Adoption of New Agricultural Technology: A Survey

By Seok-Jung Chang*

A great deal of research has been done on the diffusion and adoption of innovations.[1] The Diffusion Documents Center in the Department of Communication at Michigan State University maintains an inventory of current adoption studies, which by 1971 numbered over 1,500 publications (Rogers [14], p. 41). These adoption studies have been done in the fields of rural sociology, communication, anthropology, extension education, agricultural economics, marketing, *etc.* The types of innovations studies are also quite varied including teaching methods, medical drugs, agricultural technology, new products, city manager system, *etc.* A summary of the adoption research traditions and the main issues in the literature can be found in Rogers ([12], [14]), Katz *et al.* [6], Jones [5], and Lowdermilk [8]. Also, many of the empirical findings have been summarized in Lionberger [7], Rogers [14], Jones [5], and Lowdermilk [8].

Since the innovations investigated in the literature cited above are quite varied in nature, only studies of the adoption of agricultural technologies will be reviewed here with special emphasis on explanation of the differences in adoption among farmers.

Current interest in the adoption of agricultural innovation began in the early 1940's with a study of hybrid corn adoption by two rural sociologists, Ryan and Gross [16], and thereafter rural sociological research has dominated in the literature on the diffusion-adoption of new agricultural technologies.[2]

---

* The author is Councilor, Ministry of Science and Technology, Korea.
(1) Diffusion can be defined as the communication of information about the innovation, and adoption can be viewed as the mental process through which an individual passes in deciding to use it (see Coughenour [2], p. 6). However, the act of using an innovation has been generally taken by researchers as evidence of both diffusion and adoption. Thus, little attention has been given in most of the literature to this distinction between diffusion and adoption.
(2) See Rogers ([14], p. 54; [12], p. 32; [13], p. 27) and Jones ([5], pp. 1-3).

Ryan and Gross [16] investigated the diffusion of hybrid seed corn in two small Iowa communities, where hybrid seed was not available until about 1928 but was almost completely adopted by 1941. The major findings from their investigation are:

(1) Farmers did not adopt hybrid seed immediately upon hearing about it, and they did not turn their corn acreage completely to hybrid seed immediately after their initial adoption. The time period from first hearing to first use averaged roughly five years, and the period from first use to complete adoption required about three years.

(2) Most farmers first heard of hybrid corn from commerical salesmen but neighbors were most influential in leading them to adopt it. Different information sources were found to be important in the awareness-adoption process.

(3) All farmers did not adopt hybrid corn at the same time, but the adoption sequence of hybrid seed in these communities followed a bell-shaped pattern.

Although Ryan and Gross found that the initial adoption of hybrid corn was quite different among farmers, no analysis was offered to explain why some farmers are earlier adopters and others are later adopters. They observed that the median share of corn acreage under hybrid seed for the farmers first using hybrids in 1934 amounted to only 20 percent of their total corn acreages for that year and, thereafter, 29, 42, 67, 95, 100 percent for the following years from 1935 to 1939. Thus five years after initial use were required to reach a 100 percent use. They interpreted this time span as a personal experimentation period before complete acceptance, even though the partial use of hybrids in the farmer's corn acreage was often too large to represent a trial. In fact, the share under hybrid corn must be determind by the same factors that determine the final adoption decision. These levels of use involve more than a trial to obtain information.

The Ryan and Gross investigation of the adoption of hybrid seed corn was so influential for later studies by rural sociologists that it led them to lay primary stress on the role of communication channels and the investigation of farmer characteristics to explain variation among farmers in adoption of agricultural innovation.

Rogers [12] subsequently published a book, *Diffusion of Innovation*, in

which he generalized previous research findings and synthesized theories on the adoption and diffusion of innovations. He classified all individuals in a social system into five categories of innovativeness (innovators, early adoptors, early majority, later majority, laggards) according to their time position when they first begin using an innovation. Innovativeness is viewed as a generalized behavioral trait, i.e., the propensity of an individual to be relatively early in his adoption of innovations compared to other members of his social system. Thus, the individual who is late in adopting one innovation is assumed to be late in adopting other innovations. Following the empirical finding of the bell-shaped distribution of individuals in the adoption sequence, his classification is shown in Figure 1. [3]
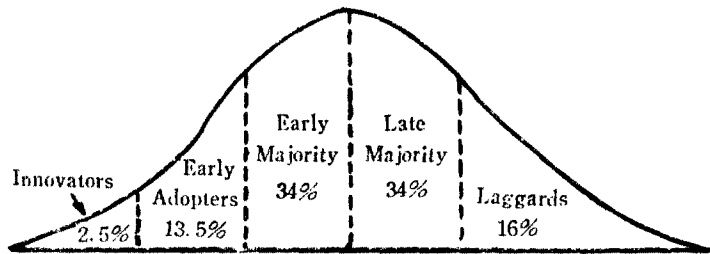

