Technology Transfer and The University

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Abstract

This article contains a review of current thoughts on technology transfer and the role of the university in this process. Factors which affect the rate at which technology transfer takes place are briefly reviewed. Opportunities for universities to facilitate the process of technology transfer are discussed. The increasingly aggressive role being played by universities and the risks associated therewith are noted. The conclusion is reached that, with appropriate safeguards, benefits far outweigh the attendant risks.

Introduction

The economic health of the nation and of the world is a matter of great concern to political leaders, industrial leaders, labor leaders, and citizens of every description. Large amounts of resources are devoted to research and development efforts in the expectation of contributing to increased economic vigor. However, unless the results are disseminated through the process of technology transfer, the expectations will be largely unrealized. Therefore, the agencies of transfer are worthy of study. The purpose of this paper is to review some current thoughts on technology transfer and the role of the university in this process.

Background

Science encompasses the body of knowledge and understanding of how the universe functions. Science is, therefore, a very broad and inclusive concept. Technology, on the other hand, involves the application of science to the solution of practical problems and is, therefore, much narrower in scope. The state of technology existing at any given time is frequently conceptually defined in terms of a production function relating quantities of inputs to quantities of outputs.

Technological change is a complex dynamic process involving an advance of the science - technology base. Several activities have been recognized in the literature as having a part in technological change, namely, invention, innovation, and diffusion. Invention involves the generation of a new idea or technique and thus constitutes an advance in science. An innovation is the first application of an idea or technique to a commercially useful product or service. It can be thought of as the process of establishing a new production function and, thus, constitutes an extension of technology. Following innovation, the lengthy process of diffusion to other users commences. The subject of technology transfer encompasses innovation and the entire diffusion process. (Rosenberg, 1976, pp. 62-77; Gruber, 1969, pp. 255-282; Gee, 1974)

Importance of Technology Transfer

It is generally recognized that technological change is one of the most significant factors in determining the nature and course of the economy and social structure of this country. The Committee for Economic Development, an independent research and educational organization of two hundred business executives and educators, stated the case this way:

Firms that have invested heavily in developing technology and carrying it forward into commercial products have been shown to have about twice the productivity rate, three times the growth rate, nine times the employment growth, and one-sixth the price increases as firms with relatively low investment in these activities. This experience underscores how important technological progress can be to all American industry and to the achievement of some of this nation's most important social and economic goals.

It is vitally important that policy makers realize that the future quality of our lives is directly tied to the scientific and technological progress we make today. However, while praising its benefits, we also recognize its potential hazards. Great industrial and technical strides have sometimes caused pollution, new health problems, and social disruption. But if progress has brought problems - and it has - then the answer is not less knowledge, but more. Technology, properly directed, can help social policy deal with these problems, and it can increase benefit-cost ratios in the process. (CED, 1980, p. x)

It is clear that, if national goals of improved living

standards and increased national security are to be realized, it will be necessary to find ways to stimulate technological change. Technological change can become effective only through the process of technology transfer.

Factors Affecting Technology Transfer

A number of investigators have examined the technology transfer process and have commented on factors which influence the process. (Mansfield, 1968; Mansfield, 1977, Williams, 1967; Gruber, 1969) These factors can be segregated into four categories: characteristics of the receiver of the technology, characteristics of the technology itself, characteristics of the environment in which the transfer process takes place, and strategic factors. Any agency - governmental, educational, or independent - which wishes to establish a program to foster technology transfer must take these factors into account.

Characteristics of the Receiver

In order for technology transfer to take place, the receiver must be willing and able to adopt a new technology. Adoption of new technology entails a certain amount of risk. Characteristics of the receiver which have been studied in the context of technology transfer are related to the firm's ability and willingness to accept this risk. These characteristics include the size of the firm, rate of growth of the firm, level and trend of profit of the firm, liquidity of the firm, age of the firm's managers, organizational structure of the firm, and the firm's commitment to long run considerations as compared to short run results.

