[11] ——— , "The Demand for Money in the United States Yet Again", University of Western Ontario, mimeo, 1979.

[12] LIEBERMAN, Charles, "The Transactions Demand for Money and Technological Change", *Review of Economics and Statistics*, Vol. 59, August 1977.

[13] ——— , "The Long-Run and Short-Run Demand for Money, Revisited", *Journal of Money, Credit and Banking*, Vol. 12, Feb. 1980.

[14] McCLEAN, A. Wendell A., "The Stability and Predictive Efficiency of the Traditional Money Multiplier in the Jamaican context: A Comment on Bourne's Analysis", University of the West Indies, Cave Hill Campus, *Social and Economic Studies*, Vol. 30, Sept. 1981.

[15] MEYER, Paul A. and John A. NERI, "A Keynes-Friedman Money Demand Function", *American Economic Review* Vol. 65, September 1975.

[16] RAMA SASTRY, A.S., "The Effect of Credit on Transactions Demand for Cash", *The Journal of Finance*, Vol. 25, September 1970.

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Adoption of Agricultural Technology: Developments in Agro-socio-economic Thought

ABSTRACT

The evolution of socio-economic thought concerning the diffusion of innovations started with a debate about the relative importance of social and economic factors in the adoption of hybrid corn and hybrid sorghum in the United States during the 1928-1941 period. Sociologists and economists agreed that an array of factors, not too well understood, and varying from one farm and farm area to another, stimulate adoption.

The literature on the Green Revolution of the 1960s had added new dimensions to the debate by considering not only adoption and production, but a host of other conditions such as markets and income distribution. The very nature of the adoption process tends to favour early adopters with favourable social and economic characteristics. Those less fortunate fall behind because they are unable to assume the added production costs and the risks associated with the potentially higher returns from the new technology.

These new findings point to the necessity of formulating technological packages based on integrated socio-economic research where the entire decision environment of the farmer is considered.

INTRODUCTION

Rapid and sustained increases in agricultural productivity and production have been the primary goals for programmes designed to develop agricultural technology and to stimulate producers in adoption of the technology. This condition was the cause and consequence of diffusion of hybrid corn and hybrid sorghum in the United States during the 1928-1941 period. A controversy among social scientists concerning whether adoption was a result of economic or social stimuli followed the U.S. hybrid diffusion experience. More recent experience in the 1960s following development of the high-yielding wheat varieties at CIMMYT in Mexico and the rice varieties developed at IRRI in the Philippines parallels the early experience and controversy. Production potentials for a 'green revolution' clearly superseded the socio-economic absorption capacity of many agricultural sectors to effectively benefit from the potential. The capacity of social scientists and planners to understand and help direct the process is still not in place.

Although the diffusion causality argument in the U.S. might be declared 'a draw', recent research activity in LDC's has stimulated a need to return to the basic elements of the debate. The purpose of this paper is: (1) to review diffusion thought concerning the U.S. 'green revolution' (2) to reflect on the debate between the economists and sociologists relative to past U.S. experience and present international experience in adopting hybrids and improved varieties; and (3) to consider the broad group of integrated phenomena that influence adoption of green revolution technology. The paper, while reviewing some important literature, is not a complete assessment of the entire subject matter area; instead, it links social-science thought concerning the early professional concerns to recent experience as a basis for more fully understanding agricultural research and extension needs at present.

DIFFUSION OF CORN AND SORGHUM HYBRIDS IN THE UNITED STATES

Diffusion of hybrid seed corn and sorghum in the U.S. agricultural sector did not alone stimulate major socio-economic changes. Yet the combined effects of this technology with many other farm innovations and demand stimuli did rapidly accelerate agricultural productivity and ultimately agricultural production of grains and livestock. With Ryan and Gross, hybrid seed corn became a classic example of diffusion in agriculture and other disciplines [21]. Their work, more than any other, influenced the methods, findings, and interpretations of rural sociologists while calling forth a response from the economists. Had it not been for their work, the present discussion might have followed a different pattern.