Fig. 1. Categorization of adopters

Rogers concluded that innovativeness is correlated with such variables as (1) personal characteristics (age, social status, financial position, mental ability, etc.), (2) communication behavior, and (3) social relationship. He argued that, on the basis of these variables, one can predict the innovativeness of an individual and forecast an individual's adoption behavior. Thus, the variation in adoption among farmers is attributed to differences in the behavioral trait, the innovativeness of individul farmers, which can be related to characteristics of farmers. However, this approach, which has been the most popular analytical approach to adoption in rural sociology, has been criticized by rural sociologists themselves. A number of studies have been done to find the characteristic variables related to innovtiveness, but the findings are not unanimous. [4] Lionberger [7] (p. 110) objected

---

(3) Rogers [12] (p. 154) said, "It has generally been found that many human traits are normally distributed, whether the trait is a physical characteristic such as height or a behavioral trait such as the learning of information. Hence, a variable such as degree of innovativeness might be expected to be normally distributed also."

(4) See Lionberger [7] (pp. 96-102) and Rogers [12] (pp. 171-183).

that, without a more fundamental basis of explanation, "We shall probably continue to talk of differences in findings, which tell us almost nothing about the reason why the differences exist."

Like most adoption researchers in rural sociology, Rogers ignored the possibility that the profitability of a given innovation may differ among farmers and therefore may cause differences in adoption among farmers. He did, however, mention that the different rates of adoption among different innovations are determined by the characteristics of each innovation such as relative advantage, compatibility, complexity, divisibility, and communicability (Rogers [12], p. 146). Rogers assumed that all characteristics of an innovation are intrinsic, whereas in fact the relative advantage (profitability) depends upon the particular situation of the potential adopter.[5]

Rogers specified five stages in the adoption process through which an individul passed from first hearing about an innovation to final adoption. These stages are given as awareness, interest, evaluation, trial, and adoption (Rogers [12], p. 81). At the awareness stage the individual is exposed to the innovation but lacks complete information about it. He then becomes interested in the innovation and seeks information about it at the interest stage. At the evaluation stage the individual mentally applies the innovation to his present and anticipated future situation, and then decides whether or not to try it. The individual uses the innovation on a small scale in order to determine its utility in his own situation at the trial stage. At the adoption stage the individual decides to continue the full use of the innovation.

Like Ryan and Gross, Rogers viewed the partial use of the innovation before full use as the trial in order to determine the usefulness for its full use. When he argued that an individual uses an innovation on a small scale to make a decision about full use, he passed by the fact that the scale of partial use is often too large to be considered as just a small scale trial, and therefore the differences in the scale of partial use, as well as the differences in first use or in complete use, of an innovation among farmers require explanation.

(5) Coughenour [2] (p. 9) discussed the importance of distinction between the intrinsic and the extrinsic characteristics of an innovation in relation to its adoption.

An alternative approach has been followed by Griliches [4] in analyzing the differences in adoption of hybrid corn among various areas in the United States. To characterize the marked geographical differences in the development of hybrid corn adoption, he reduced differences among areas to differences in the date at which an area began to use, the rate of acceptance, and the long-run equilibrium percentages of the corn acreage under hybrid corn.[6]

The differences among areas in the date of initial adoption of hybrid corn were explained by the differences in the availability of hybrid seed ("supply conditions"). The differences among areas in the long-run equilibrium use of hybrid corn acreage as a percentage of total corn acreage and in the rate of approach to that equilibrium (rate of acceptance) were explained on the basis of differences among areas in profitability of the shift from old varieties to hybrid varieties ("demand conditions").[7]

The most important conclusion in his study is his finding that the profitability of a given innovation, such as hybrid corn, varies with the particular situation of the potential recipients (adopters), there by causing differences in adoption among regions and also among farmers within a region.

Griliches [4] (p. 522) concluded:

> On the whole, taking account of uncertainty and the fact that the spread of knowledge is not instantaneous, farmers have behaved in a fashion consistent with the idea of profit maximization. Where the evidence appears to indicate the contrary, I would predict that a closer examination of the relevant economic variables will show that the change was not as profitable as it appeared to be.

