Staff Paper P01-10 **September 2001**

STAFF PAPER SERIES

Technology Transfer From The University of Minnesota: Estimating The Economic Impact

Vernon W. Ruttan

DEPARTMENT OF APPLIED ECONOMICS

COLLEGE OF AGRICULTURAL, FOOD, AND ENVIRONMENTAL SCIENCES

UNIVERSITY OF MINNESOTA

Staff Paper P01-10 **September 2001**

Technology Transfer From The University of Minnesota:

Estimating The Economic Impact

Vernon W. Ruttan

Abstract:
There is strong synergy among research, education, technology development and technology transfer. Examples of successful public-private technology transfer linkage institutions are provided. But efforts to document the benefits of research conducted at the University of Minnesota to the state have rarely been conducted with the rigor that would be required to meet the test of professional credibility. A program of research to develop more rigorous evidence on economic benefits to the State is proposed.

Technology Transfer From The University of Minnesota:

Estimating The Economic Impact*

Vernon W. Ruttan**

In this paper I first address the synergy among research, education and technology transfer. I then discuss the economic rationale for public sector support for research; the problem of estimating the economic returns from research; and the problem of institutionalizing capacity for technology transfer. In a final section I suggest how the University might develop a more serious effort to analyze and quantify its impact on the economic growth of the state.

Synergy Among Research, Education, and Transfer.

It is generally held that there is a strong synergistic interaction between research and education. The synergy is most apparent at the graduate and professional school levels. It has generally been held, at least since Leibig, that graduate education and professional training can hardly be effective if carried out apart from research. In most fields research is less effective when carried on apart from graduate education or post-doctoral research training. And in those industries which draw on the most recent advances in science, such as agriculture, biotechnology and communications, both basic research and technology development are penalized when carried on apart from each other (Ruttan 2001, 79-82; 535-538).

The synergy between research and education often appears less apparent at the undergraduate level. The responses to a questionnaire that I administer to my own students

---

* Paper presented for University of Minnesota Impacts Conference, August 23, 2001. I have benefited from comments by James Adams, Gary Beil, Frank S. Bates, Victor A. Bloomfield, Michael Darger, Vernon R. Eidman, Robert King, Peter Nelson and G. Edward Schuh on an earlier draft of this paper.

** Vernon W. Ruttan is Regents Professor Emeritus in the Department of Applied Economics and the Department of Economics and Adjunct Professor in the Hubert H. Humphrey Institute of Public Affairs.

suggest substantial complementarities between research and undergraduate education. But I know of no credible research based evidence to support this view. Nor do I know of any credible evaluations of the efforts that have been made to revitalize the relationship between research and undergraduate education. The relationship between research and outreach has been even more tenuous. In traditional outreach activities, such as agricultural or industrial extension, outreach has often been handled by specialists who were not engaged directly in research and who conceptualized their roles as educators or consultants. I will argue later in this paper that effective contemporary outreach activities in high technology fields will involve institutionalizing more direct relationships between research and outreach.

Research as a Public Good

Attempts to evaluate the economic value of university based research are part of a broader body of thought about research as a public good. The modern version of the public good rationale for the support of scientific research was articulated by John Wesley Powell the director of the U.S. governments first scientific bureau, the Geological Survey, in 1886.

"The learning of one man does not subtract from the learning of another, as if they were a limited quantity to be divided into exclusive holdings. … That which one man gains by discovery is a gain to other men. And these multiple gains become invested capital."

It was not until the late 1950's and early 1960's, however that a formal economic rationale for public support of scientific research was articulated. Seminal articles by Richard Nelson (1959: 297-306) and Kenneth Arrow (1963: 609-626) showed that the social returns to scientific research exceeded the private returns realized by the individual firm. The knowledge produced by scientific research conducted by universities, government research laboratories and private firms "spills over" to other firms and consumers. A conclusion from this research was that the private sector could be expected to underinvest in scientific research. Public investment in scientific research at universities and other publicly supported institutions would be necessary to achieve a socially optimal level of allocation of resources to research.

It was initially assumed that the underinvestment rationale applied only to basic research. However, empirical investigations have demonstrated that the argument also applies in the area of technology development. Social rates of return to publicly supported agricultural research, across a broad range of commodities and at the sector level were shown to be several multiples of the average rate of return on conventional private sector investment (Griliches, 1958; Evenson, Waggoner and Ruttan, 1979; Huffman and Evenson, 1993).[1] Beginning in the 1970's evidence began to accumulate that the social rate of return to private sector industrial research, across a broad spectrum of industries was significantly higher than private rates of return to the firms that conducted the research (Mansfield et al, 1977: 144-166; 1991); Scherer 1982; Griliches 1992).