Characteristics of the Technology

In order to induce a firm to adopt a new technology, the firm must perceive benefits that will justify the risk involved in adoption. Consequently, characteristics of the technology that affect the rate of transfer are the amount of economic advantage of the new technology, the amount of uncertainty associated with the new technology, the expected rate of reduction of the initial uncertainty, the degree of commitment required to try the new technology, and the size of investment required.

Environmental Factors

Environmental factors that affect the efficiency of technological transfer include the degree of regulation of the flow of information, legal restrictions, political factors, size and rate of growth of the market, and the rate of return required by investors.

Strategic Factors

Any business firm must choose its strategy with care if it is to operate efficiently. Similarly, any agency which undertakes to stimulate technological transfer must give careful consideration to its strategy. No doubt, many strategic factors could be identified. Two examples will be mentioned.

A common deterrent to rapid diffusion of technology is insufficient attention to marketing principles. Development of a better way to do something is undertaken without consideration of whether there is a need for it. A new product should be "designed to satisfy a total need with some added value." (McKay, 1972)

Another factor to be taken into account is the technological gap between source and recipient. If the source and recipient entities are operating at similar levels of technology, there is not much to transfer. On the other hand, if the levels of technology are too widely separated, communication will be impeded and the technology will be too complex for the recipient to assimilate. (Boyle, 1986; Sharif, 1980)

The Role of the University in Technology Transfer

The classical conception of the university is that it is a place of contemplation from which new knowledge and ideas emerge and in which scholars are developed. However, as society has evolved, the university has attempted to adapt to the changing environment. Some critics are not pleased with the institution that has resulted. Solo notes,

"The university has come to be seen as a kind of manpower reserve that, through the pressures of sentiment or greed can be used for whatever expedience or social fashion demands." (Solo, 1972, p. 177)

Notwithstanding the criticism, there is good reason to believe that the university should expand beyond the classical ideal. It can perform valuable service by taking a more active role in an evolving society.

"In the modern world, the function of the university must surely be expanded far beyond the classical ideal. Its vision must encompass the creative thrust of science--based activities outside the academic domain. It has a role to play in the system of technological advance and in economic growth, in the process of social innovation and policy formulation and in other functional systems also." (Solo, 1972, pp. 177-178)

The university long has had a significant part in

technology transfer. It performed the relatively passive function of performing primary research to expand the base of scientific knowledge. The resulting new knowledge was disseminated through participation in conferences and publication of articles in journals. However, the mere transmission of knowledge does not necessarily result in expansion of the technology base. (Gold, 1977, p. 91) Therefore, to many, the traditional approach seemed to be out of tune with the fast pace of the modern world. Increasingly, universities are becoming actively involved in the actual process of technology transfer by negotiation of licensing agreements with manufacturers, establishment of subsidiaries to market new products, and by development of programs to encourage entrepreneurship among students and faculty members.

Licensing Arrangements

Recently, DuPont Co. negotiated a contract with the University of Houston under which they obtained rights to superconductor material developed by a research scientist at the university and under which they agreed to pay the University of Houston $4.5 million in three installments. (*Wall Street Journal*, August 24, 1988) At about the same time, in a less spectacular instance, scientists at the University of Arizona announced that a lotion designed to activate production of melanin when applied to the human body and thus induce a natural tan without exposure to the sun had been licensed by the university's agent to a major producer of dermatological products. (*Wall Street Journal*, August 26, 1988) While most such transactions do not attract the attention that these two did, these two instances are indicative of a growing trend among universities. The transactions may result from direct negotiations between the university and the manufacturer, as in the University of Houston case. More commonly, the agreement is reached through a technology broker, as in the University of Arizona case. A number of independent technology transfer companies (for example, Research Corporation and University Patents) deal exclusively in these types of activities. (Weiss, 1985) Some universities (for example, The University of Texas at Austin and Stanford University) have set up technology transfer centers which are devoted entirely to securing patents on developments arising from their research and to searching out investors. Companies typically receive about 40% of royalties for their efforts; the balance normally is divided between the university and the research scientist. (Weiss, 1985)

Smaller Universities are finding opportunities to participate, also. For example, Technology Transfer Conferences of Nashville, a nonprofit organization, arranges for regional conferences at which 9 or 10 universities of the region can showcase the results of their research. Some major corporations give the conferences good marks for permitting them a broad overview of university research. (*Chemical Week*, 1984)

