities, and by those who see the principal identification of their universities to the citizens (and producers) of their states. Such an orientation legitimizes not only applied research but the activities and roles that link research and technology transfer activities. It rewards and nurtures linkage activities, and serves as an organizational thermostat calling forth corrective measures when the links become attenuated.

Concern, however, has been expressed about the vitality of the land-grant university's sense of a mission orientation, particularly in the resources and prestige accorded to applied research or to "problem-solving" activities as it increases its commitment to basic research. Schuh, for example, has expressed concern over the commitment of the land-grant university to applied research. This concern is the one most expected in the context of the shift to basic research. It might, if not interconnected with other developments, call for little more than attention to the ever-present "balancing act" that goes on within experiment stations to the multiple influences on its research priorities,[24] and to reminders that basic research and mission orientation are not necessarily antithetical concepts. (The University California-Davis's research plan, for example, emphasizes the concept of "targeted

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[24]G. Edward Schuh (1984), "Revitalizing the Land Grant University," Paper presented at Colloquium, Strategic Management Research Center, University of Minnesota; Keith Huston, (1980), "Priority Setting Processes in the State Agricultural Experiment Stations," in OTA, An Assessment of the United States Food and Agricultural Research System, op. cit., Volume II, Commissioned Papers, Part B; Vernon Ruttan (1980), "Bureaucratic Productivity: The Case of Agricultural Research," Public Choice 35, pp. 529-547; I. Feller, et al. (1983), "The Structure of Agricultural Research in the United States: An Overview," Report prepared for Science and Education, USDA (March) (University Park, PA: Institute for Policy Research and Evaluation).

basic research which is designed to provide for the concurrent pursuit of scientific discoveries at the frontiers of knowledge and of the generation of useful and technical findings to producers of the state.)

Added to the basic/applied mix, however, is the concern, as expressed for example by Glenn Johnson, that to a great extent the former also tends to diminish the value placed in colleges of agriculture on what Johnson terms "problem-solving" activities, particularly as they relate to the standing of extension personnel.[25] Combined, these two concerns point to the principal thesis, namely, that a potential risk exists of losing sight of the need to maintain a mission orientation in the shift towards a basic research commitment.

Three other university-wide influences reinforce this trend towards loosened ties between research and technology transfer activities. First is the infusion of new scientists. The combination of the aging of the existing corps of agricultural scientists and research administration coupled with the new scientific areas which are to be cultivated requires an infusion of new scientific talent. Given the long-term contraction of agricultural and rural sectors, it is likely that newly appointed faculty in colleges of agriculture will have less direct experience with agricultural production than does the current generation. The inculcation of a mission orientation into new members in a mission-oriented organizations is not automatic. It requires an ability to demonstrate the complementarity of quality research efforts with a mission orientation. It requires the melding of research skills and

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[25]Glenn Johnson (1984), "Academia Needs a New Covenant for Serving Agriculture," Paper presented at Mississippi State University, April 16, 1984.

personalities into project-oriented teams, so that the relative scientific competencies of newer and older generations of scientists do not invidiously become associated with basic/applied orientations.

Second, there is also the question of how institutional mores affect the orientation of experiment stations (and to a lesser extent, cooperative extension). Colleges of agriculture and experiment stations are part of larger organizations. Their standing, in terms of funding, influence, and prestige may vary from great to small, from "academic crown jewel" to "country cousin" in Emery Castle's words, but they are not autonomous organizations.[26] If only for the protection of tenure track researchers and extension specialists from the criteria of university-wide promotion and tenure committees, internal performance standards must be adopted that are compatible (although not necessarily identical) with those of other parts of the university. The influence of the American Council of Education (Jones-Lindzey) rankings on intra-university priorities and rewards may be subtle, but it is nevertheless real.

Third, the current fascination with improved collaborative relationships between university researchers and private industry may serve to improve the transfer of university-based research but in a way that reduces the importance of the extension component of the land-grant system. Strengthened university-industry ties may produce a situation in which industry is able to have academic research bring a product

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[26] Emery Castle (1980), "Agricultural Education and Research: Academic Crown Jewels or Country Cousin," Kellogg Foundation Lecture, National Association of State Universities and Land Grant Colleges (Washington, DC).

closer to the market. The firm, buttressed by the tacit university endorsement of the technical qualities of its product, then relies on its already developed, and apparently newly strengthened technology delivery mechanisms, to provide information to producers. Sales representatives, supported by a firm's technical staff, also may be able to reach into research-based supporting material generated by the SAES system to directly reach and benefit farmers. Over time, the more access that firms have to the land-grant systems' research findings, the less necessary are the services for a third party "neutral." If this pattern does, in fact, emerge, the university may find itself subject to competing internal pressures, as the efforts of the experiment stations to effectively transmit its new findings may lead to more close linkages with a competitor for the county extension system.