These studies, combined with a slowdown in U.S. productivity growth during 1970-95, led to a view that underinvestment in private sector R&D represented a serious constraint on economic growth (Jones and Williams, 1998). The response by the federal government was a series of institutional innovations designed to enhance commercial technology development (Table 1) The first of these was the Bayh-Dole Act (1980) that permitted universities, non-profit organizations and small businesses to acquire ownership of inventions based on research funded by the federal government and to license these inventions to industry for commercialization. The effect of the Bayh-Dole Act was to substantially increase incentives for research directed to

[1] Estimates of the social rate of return include benefits to other firms and consumers in addition to the rate of return to the organization (public or private) that conducts the research.

technology development at universities and federal laboratories. It also led to much greater effort on the part of university faculty and administration to establish intellectual property rights to the technical knowledge generated by university research. In addition to the legislative mandates listed in Table 1, there have also been several initiatives by federal agencies. One that has been particularly important was the initiation by the National Science Foundation, beginning in the early 1980's, of funding for Industry-University Cooperative Research Centers (IUCRS) designed to institutionalize industry-university research cooperation. The University of Minnesota has not, however, taken a proactive role in evaluating the economic benefits of the spillover to the private sector and to citizens from its research, development and technology transfer efforts.[2]

Research Benefits

Efforts by the University of Minnesota to document research benefits to the State have rarely been conducted with sufficient rigor to carry conviction. I have classified the evidence used to document benefits under three general headings: (a) pork-barrel benefits; (b) spin-off benefits; and (c) growth benefits.

Pork Barrel. The argument is often made that university research, particularly research funded by the federal government, generates substantial revenue for the State. In 1992, for example, The Schuh Report indicated that research and related programs were the source of over $200 million in revenue from the federal government. In 2000 this figure, as reported by the University Office of Institutional Research and Reporting, amounted to $455 million (both in current dollars).

---

[2] A number of community colleges have funded studies of the socio-economic benefits of community colleges prepared by a consulting firm that that has developed a standard format for estimating economic and social benefits (Christopherson and Robinson, 2000).

The pork barrel argument is regularly made by the university administration in testimony to the state legislative bodies and reported in the press. There is nothing fundamentally wrong with the numbers that are reported. But the numbers clearly represent an understatement of the value of the research conducted with such funds. By considering only the direct and indirect effects of university expenditures, the pork barrel argument, even in the hands of sophisticated practitioners (Leslie and Lewis 2001; Leslie and Slaughter 1992) fail to capture the contribution of the new knowledge and the new technology generated by university research on state economic capacity. There is an implicit assumption that the benefit to the State of university research can be evaluated on the same terms as other pork-barrel projects—a new highway interchange at the intersection of state 53 and 169 between Virginia and Ely, for example. The reason the pork barrel argument is made is not because it is adequate but because it is simple.

Spin Off. Attempts have occasionally been made to go beyond the pork barrel argument to identify the benefits to the private sector and the state from University of Minnesota education and research. One of the more ambitious attempts was the report "The IT 400" (Institute of Technology 1991). The report identified 400 companies, led by heavy hitters such as Medtronics and ADC Telecommunications, founded or co-founded by IT alums between 1950 and 1990. An equally impressive follow up report that emphasized the new products resulting from research at the University of Minnesota was prepared by the Minnesota High Technology Council (1993).

The information from the spin-off studies, like the pork barrel data, is useful. They attempt to estimate the benefits from research (or research and education) rather than the costs. But, in contrast to the pork barrel studies, they tend to overestimate the benefits. This overestimate is the result of implicitly assuming that the University research (or research and education) is the single critical incremental input rather than a complement to other inputs in accounting for benefits.

Economic Growth. The University has seldom invested in the capacity. needed to evaluate the economic benefits of the research it has conducted, needed to meet state of the art benefit-cost or rate of return criteria. There have been several excellent descriptive reports such as the historical study of the role of the university in the development of the taconite industry (Davis 1964). In the early 1990s Edward Schuh of the Humphrey Institute chaired a task force that assembled several case studies of university based technical innovations (University-Wide Task Force, 1992). More recently Frank Bates, of the Department of Chemical Engineering and Material Science has attempted to estimate the "value added" to economic activity, primarily in terms of the higher incomes earned by graduates of the Department of Chemical Engineering and Materials Science.