While he emphasized profitability, he paid little attention to the fact that risk may also be an important factor affecting a farmer's decision to adopt an innovation. Farmers' behavior under uncertainty may be consistent with the predictions of a utility maximization model but may not necessarily be

---

(6) Logistic growth functions are fitted to data by areas and the three parameters of the logistic are estimated; origins, slopes, and ceilings. These correspond to the beginning data of use, the rate of acceptance, and the equilibrium percentage of use of an innovation, respectively.

(7) Mansfield [9] also found that differences in rate of adoption among twelve different innovations were positively related to differences in their profitabilities.

consistent with the predictions of a profit maximization model. Under the hypothesis of profit maximization, it is difficult to explain why a farmer uses both varieties, traditional varieties and new hybrid varieties, at the same time for several years and why his acreage under hybrid corn ranged from 10 to 90 percent of his total corn acreage.

Another hypothesis to explain the differences in adoption of an innovation among individuals suggested by Nelson and Phelps [10] (p. 69) is that "education enhances one's ability to receive, decode, and understand information" so that "the more educated a manager is, the quicker will he be to introduce new techniques of production."[8] They presented evidence for this hypothesis in the empirical findings of rural sociologists' works[9], where the education level often has been found positively related to earlier adoption of an innovation. Under this hypothesis, differences in adoption of an innovation among farmers are attributed in part to the different amounts of information about an innovation farmers have acquired because of their different abilities. Although Nelson and Phelps did not rigorously explain the role of information in the adoption decision, their point is important in understanding differences in adoption among farmers.

Although risk (or uncertainty) has been often mentioned in the adoption studies, there has been a notable absence of theory to conceptualize the role of risk in explaining the adoption of an innovation.

Schultz [18] (p. 167) mentioned that:

> The true yield variability of the new factor…will not be known, while that of the old factor is well known from experience over many decades. Thus there would be inherent in the prospective yield of the new factors these new elements of risk and uncertainty. They must be taken into account in determining profitability.

But he did not go further to explain how risk can be included in determining profitability and how it affects through this the acceptance of a new factor.

---

(8) Welch [20] further generalized the effect of education on a production activity as consisting of a "worker's effect" and an "allocation effect." The worker's effect refers to technical efficiency, more output from a given bundle of inputs. The allocative effect means the improvement of allocation of inputs and outputs on the assumption that education increases the ability to acquire, decode, and sort market and technical information.

(9) Nelson and Phelps refer to E.M. Rogers, *Diffusion of Innovation* (1962), Chapter 6.

In the study of Mayan corn farmers in Mexico, Cancian [1] (p. 6) argued that "because of the uncertainty about outcomes of new activities, the economic man model cannot provide a complete framework for description," and tried to show that "the differences between Zinacantecos who took up the new practices relatively quickly and those who did not can be explained—in part—by a general theory of differential response to uncertainty." He presented a theory relating the individual's rank in a social stratification system to the inclination to take risk.[10] In his analysis, he defines similar attitudes toward risk by assuming that equal risk, for persons of different ranks, is represented by the investment of an equal proportion of the total resources of each person under conditions of equal uncertainty (Cancian [1], p. 137). But this definition makes it difficult to explain differences in adoption of a specific size of innovation using his theory because the risk will be proportionately less for a rich than a poor farmer. Thus, in his analysis it is not possible to conclude whether differences in adoption are due to different attitudes toward risk or due to the different level of risk.

Gerhart [3] also hypothesized that the adoption of hybrid maize seed in western Kenya is related not only to the profitability of the innovation but to the uncertainty of its success. He argued, "The continued presence of drought-resistant crops in the crop mix of certain areas but not in others is most probably due to risk-aversion action rather than taste preference," (Gerhart [3], p. 130). Thereby, he tested whether the adoption of hybrid maize was related to the presence of drought-resistant crops in the maize field, as a variable representing a risk-averting action. Based on his finding of a negative and significant relationship between them, he concluded that the farmer's perception of risk is an important negative influence on adoption. In his analysis, he was not able to distinguish between the effect of risk-aversion and the effect of risk perception on adoption. Therefore, his conclusions were vague as to whether differences in adoption are due to differences in risk aversion or due to differences in the perceived risk.

In a study of Philippine rice-farmers, Roumasset [15] was interested in testing the hypothesis that risk inhibits the adoption of new technologies

---

(10) His theory proposed the negative relationship between the individual's rank and the inclination to take risk, which is contrary to one in Rogers [12].

by small farmers. The main focus was on the level of fertilizer use in relation to risk. He developed two "safety-first" lexicographic models in which farmers are assumed to have security as the first goal and expected profits as the second. However, he found that farmers' behavior was not consistent with that predicted by the "safety-first" rules. Although his conclusion that risk does not affect the decision to use fertilizer does not necessarily follow from this finding, he distinguished conceptually between risk per se and farmers' attitudes toward risk in building his models.