Hybrid Adoption: Social Stimuli

The unique setting for the diffusion of hybrid seed corn included the years from 1928 to 1941. Depression in the world and national economy during the 1930s, drought throughout the North American mid-west in the mid 1930s and the war in Europe changed the effective supply and demand for agricultural commodities. Most critics assume that such conditions have some bearing on the diffusion of agricultural innovations. But Ryan and Gross remark that, even with these, the rapid spread of hybrid seed was remarkable given the slowness with which many sound economic practices are accepted.

The principal characteristic of the adoption process, set forth by Ryan and Gross [23], was that first use of hybrid seed corn by the entire producer group followed approximately a bell-shaped or normal distribution. In fact, two similar distributions prevailed, one for knowledge of the innovation and another for first use of the innovation with the latter lagging the former by seven years. Based on these observed distributions, Ryan and Gross described the *inter-*

active effect as a process through which individuals in a social system who have adopted an innovation influence those who have not yet adopted [21]. More recent research has attributed adoption of innovations to the interaction effect and social congruence [14].

Awareness, trial and adoption were designated as three important and distinguishable stages in the adoption process. Although the duration of the community adoption period was about 14 years, the typical individual took nine years to pass from awareness to adoption (first use). In general, cosmopolite information sources were most important for the earliest adopters and interpersonal information sources were more important than personal sources for early adopters than for later adopters. But no matter how convincing interaction and social congruence conditions were in adopting hybrid seed, most farmers insisted on personal experimentation before full use of the innovation. Ryan and Gross presented other implications, both that elicited and enhanced further research on diffusion of innovations.

Hybrid Seed Research: Economic Stimuli

Griliches' [12, 13] work is not diametrically opposed to that of Ryan and Gross. However, it did engender, in the eyes of rural sociologists, some injustice to sociological considerations within the diffusion process. Griliches [12] attempted to determine the realized social rate of return on public and private funds invested in hybrid corn research up to 1955. He further explained the adoption rate of hybrid corn by the profit motive.

The study revealed spectacular social and economic returns on investments in hybrid seed corn research. Estimates using an external rate of interest reveal that a dollar invested in hybrid corn research earned 10 cents annually from 1910 to 1955 and $7 annually thereafter. The internal rate estimate indicated that the dollar earned 40 cents annually throughout the entire period. With these and other

findings as background, Griliches discusses profitability as the major determinant of adoption. Profitability was defined as a net return differential, where net returns for open-pollinated seed corn were subtracted from net returns for hybrid seed corn.

Griliches [12, p. 522] stimulated a lengthy debate as he summarized his work by stating:

> It is my belief that in the long run, and cross-sectionally, these variables (sociological variables) tend to cancel themselves out, leaving economic variables as the major determinants of the pattern of technological change. This does not imply that the sociological variables are not important if one wants to know which individual will be first or last to adopt a particular technique, only that these factors do not vary widely cross-sectionally.

He explained about 60 per cent of the variation in the rate of adoption of hybrid corn by the profit motive, thereby releasing a storm of social congruence versus profitability controversies. Griliches [11] later retracted slightly from his strong position, yielding to the pressure of evidence that the rate of adoption of hybrid corn was not explained entirely by economic behaviour.

Conflicting Concepts and Interpretations

Bradner and Straus discussed adoption of hybrid sorghum for the state of Kansas. They argue that the likelihood of technological innovations being accepted is enhanced when these innovations are related to an existing cultural pattern. Concerning Griliches' earlier statement on the importance of profitability in the adoption rate of hybrid corn and sorghum, Bradner and Straus [3] wrote: "In such a conceptualization of the change process, factors such as socioeconomic status, economic resources and group and individual values tend to be seen merely as auxiliary inhibitors or facilitators of the change process" (p. 381).