The only studies that I have been able to identify that meet the formal analytical criteria established by economists for evaluating the net benefits or rates of return to research conducted at the University of Minnesota were studies, of soybean and barley breeding research, conducted in the Department of Agricultural and Applied Economics (Miner 1983; Macagno, Sundquist and Rasmusson, 1992). The annual social rate of return to research estimated in these two studies ranges from 55 percent (soybeans) to 91 percent (barley)—high by any standard.[3] The significance of the rate of return studies is that they measure growth in the states capacity to generate new and continuing income streams generated by the new knowledge and new technology from university research.

[3] Estimates of the rate of return to research have been based primarily on two methods. One method is based on social accounting methodology. A second method uses econometric estimation. In both cases the objective is to measure the change in multifactor productivity (output per unit of total input) that can be attributed to research.

I do not suggest that evaluation in terms of economic benefits is appropriate for all of the activities, or even all of the research, conducted by the University of Minnesota. But I do insist, when economic benefits are claimed, that they should meet a test of professional credibility. One might ask if it matters that the estimates are not sufficiently rigorous to meet professional standards. Perhaps "good enough" is good enough in Minnesota. Perhaps I am only trying to carry coals to Newcastle. Apparently the consumers of the reports and studies have not felt it sufficiently important to criticize the pork barrel and spill over studies.

Technology Transfer Institutions

Technical innovations are rarely transferred directly from university laboratories to agricultural, medical or industrial application. They are often transferred as a result of the individual efforts of research entrepreneurs who establish a direct relationship, sometimes established through consulting or other personal arrangements, with sponsors. The University has also employed formal institutional arrangements to facilitate technology transfer. I have in mind, for example, the Minnesota Extension Service and the Office of Patents and Technology Marketing (formerly part of the Office of Research and Technology Transfer Administration (ORTTA)). The increased importance of more direct linkages reflects the close articulation between advances in science and technology in newer fields such as biotechnology and materials science and between public and private science and technology (Figure 1).

The Minnesota Crop Improvement Association (MCIA) was an early example of a public-private linkage institution. The Association was established to transfer new crop varieties developed at the University of Minnesota Agricultural Experiment Station to the private sector for multiplication and diffusion. When the performance of a new crop variety developed by a

University plant breeder was judged to warrant seed release for farm production, the “breeder seed” was released to the Association for multiplication. The Crop Improvement Association, a non- profit corporation whose owners were mostly farmers and small seed companies, was also designated by the state legislature as the official Minnesota seed-certification agency. Rights to produce and market the public seeds were licensed to members of the Association. The seed-certification program was designed to ensure the purity and quality of seed sold by the producers of both public and private seeds. The activities of the association were financed by the seed certification fees (Ruttan 2001: 386). This past year MCIA was assigned the additional responsibility by the UMN Board of Regents of serving as the exclusive marketing agent for agronomic materials developed by the Minnesota Agricultural Experiment Station.

The Industrial Partnership for Research in Interfacial and Materials Engineering (I Prime) is a joint activity of the University of Minnesota Institute of Technology **Center for Interfacial Engineering (CIE)** and the more recently established **Materials Research Science and Engineering Center (MRSEC).** The CIE was established in 1988 when the Institute of Technology received a grant from the National Science Foundation (NSF) to establish an Engineering Research Center (ECR). The industrial partnership established by the CIE involved several levels of cooperative participation including collaboration in research and technology development among industrial scientists and engineers, university faculty and students. The research ranged from directed proprietary research by university staff holding post- doctoral appointments to member-company employees conducting research on campus in collaboration with university faculty. A membership fee structure was established for sponsors and affiliates that varied with the intensity of collaboration and the size of the firm.

In 1998, at about the time when NSF funding for IUCRs was winding down the NSF began a new program of support for Materials Research Science and Engineering Centers. In order to simplify the management of its industry-university partnership activities, and to avoid confusion among the industrial partners, the Department of Chemical Engineering established I Prime as an umbrella organization. The industrial partnership program now includes five areas. Coating Processes Fundamentals, Nanostructural Materials and Processes, Porous Materials, Magnetic Hetero-structures, Microstructured Polymers and Artificial Tissues. Support from the I Prime industrial partners has amounted to slightly above $1.0 million in recent years.