Moving from the macro to the micro level, several issues emerge concerning relationships among researchers, specialists, and county agents. The organizational changes noted earlier concerning greater use of joint appointments, regional research centers, placement of specialists in academic departments, and, in general, improved communications between research and extension personnel serve mainly to strengthen ties between researchers and extension specialists; they leave unanswered the question of the function of the county extension agent, or of how closer linkages between research and specialists affect the accessibility or utility of the specialist to the agent.

The Penn State study confirmed many traditional verities about the various ways county agents transfer and interpret the most recent findings from its experiment stations to growers and also pass on to researchers questions arising from producers. The study also identified

several important roles that county agents perform, such as serving as a link between commodity marketing order boards and university researchers in defining projects that combine scientific interest and commodity-specific relevance issues that are seldom identified. The study, however, also suggests a debate, muted at most times but occasionally breaking through, concerning the functional importance of the county agent in the transfer of agricultural technologies.

Interviews with persons both within and outside the land-grant universities suggested that farmers and other clients are turning increasingly to extension specialists and researchers at the land-grant university for answers to agricultural technology problems because of the increasing complexity of agriculture. In some states the ratio of specialists to agents has increased as a consequence. In these instances, county agents see the specialists as intruding on the agent's job even though the agents concede they originally pushed for more specialized assistance. Strains between specialists and agents were pointed to in almost every state visited, except where agents perceive themselves to have an independent base of expertise based upon their own research and study.

Extension administrators and personnel widely recognize that advances in agricultural technology have been substantial and increasingly complex. Producers are seen as wanting information not only on recommended "best practices" but also on answers to the more difficult "what if" sort of questions concerning the interdependency of decisions involved in agricultural production. Extension officials believe that the state extension systems have responded to these demands for technical expertise by staff development and professional improvement

programs. Extension is seen as the leading source of information on selected practices. Its contribution to improved production practices, however, in the view of extension personnel does not always require it to be the first or only source of information on these practices. Extension's ability to provide information that reinforces information provided from other sources, public or private, and its standing as a "neutral" source that can be turned to when producers are in doubt about the validity of the information they have otherwise received are seen as contributing to the acceptance of the most economically useful items from the overall streams of new products or practices that research makes possible.[27]

On the other hand, respondents from all sectors interviewed expressed concerns that county agents are falling behind in their ability to comprehend and communicate new practices. To some extent, this observation relates mainly to the rate at which in-service staff development programs are able to keep pace with the changing technical complexity of production techniques for specific commodities and with changes in the mix of commodities produced within a state. It relates also to the training and qualifications of agents relative to those of

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[27] It is not a question of whether industry or the county agent should do the job. Both can and indeed do perform excellent service, hopefully, each telling the same story. The performance of decades shows clearly that farmers adopt improved practices quickly when given the benefits of agent-industry service. Put another way, reaching the audience with identical information from as many sources as possible is an age-old and effective extension teaching device. At the same time, farmers continue to seek the unbiased advice of the county agent who stands at the wellspring of information--owing neither allegiance to nor promoting any special interest (C. Palm (1966), "How County Agents Can Work Closer with Industry," Farm Technology (September-October), pp. 9-10).

producers in the state, itself a trend that is related to higher levels of education for producers and the advent of professionally managed farms. It also relates to the multiple responsibilities often assigned to county agents, including agricultural agents, which limit the time they have to develop the competencies required to provide the services requested by their more technically sophisticated clients.[28]

Attentuation of ties between research and extension programs paradoxically may involve greater pressure on university researchers to make themselves more accessible to producers. The need to maintain the continued support of the public through continuing demonstrations of the application of its research endeavors will perhaps serve as the major prod for the "research" segment of the public agricultural research sector--the state experiment stations system as well as ARS--to integrate forward into a more active technology transfer role. However begrudgingly done, as a matter of self-interest academic scientists may take on more "extension-like" work, not as part of their "formal" budgeted assignments, but as a pragmatic accommodation to the demands of those who support them. However much obeisance is paid to traditional organizational boundaries, the research system will not by the default

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[28]The Users Advisory Board has made clear its position on this issue. "Greater attention must be given to training local extension agents in emerging biological and computer technologies to shorten the transfer time between discovery and adoption of strategic research. There is a need to reestablish an effective body of extension agents who are closely linked to the agricultural departments and experiment stations of our land-grant universities where fundamental advances in agricultural science and technologies will occur. Without such linking, we believe the capacity of the CES to transfer agricultural research and education will diminish" (National Agricultural Research and Extension Users Advisory Board (1983), Appraisal of the Proposed Budget for Food and Agricultural Sciences. Report to the President and Congress (February), pp. 32-33).

of its "marketing" arm permit its new products to remain in the laboratory. It will seek its own outlets.