According to Bradner and Straus, contrary to 'economic need' (a vague use of the term) and contrary to extension service advice, the use of hybrid sorghum diffused more

rapidly in northeastern than southwestern Kansas. Southwestern Kansas, being less humid than northeastern Kansas, is a wheat-sorghum area, whereas the latter is mainly the Kansas corn belt. Thus, sorghum has greater economic importance in southwestern Kansas. It was recommended by the Kansas experiment station that hybrid sorghum not be planted in northeastern Kansas because of possible lodging. Bradner and Straus [3, p. 383] concluded that:

> If economic need determined the rapidity of adoption of hybrid sorghum, the higher rate of adoption would have been in the southwestern sorghum area rather than northwestern corn area. Bearing in mind that these data refer to only one state and one year, the following tentative conclusions emerge: (1) Familiarity or congruity of the new practice with the recently accepted practice of planting hybrid corn probably accounts for the dramatically higher acceptance of hybrid sorghum in the hybrid corn area. (2) Even in a technologically advanced society which places high value on economic gain, congruity is a basic element in the diffusion process and in the present case even appears to have been of greater relative importance than was economic need.

As might be expected, Griliches [11, p. 354] responded to these claims with vigour, stating:

> I would like to point out, first, that the diffusion pattern of hybrid sorghum in Kansas is very much what my study would have predicted and second, that 'congruence' and 'profitability' are not and should not be alternative and mutually exclusive explanations of the same behavior.

The crux of the debate is that sorghum production in southwestern Kansas when compared to the northeastern areas has the least comparative disadvantage. Within the southwestern area wheat holds a comparative advantage over sorghum as does corn in the northeast; but sorghum production in the northeast holds an absolute advantage over sorghum in the southwest. Griliches implied that profitability was an absolute comparison between the old and new variety for each area of the status. The Bradner-Straus argument is based on the very different concept of 'economic need' which implies economic welfare considerations.

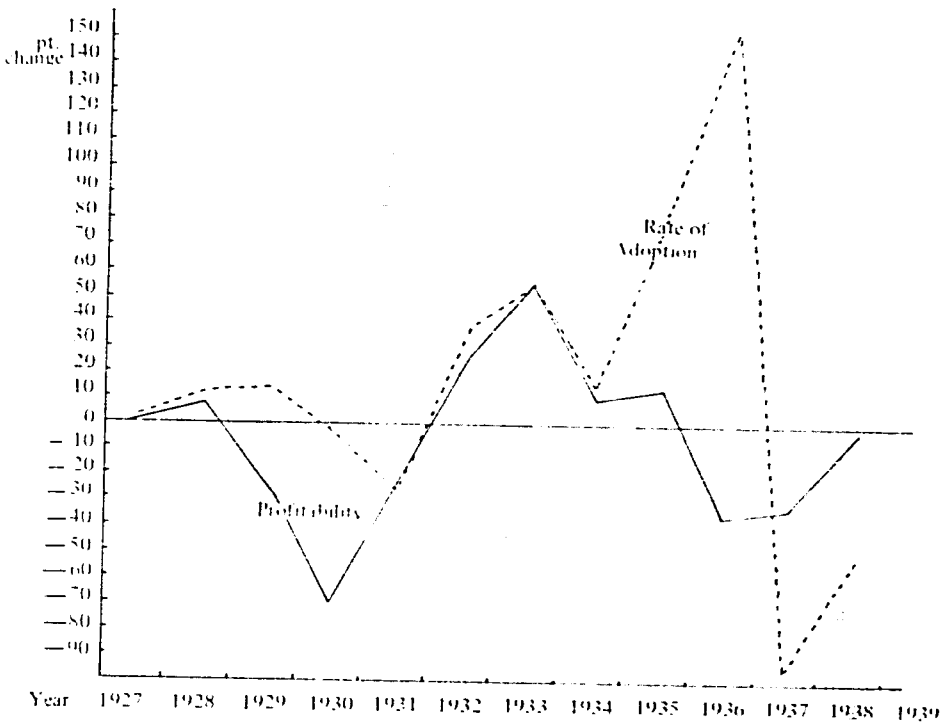
Havens and Rogers [14, p. 410] believed "that once an innovation has fulfilled the minimum considerations of profitability, it is largely the amount of *interaction* between individuals who have and have not adopted an innovation that determines the ratio of adoption for individual farmers". They defined interaction as the cumulative percentage of adoption and concluded that:

> . . . what really determines the rate of adoption of an innovation is the adopters' perception of profitability and not objective profitability. There is a vast tradition of social psychology research which indicates the importance of *group interaction* in determining the selectivity of perception, including perception of profitability [p. 410].

Reflections on the Debate

When studied, profitability and the interaction effect can provide evidence of the joint impact of social and economic factors on the adoption process. Figure 1 does that for the hybrid corn case in the U.S. during the 1927-39 period by means of the percentage point change. Percentage point change in profitability was determined by converting each profitability value to a per cent of the mean ($2.34) for the 1927-39 period and specifying the year to year differences in the values. Percentage point change in rate of adoption was determined by computing the per cent each annual difference in the cumulative adoption figure is of the mean (7.1) for the 1927-39 period and specifying the year to year differences in these values. Figure 1 shows that the direction of change in the adoption rate of hybrid seed corn lagged behind that of profitability by one year from 1928 through 1932. The lag might be explained by perceptive profitability and a 'cob web' production response. Corn producers expected next year's profits to be low also, so that potential profit differentials between open pollinated and hybrid corn were not sufficiently large to cover the risks associated with change and to induce an increased rate of adoption. Stimulating this situation was the depression which

FIGURE 1: GRAPHIC COMPARISONS OF ANNUAL CHANGE IN PROFITABILITY AND ADOPTION OF HYBRID CORN IN THE U.S. 1927–39



	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
Yield/ Acre	26.6	26.6	25.7	20.5	24.1	26.5	22.6	15.7	24.6	16.2	28.1	27.7	29.2
Price/ bu. Chicago	1.00	.93	.84	.62	.36	.34	.50	.86	.74	1.21	.57	.48	.54
Profit-ability	3.38	3.36	3.58	2.88	1.25	.69	1.31	2.60	2.82	3.15	2.32	1.55	1.47
Cum.% Adopt	.3	.7	2.0	4.2	6.1	6.1	8.8	15.4	23.1	36.6	61.0	78.7	92.6

caused corn prices and profits to decline sharply until 1933 and 1934. We might have expected the rate of adoption to increase during this period if the interaction effect had been most important.

Fluctuations between 1932 and 1935 indicate that the forces of interaction and profitability achieved equilibrium. Introduction of the Agricultural Adjustment Act (AAA) and severe drought served as stabilizers of perceived price conditions. Then in 1934 and 1935, with high yields per acre and relatively stable prices, compared to the depth of the depression in 1931 and 1932, absolute profitability was fairly high. Expectations were good and risk concerns were less restrictive. The interaction effect reached a 'take off' which was again enhanced in 1936 by high prices and profitability. Interaction and profitability were no longer in equilibrium such that increased adoption of hybrid corn resulted in declining profitability; recent adopters were absorbing part of the windfall gain that had accrued to producers of hybrid seed from 1934 to 1936. Also, depressed economic activity at the national level helped to deflate prices during this period. The decline in rate of adoption from 1937 to 1938 partly resulted from a decline in perceived profitability but was inevitable due to the reduced number of potential adopters remaining. Yet without the decline in profitability we might have expected the change in rate of adoption in 1938 to be above that of 1939 so that the decline would not have been so abrupt.