In other studies such as Tinnermeier [19], Yudelman *et al.* [21], Schluter [17], and Peacock [11], the importance of risk in adoption also was mentioned but rigorously specified models were not developed and used in the analysis.

As indicated in this brief review, each theoretical approach has emphasized rather different factors that may lead to differences from farmer to farmer in adoption of an innovation. However, no efforts have been made to integrate these factors into a general theory which explains why and how these factors affect adoption, as they have been observed to do. Since the adoption of an innovation requires a decision by an individual, it is suggested that the explanation of differences in adoption of an innovation among farmers should begin with a clear conceptualization of the objectives of farmers, the variables influencing these objectives, and how they are functionally related to the adoption decision. Few such attempts have been made.

References

[1] Cancian, F., *Change and Uncertainty in a Peasant Economy*, Stanford University Press, Stanford, California, 1972.

[2] Coughenour, C.M., "Some general problems in diffusion from the perspective of theory of social action: Diffusion research needs," *Bulletin SR* 89(1968), University of Missouri Agricultural Experiment Station, Columbia, Missouri.

[3] Gerhart, J.D., *The diffusion of hybrid maize in western Keyna*, Unpublished Ph. D. thesis, Department of Economics, Princeton University, Princeton, New Jersey, 1974.

[4] Griliches, Z., "Hybrid corn: An exploration in the economics of technological change," *Econometrica*, 25(1957), 501-522.

[5] Jones, G.E., "The adoption and diffusion of agricultural practices," *World Agricul-*

tural Economics and Rural Sociology Abstracts, 9(1967), 1-34.

[6] Katz, F., M.L. Levin and H. Hamilton, "Traditions of research on the diffusion of innovation," *American Sociological Review*, 28(1963), 237-252.

[7] Lionberger, H.F., *Adoption of New Ideas and Practices*, The Iowa State University Press, Ames, 1960.

[8] Lowdermilk, M.K., *Diffusion of dwarf wheat production technology in Pakistan's Punjab*. Unpublished Ph. D. thesis, Department of Education, Cornell University, 1972.

[9] Mansfield, E., "Technical change and the rate of imitation," *Econometrica*, 29(1961), 741-763.

[10] Nelson, R.R. and E.S. Phelps, "Investment in humans, technological diffusion, and economic growth," *American Economic Review*, 56(1966), 69-75.

[11] Peacock, D.L., *The adoption of new agricultural practices in Northeast Brazil: An examination of farmer decision-making*, Unpublished Ph. D. thesis, Department of Agricultural Economics, Michigan State University, 1972.

[12] Rogers, E.M., *Diffusion of Innovation*, The Free Press, New York, 1962.

[13] Rogers, E.M. "A communication research approach to the diffusion of innovation: Diffusion research needs," *Belletin* SR 89(1968), University of Missouri Agricultural Experiment Station, Columbia, Missouri.

[14] Regers, E.M., *Communication of Innovations*, The Free Press, New York, 1971.

[15] Roumasset, J.A., *Risk and choice-of-technique for peasant agriculture: The case of Philippine rice farmers*, Unpublished Ph. D. thesis, Department of Economics, University of Wisconsin, 1973.

[16] Ryan, B. and N.C. Gross, "The diffusion of hybrid seed corn in two Iowa communities," *Rural Sociology*, 8(1943), 15-24.

[17] Schluter, M., *Differential rates of adoption of the new seed varieties in India: The problem of the small farm*, Occasional Paper No. 47, Department of Agricultural Economics, Cornell University, Ithaca, New York, 1971.

[18] Schultz, T.W., *Transforming Traditional Agriculture*, Yale University Press, New Haven, Connetticut, 1964.

[19] Tinnermeier, R., "Technology, profit and agricultural credit. Small Farmer Credit Analytical Papers," *AID Spring Review of Small Farmer Credit*, SR 119, Agency for International Development, Department of State, Washington, D.C., 1973.

[20] Welch, F., "Education in production," *Journal of Political Economy*, 78(1970), 35-59.

[21] Yudelman, M., G. Butler and R. Banerrji, *Technological change in agriculture and employment in developing countries*, Development Center Studies Employment Series No. 4, Development Centre for the Organization for Economic Co-operation and Development, Paris, France, 1971.