The Supercomputing Institute for Digital Simulation and Advanced Computing was established in the mid-1980's to provide high-performance computing technologies and related programs to researchers at the University of Minnesota and other universities and colleges in Minnesota. The Institute is equipped with leading edge supercomputing technology.[4] It sponsors symposia, workshops and seminars to promote supercomputing research. Efforts to establish long term industry-university institutional relationships have been more effective with computer manufacturing firms (such as IBM at Rochester) than with the research units of corporate users. The Institute has played a facilitating role, however, in collaborative and consulting relationships between individual university researchers and industry in the area of supercomputing applications.

I refer to the above three linkage institutions to illustrate some of the range of institutionalized technology transfer activities in which the University is involved. For a partial

[4] In 1981 the University of Minnesota was the first American university to acquire a supercomputer (a Cray-1B). The Supercomputing Institute was created in 1984. After a somewhat troubled early history involving relationships between the Supercomputing Institute and the Supercomputer Center (established to own and manage the supercomputing facilities and market supercomputing services) new arrangements were established to provide unified management. The Supercomputing Institute has recently installed a 128 processor SGI Origin 3800 with 192 GB of memory and a 64-processor SGI Origin 3800 with 96 GB of memory. These supercomputers utilize 500 MHz R14000 processors. With this installation the Institute offers its researchers access to the largest SGI Origin 3000 series supercomputers in the upper Midwest.

listing of other public-private linkage institutions at the University of Minnesota see Table 2. I am not aware of any attempts to evaluate the specific economic impacts of these institutions. A recent national study by James Adams has, however, shown that institutional arrangements involving direct contact between university and industry scientists and engineers are more effective than other forms of contact such as conferences or electronic communications. Firms prefer to work with local universities. And such arrangements tend to have larger local impacts than other forms of technology or knowledge transfer (Adams 2001). It is also clear that there is no single best design for effective linkage institutions.

Major constraints on the success of public-private linkage institutions initiated by the university have included (a) inappropriate institutional design and (b) uncertain long- term University commitment. A partial list of such failed institutional initiatives would include (a) North Star Research and Development Institute and (b) the Washington Avenue High Technology Corridor.

A Modest Proposal

Any public or private organization that is engaged in a substantial R&D effort should have an internal capacity to evaluate the economic productivity and social impact of its activities (Guston, Woodhouse, and Sarewitz 2001). The management of a private firm must be able to satisfy its Board that its R&D efforts are making an effective contribution to firm profitability and growth. The management of a public institution that conducts substantial R&D should be able to provide both the legislative bodies and the broader public that provide its funding with credible evidence that its research activities are making an effective contribution to its mission. The University of Minnesota has not yet established such capacity.

I would like to suggest that the Office of the Vice President for Research should draw on funds generated from intellectual property rights revenue to support a modest program of research on the benefits to the State of Minnesota of research and technology transfer activities conducted by the university. The program might have two components. One would be an institutional program that would each year initiate one or two projects designed to measure the impact of a major research and technology program, such as those listed in Table 2. Responsibility for such a program could be located in the Office of Institutional Research and Planning. A second should be an investigator initiated small grants program that might be administered by the Faculty Research Grants program. The mandate for the small grants program should be defined broadly to include evaluation of cultural, social and environmental benefits of civic engagement as well as the economic benefits of university research. The objective of the two research activities should be to build up over a period of time, a portfolio of research based evidence that meets the tests of quality that are applied to other areas of research and scholarship.

Table 1. Federal Technology Transfer Initiatives

Year	Legislative/Executive Initiatives	Highlights
1980	Bayh-Dole Act (PL 96-517)	Permitted universities, nonprofit firms, & small businesses to own title to inventions from research funded by the federal government so they may license these inventions to industry for commercialization.
1980	Stevenson-Wydler Technology Innovation Act (PL 96-480)	Mandated federal labs to take and active role in technical cooperation with industry by establishing at each laboratory an Office of Research and Technology Application (ORTA).
1982	Small Business Innovation Development Act (PL 97-219)	Required federal agencies to provide special funds for small business R&D within the scope of their agency mission.
1984	National Cooperative Research Act (PL 98-462)	Encouraged firms to enter into joint precompetitive R&D ventures without fear of antitrust laws and eliminated the treble damages standard of antitrust laws in litigation arising therefrom.
1986	Federal Technology Transfer Act (PL 99-502)	Empowered government-owned government-operated labs (GOGOs) directly to enter into cooperative R&D agreements (CRADA) with firms and established the Federal Laboratory Consortium (FLC) for Technology Transfer.
1987	Executive Orders 12591 and 12618	Further articulated the Federal Technology Transfer Act for administrative purposes.
1988	Omnibus Trade and Competitive Act (PL 100-418)	Designated the National Institute of Science and Technology (NIST) as lead agency to establish and administer Manufacturing Technology Centers (MTC).
1989	National Competitiveness Technology Transfer Act (PL 101-189)	Extended the CRADA authority to all government-owned contractor-operated federal labs (GOCOs).
1993	Defense Authorization Act (PL 103-160)	Directed the Advanced Research Projects Agency (ARPA) to promote dual-use technology via technology reinvestment.