Concluding that either interaction or perceived profitability caused adoption seems unreasonable. Both were important. But other variables such as weather, price uncertainty and agricultural policy were conducive to influence decisions about adoption. Farmers consider the impact of innovations on their combined socio-economic positions. For example, relative advantage, compatibility, complexity and divisibility of an innovation are important sociological con-

siderations [Rogers 21, pp. 124-134] with parallel agricultural economic concerns. These economic considerations include comparative advantage, scale and biological feasibilities, coordination of input and product markets with complex production systems, and the opportunity to diversify or spread risk associated with changing from known to relatively unknown technologies.

External conditions, both social and economic, influence individuals' attitudes toward innovations. Ryan and Gross [23, p. 16] explain this influence when stating that "the intensity of the latter (influences and incentives) is affected by knowledge of precious acceptances, especially when the various acceptors are competitors and the trait raises the general productive level". Consequently, losses and windfall profits are important in the decision-making process as agricultural producers consider technological change.

The qualification of objective and perceptive profitability raised by Havens and Rogers should be emphasized because these concepts are linked to present conceptualizations concerning adoption of improved technologies by small farmers. That is, the qualification relates directly to risk perception and risk aversion, two conditions not emphasized in the early debate.

HYBRID ADOPTION GOES INTERNATIONAL

Extensive national debate concerning the relative importance of influential socio-economic factors in the adoption process for hybrids evolved prior to introduction of the 'green revolution' to world agriculture. Recent discussions concerning this dilemma are particularly important and relevant to problems that have resulted from significant increases in agricultural technology, yields, and production. The dilemma is particularly acute with respect to distortions in rural income distribution, intensified rural poverty, rural to urban migration, and urban unemployment and poverty.

The Adoption Process Revisited

Economists persist in trying to explain the economics of the adoption process as a key to better understanding the performance of the world agricultural sector. Kisley and Shchori-Bachrach [16] have recently presented an economic theory of the process of diffusion of innovations. Determined by comparative advantage considerations, an innovation is first adopted by skilled and experimenting entrepreneurs who then pass the skills down to smaller scale firms. An 'innovation cycle' is produced by the exit of early skilled producers when prices decline due to substantial supply increases. They also suggest that technological change is affected by the distribution and the average level of skill. Dalrymple [6], however, questions the scant attention given to many factors other than human skills involved in the innovation cycle. These factors include characteristics of the adopter, the nature of the technology, profitability and the nature of the economy. He also questions the fact that no consideration is given to variations in the basic factors of production.

Hiebert [15] has tested a model of new seed adoption by examining the effect of 'learning' under uncertainty on the decision to adopt fertilizer responsive seed varieties. He empirically validates Griliches' early findings showing that the rate of adoption is directly related to the profitability of adoption [12]. Using data from rice growers in the Philippines, Hiebert concludes that farmer skills, information transmitting activities, and physical environment are important determinants of the likelihood that he will adopt high yielding seed varieties.

Attention to the entire family and farm household impact on the adoption process is recent and quite meaningful given the subsistence nature of many low income farm areas in LDCs. A model of the peasant household has been developed by Beniot where different factors hypothesized to

explain peasant adoption are condensed in a linear programming framework and applied to the Puebla area in Mexico. Opportunity costs of time and uncertainty seem to explain the observed low adoption rates and peasant participation in modernization projects. After challenging the view that labour-using technologies *per se* will rapidly increase agricultural production, he emphasizes the complimentarity between organization and communication in diffusion processes. Rochin [22, p. 188] also supports the household labour restriction hypotheses by indicating that "there is considerable reason to believe that in many instances labor may be the more immediate constraint of innovations".