Marketing Subsidiaries

While these licensing arrangements are often satisfactory, frustrations are frequently encountered. To circumvent such difficulties, some universities are attempting to take their ideas directly to market through special subsidiaries set up for this purpose. Notable examples include BCM Technologies, Inc., a subsidiary of Baylor College of Medicine, founded in 1983 for the purpose of commercializing the results of medical research; and University Technology, Inc., founded by Case Western Reserve for the purpose of marketing ideas from the university's medical and engineering schools. The University of Connecticut Research and Development Corporation has been established as a subsidiary of the University of Connecticut Foundation (technically independent of the university) to exploit research results from the University of Connecticut. (Weiss, 1985)

Entrepreneurship and Innovation

The link between entrepreneurship and innovation has long been recognized. (Schumpeter, 1939, pp. 87-109) Therefore, some universities have sought to foster technology transfer by setting up entrepreneurship programs. In 1973, the National Science Foundation initiated a program under which innovation centers were set up at three major universities: Massachusetts Institute of Technology, Carnegie-Mellon University, and the University of Oregon. Faculty members, community associates, and students participate in the projects which include formal classroom instruction in business and engineering subjects and actual clinical experience in generating ideas, developing new products, and initiating business ventures. In the first three years of the program, 24 new ventures, which employed almost 800 people, were undertaken. The 24 firms had introduced 27 new products. (Colton, 1979)

In Great Britain, the concept of a science park has been introduced and has generated a great deal of enthusiasm. According to the UK Science Park Association, a science park is a property based initiative having formal links with a university, designed to stimulate formation of knowledge based businesses, and with management actively engaged in the transfer of technology and business skills to the organizations on

site. The popularity of the concept is evident from the fact that, whereas there were only two science parks with about 30 companies and 400 personnel in 1982, there were 28 parks with over 400 resident firms employing more than 5300 people in 1986. The failure rate among these firms is unusually small (less than one-third the rate for all businesses) despite the preponderance of small start up firms. Heads of Science Park companies that were interviewed reported that "moving onto a Science Park had significantly improved the environment for generating ideas for new products" (Rowe, 1987)

Strategic Considerations

If the university wishes to make its technology transfer program as effective as possible, it is necessary to make the proper strategic choices. It has been suggested that how a technology, once developed, will be transferred must be considered right along with technical merit at the research proposal stage. This means that technology should be developed in such a way that it will be easily transferred, rather than developing a technology and then deciding how to attack the problem of transfer. Boyle states:

In the same way that a supplier needs to know the factors affecting demand for his product, a university must know why industry decides to use the R&D capability of the academic if it is to succeed in increasing the industrial relevance of its research output. (p. 41)

Ethical Issues

After reviewing these activities, it is easy to see why some people are concerned about the ethical dilemmas which may arise. Concerns have been expressed about incentives for scientific secrecy as opposed to the open communication that has been an academic ideal, incentives to select areas of investigation on the basis of likelihood of producing marketable ideas rather than on the basis of educational relevance, and bias in favor of applied research as opposed to basic research. However, most educators seem to feel that the benefits to society and the educational institution outweigh the drawbacks. Keith Brodie, president of Duke University, advocates development of specific written policies to guide faculty members, protect the university, and educate industry to the differences in the educational and industrial spheres of endeavor. (Mangan, 1987)

Conclusions

Technology transfer is a complex dynamic process through which new technological concepts are applied in commercial production. Technology transfer is fundamental to the development of society for it is only through advancements in technology that a society can more effectively use its resources. Many factors affect the rate at which this process of technology transfer takes place. These factors can be categorized as characteristics of the recipient of technology, characteristics of the technology being transferred, characteristics of the environment, and strategic factors.

Universities have long had an important role in the generation of new knowledge and a limited role in technology transfer. However, increasingly the university is playing a much more aggressive role in the transfer process. While this more aggressive role carries with it the risk that the university may at times be confronted with ethical dilemmas, the consensus is that, with appropriate precautions, the benefits far outweigh the risks.

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