Source: Young S. Lee, ed. *Technology Transfer and Public Policy*. Westport, CT: Quorum Books, 1977: 225-73.

Table 2. A Partial List of University of Minnesota Based Public-Private Linkage Institutions

Biological Process Technology Institute

Center for the Development of Technological Leadership

Center for Urban and Regional Affairs (CURA)

Executive Development Center

Industrial Partnership for Research in Interfacial and Materials Engineering (I Prime)

Minnesota Biomedical and Bioscience Network (MBBNet)

Minnesota Crop Improvement Association

Minnesota Geological Survey

Minnesota Institute for Sustainable Agriculture

Natural Resources Research Institute (Duluth)

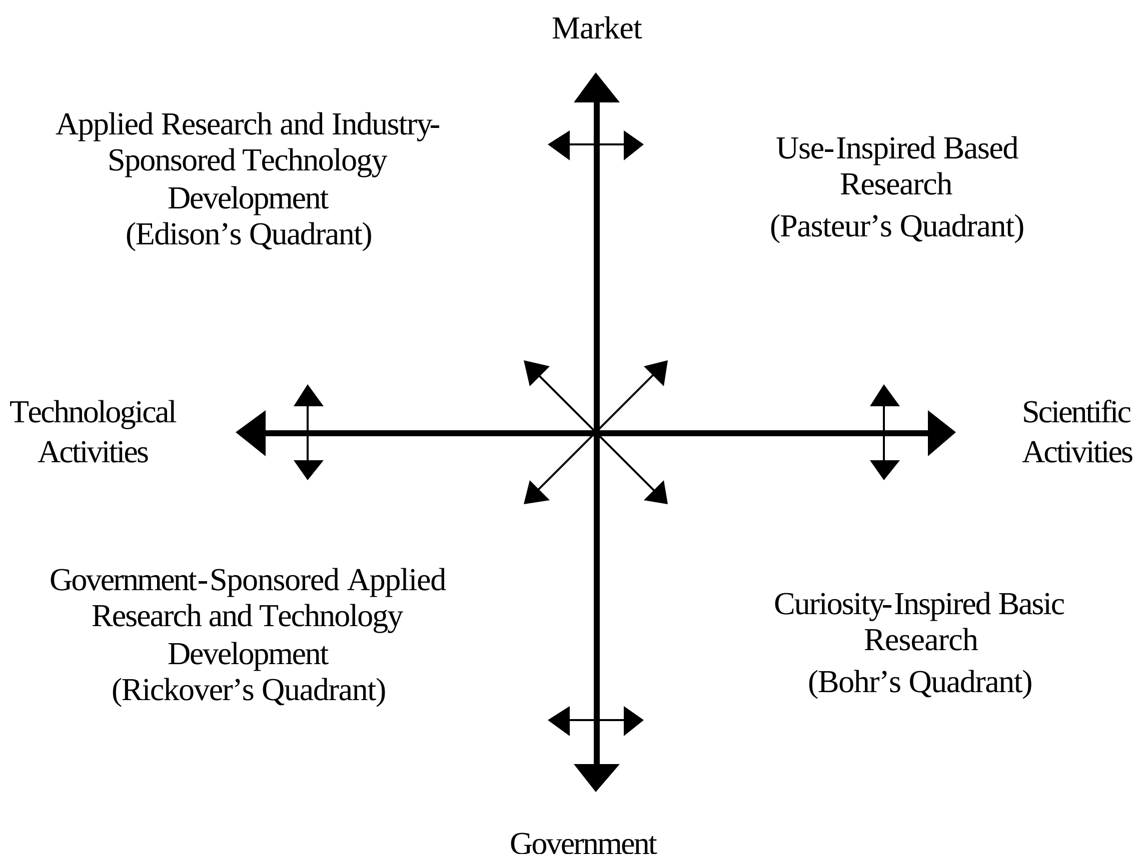
Office of Patents and Technology Marketing