But possibly most effective in explaining adoption behaviour are those studies now attempting to understand the complex role of risk associated with innovation. Perrin and Winkelmann [19] have summarized recent findings of farm-level studies on the adoption of new wheat and maize varieties including fertilizer use with respect to impediments to farmer adoption of new varieties. Adoption studies conducted by CIMMYT and encompassing countries as diverse as Kenya, Colombia, El Salvador, Mexico, Tunisia, and Turkey show that, to a limited extent, differences in farmer adoption behaviour can be explained by differences in information, in the availability of inputs, in market opportunities for the crop, and differences in farm size and farmer risk aversion or risk perception. The latter variable has been used in other economic models [Gould 10, Moscardi 17, O'Mara 18] and in a sociological model [Cancian 4] relating stratification to risk-taking in agricultural innovations. Further research is needed, however, to better understand perceived risk aversion thresholds relative to varied types of innovations and the relative costs combined with profit and loss probabilities related thereto.

An Impact of Green Revolution Varieties in LDCs

New seed varieties intended for developing countries, coming from CIMMYT in Mexico and IRRI in the Philippines, fomented considerable enthusiasm for a green revolution in world agriculture. The early literature expressing hopes and desires is extensive and well known. Now, however, socio-economic concern is both with the adoption process and the social and economic impact of productivity advances.

Recent studies have provided less impressionistic assessments of the green revolution. The dust raised by enthusiasm had not settled when Falcon advanced his concern about the resulting production, marketing, and income distribution problems associated with introduction of advanced agricultural technology in LDCs. Dalrymple [7] comparing trends in grain area and yield in developed and developing nations for the period 1948-52 through 1967, concludes that, in terms of production in developed nations, area has remained fairly constant and yield accounts for virtually all of the increase. The increase in developing countries, however, has resulted from a combination of changes in area and yield.

Success in production with improved varieties has required adaptive research to meet regional and local production differences. Evenson [8, p. 393] affirms that "while the high yielding varieties did contribute very significantly to increased production, they were by no means the sole source of productivity gains in LDC agriculture". According to him, new varieties contributed about one-fourth of total growth while indigenous research discovery and regional or borrowed research discoveries equally accounted for the remaining growth. It could be add[illegible] relative to indigenous research discovery that the extent to which the new technology is truly adapted to small farm situations or existing cultural patterns in terminology used earlier by Bradner and Straus, determines the degree to which socio-economic benefits and co[illegible]s are evenly distributed throughout the country.

Purvis reached conclusions similar to those of Evenson after studying the impact of the new varieties under Tunisian dryland conditions. Increased productivity of the new wheat varieties has been about one-third greater than for the existing established varieties. Since high average yields were obtained on small farms, the new seeds will have to be adapted to the resource conditions of that sector. If not, further productivity increases will require large-scale investments in machinery and consolidation of small farms into larger farms more suitable for mechanization. The green revolution under dryland conditions, Purvis [20, p. 56] concludes, "may be slower and even more costly economically, socially, and politically than under irrigated conditions for which the new varieties were originally developed".

With indigenous research, discovery and adaptation, risks associated with adoption can be reduced and so can social adjustment problems particularly related to income distribution and unemployment. In analyzing the impact of new wheat varieties in the Indian Punjab, Sidhu affirms that the technical change has not gone in either the labour or the capital-saving direction but has resulted in cost-saving of about 25 per cent per acre due to an increase in use of well developed inputs. This then requires well developed input distribution systems again to reduce risk associated with use of improved varieties. In the flurry of activity associated with production research and adoption, the importance of input markets may be overlooked.

Some economists go on to argue that world agriculture must be mindful of the over-production trap resulting from green revolution agriculture. Canterberrry and Bickel [5] are concerned not with widespread starvation, but with a potential grain glut on world markets. Their concern, while expressed prior to the recent grain shortages, stems from rice productivity increases and the impact of both production and consumption changes on the price of that grain in the

major producing nations of the world. Regardless of the world food and income situation, the concern may not be valid. In a recent study of the effects of increased productivity in basic grain production due to new technology being developed in Guatemala, Alvarez [1] has indicated that traditional farmers grow basic grains mainly for home consumption and basic income needs. As they move out of subsistence, the new basic grain technology is adopted to raise their incomes and also free land to be devoted not to basic grain production but to the production of other cash crops. Thus, over-production of grains will not result.