This pressure may reflect itself in an increase in the number of extension specialists, and/or in the relative elevation (in terms of compensation, status, and promotability) of the specialist role within colleges of agriculture. In practice, the combined influence of a shift to a more basic research orientation by agricultural scientists, the concentration of agricultural productivity, and the increasingly competitive character of private-sector suppliers of agronomic information and its equivalent, may lead to technology delivery systems involving scientists, specialists and producers. County extension agents may, as outlined above, continue to deliver many services to producers, and may, in the aggregate continue to enhance the economic well-being of producers, but their importance in those activities that constitute technology transfer may diminish as indeed it already has.[29]

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[29]"The extension service is not, as of 1977, the only supplier of technical information to farmers. There are numerous other suppliers of technical information that should be mentioned. The various breed associations, crop improvement associations, and farm management associations regularly supply their members with up-to-date technical information. The farm newspapers and journals continue to be an important source of technical information, as has been the case for many decades. Important new sources are the feed, seed, fertilizer, and machinery salesmen, or representatives, of private firms and farmer-owned cooperatives. The information provided by salesmen may in some cases be biased, but it is likely to be more specific and possibly more relevant to production conditions of a particular geographical area than, for example, the information provided by a state extension specialist. Thus farmers are increasingly obtaining their technical information regarding inputs from the area sales representatives of private firms and farmers' cooperative associations. Finally, some of the larger, more aggressive farmers are hiring technical consultants and consulting services to provide them with technical information as it relates to their specific production situations. As the size of farms continues to grow, this source of technical information will almost certainly become increasingly important" (Willard Cochrane (1970), The Transformation of American Agriculture (Minneapolis, Minnesota: University of Minnesota Press), p. 251).

Indeed, it is at this point that the contradictions in what is occurring between the research and extension communities most clearly need to surface. If the research community is content to leave "transfer" activities to cooperative extension either because it accepts extension's claims to this function or because it prefers to concentrate on more "intellectually" gratifying tasks, and if extension claims this role even if it is not able to perform it effectively, a societal loss will occur in terms of the gains in productivity achievable if the new knowledge had been incorporated into production. Furthermore, over time, this lack of transferable benefits from research will find its voice in the growing disenchantment of producers both with the research and extension communities.

There are other potentially adverse elements in this emphasis on the research content. It is commonplace to speak of feedback that extension personnel provide to researchers concerning "grassroots" research needs. Busch and Lacy's study suggests that this factor is quite insignificant, ranking 15th of 16 possible criteria (although there may be more indirect channels). It would be ironic if at the same time contemporary treatments of corporate excellence place increasing weight on contact with customers, the public system most associated with this desirable trait suffers a loss in this capability.[30]

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[30]James Utterback has noted that success of some firms in generating commercially successful innovations ". . . implies special connections with your environment, not general connections. And connections with particularly creative and demanding users. And it demands that the connection be informal and personal. . . . A lot of translating and testing goes on between the producer of technology and the customer. Often there is a great deal of interaction between the possible users and the organization that brings a major product change into the market." As quoted in T. Peters and R. Waterman, Jr., In Search of Excellence (New York: Warner Books Edition), p. 117.

V. Conclusion

The futures of public-sector research and extension organizations are interconnected. Unless changes are made to maintain strong linkages between research and technology transfer components, it is likely that both segments will suffer and that the attainment of important societal goals will fall short of optimum. Public-sector research organizations will suffer, for example, if basic research activities are emphasized to the detriment of the more client-oriented applied research needed to justify continuing levels of public and political support. The debates of the 1960s and early 1970s concerning the public return from its investment in R&D clearly demonstrate that mission-oriented research must be linked to research utilization/technology transfer programs to maintain continuing public support.

Recent congressional approval of competitive grant funds can readily be withdrawn in subsequent budgets, especially if in the context of strong pressures to reduce federal deficits these funds are seen as being subtracted from even nominal increases in formula funding. Already a backlash against the excessively basic research orientation of ARS and the experiment stations can be detected in the statements of agricultural representatives.[31]

The "honeymoon" period within which the research community has to demonstrate its claim that the path to significant advances in

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[31] "The drift toward basic research at the expense of applied research has gone too far. How many more millions of dollars are going to be dumped into our bulging biotechnology research centers before we realize that many farmers will not be around to enjoy any of the practical ideas that may result! Note the word may!" (Gordon Berg (1985), "Bridge Over Troubled Waters" (editorial) Ag Consultant and Fieldman 41 (January), p. 34).

agricultural productivity and agricultural profitability may be quite short. For example, while public funding to support basic research in agricultural biotechnology can at present be justified in terms of "science" alone, past experience suggests that potential "pay-off" is never absent from the executive or congressional bottom-line. For its part, without linkages to new research, the technology transfer component will suffer because of accelerated obsolesence, which erodes the productivity of the information and technical assistance it offers.