Retail Food Industry Center

Supercomputing Institute for Digital Simulation and Advanced Computing

Veterinary Diagnostic Laboratory

Figure 1. **Quadrant Model of Organization of Scientific Research and Technology Development.**



Sources: Adapted from Donald E. Stokes, *Pasteur's Quadrant: Basic Science and Technological Innovation*, Washington, DC: Brookings Institution, 1997; Maureen McKelvey, "Emerging Environments in Biotechnology," in *Universities and the Global Knowledge Economy*, Henry Etzkowitz and Loet Leydesdorff, eds., London: Pinter, 1997: 63.

References

__________. 1991. "The IT 400." *University of Minnesota Institute of Technology Items* (Summer).

__________. 1993. *Products of an Unheralded Industry*. Bloomington, MN: Minnesota High Technology Council. (April).

Adams, James D. 2001. "Comparative Localization of Academic and Industrial Spillovers."

Gainsville, Fl: Department of Economics, University of Florida (mimeo).

Adams, James D., Eric P. Chiang and Katara Starkey. 2001. "Industry-University Cooperative Research Centers." *Journal of Technology Transfer* 26: 73-86.

Christophersen, Kjell A. and Henry Robinson. 2000. *The Socio-Economic Benefits of Community Colleges*. Moscow, ID: CCBenefits Inc. (http://www.ccbenefits.com).

Daves, E. W. 1964. *Pioneering with Taconite.* St Paul, MN: Minnesota Historical Society.

Evenson, Robert E., Paul E. Waggoner and Vernon W. Ruttan. 1979. "Economic Benefits from Research: An Example from Agriculture." *Science* 205: 1101-1107.

Griliches, Zvi. 1958. "Research Costs and Social Returns: Hybrid Corn and Related Innovations." *Journal of Political Economy* 66: 419-41.

Griliches, Zvi. 1992. "The Search for R&D Spillovers." *The Scandinavian Journal of Economics* 44: 29-41.

Guston, David H., E. J. Woodhouse and Daniel Sarewitz, 2001. "A Science and Technology Policy Focus for the Bush Administration." *Issues in Science and Technology* 17: 29-32.

Huffman, Wallace E. and Robert E. Evenson. 1993. *Science for Agriculture: A Long Term Perspective.* Ames, IA: Iowa State university Press.

Jones, Charles I. And J. C. Williams. 1998. "Measuring the Social Return to R&D." *The Quarterly Journal of Economics.* 113 (4): 1119-35.

Leslie, Larry and Darrell R. Lewis. 2001. "Economic Magnet and Multiplier Effects of the University of Minnesota." Paper presented for sesquicentennial symposium, University of Minnesota, August 23, 2001.

Leslie, Larry and Shelia Slaughter. 1992. "Higher Education and Regional Development." In *The Economics of American Higher Education*, William E. Becker and Darrell R. Lewis (eds). Dordrecht, Netherlands: Kluwer Academic.

Macagno, Luis F., W. Burt Sundquist and Donald C. Rasmusson 1992. *Gains from Agricultural Research in a Multi-Market Framework: The Case of Malting Barley*. St. Paul: University of Minnesota Department of Agricultural and Applied Economics, IR-6 Information Report No. 92-1.

Mansfield, Edwin. 1991. "Academic Research and Industrial Innovation." *Research Policy* 20: 1-20.

Mansfield, Edwin, J. Rapopont, A. Romero, Evillani, S. Wagner and F. Husil. 1977. *The Production and Application of New Industrial Technology*. New York, NY: Norton.

Minor, Alan G. 1983. *The Contribution of Research to Soybean Yields.* St Paul, MN: University of Minnesota Department of Agricultural and Applied Economics, Staff Paper P83-8

Ruttan, Vernon W. 1992. *Technology, Growth and Development: An induced Innovation Perspective.* New York, NY: Oxford University Press.

Scherer, Fredrick M.1982. "Interindustry Flows and Productivity Growth." *Review of Economics and Statistics* 64: 627-634.

University-Wide Task Force. 1992. *The University of Minnesota as an Engine of Economic Growth.* Minneapolis, MN: Hubert H. Humphrey Institute of Public Affairs (the Schuh Report).