Further reflection on the U.S. hybrid experience would suggest that farmers in less developed countries now react very similar to those of U.S. farmers during the depression, drought and 'new' agricultural policy years of the 1930s. One distinct difference is that alternatives to basic grain production in the more tropical climatological areas of many less developed countries are more numerous than in the U.S. midwest to support the finding of Alvarez.

CONCLUSION

The evolution of socio-economic thought concerning the diffusion of innovations began with a debate about the relative importance of social and economic factors in the adoption process. Aside from disciplinary pride, the debate has merit because successful introduction of agricultural technology necessitates knowledge of the conditions that stimulate adoption and diffusion of innovations. But as often occurs, most sociologists and economists ultimately agreed that an integrated group of factors, not too well understood, and varying from one farm and farm area to another, stimulate adoption.

With world-wide enthusiasm based upon yield and production successes leading to hope for a 'green revolution' in world agriculture came a broader need to consider not simply

adoption and production but a host of other conditions such as markets and income distribution. The very nature of the adoption process, both socially and economically, tends to favour those early adopters with favourable social and economic characteristics. Those less fortunate can fall behind because they are able to assume neither the added production costs nor risks associated with potentially higher returns from the new technology.

Thus, the most recent but not final word on why farmers in LDCs do or do not adopt innovations relates to the welfare of the entire household and small farm unit. Various socio-economic conditions and perceptions influence the degree to which traditional 'small farmers' seek to avert risk in the struggle to augment their income. To successfully understand risk aversion and perception and to develop policies and programmes to act upon that understanding, will require multidisciplinary concern beyond that presently experienced. Integrated socio-economic research must address the entire decision environment of farmers and technological innovation. We must review our "hybrid, adoption, profitability, *green revolution*, income distribution, resource use, plenty and poverty" experience, learn from that experience and develop new concepts and programmes to deal with the food, energy and income situations within the world agricultural system.

REFERENCES

[1] ALVAREZ, Jose. "Traditional and Commercial Farm Supply Response in Agricultural Development: The Case for Basic Grains in Guatemala". Unpublished Ph.D. dissertation. University of Florida. 1977.

[2] BENITO, Carlos A., "Peasants' Response to Modernization Projects in Minifundia Economies", *American Journal of Agricultural Economics*, Vol. 58, 1976, pp. 143-151.

[3] BRADNER, Lowell and Murray A. STRAUS, "Congruence Versus Profitability in the Diffusion of Hybrid Sorghum", *Rural Sociology*, Vol. 25, No. 4, December 1959.

[4] CANCIAN, F., "Stratification and Risk-Taking: A Theory Tested On Agircultural Innovation", *American Sociological Review*, Vol. 32, 1971, pp. 912-927.

[5] CANTERBERY, El Ray and Hans BICKEL, "The Green Revolution and the World Rice Market, 1967-1975", *American Journal of Agricultural Economics*, Vol. 53 1971, pp. 258-294.

[6] DALRYMPLE, Dana G., "The Process of an Innovation Cycle: Comment", *American Journal of Agricultural Economics*, Vol. 56, 1974, pp. 652-653.

[7] ———, "Trends in Grain Area and Yield in Developed and Developing Nations", *American Journal of Economics*, Vol. 52, 1970, pp. 448-449.

[8] EVENSON, Robert, "The 'Green Revolution' in Recent Development Experience", *American Journal of Agricultural Economics*, Vol. 56, 1974, pp. 387-394.

[9] FALCON, Walter P., "The Green Revolution: Generation of Problems", *American Journal of Agricultural Economics*, Vol. 52, 1970, pp. 698-710.

[10] GOULD, John P., "Risk, Stochastic Preference, and the Value of Information", *Journal of Economic Theory*, Vol. 8, 1974, pp. 64-84.

[11] GRILICHES, Zvi, "Congruence Versus Profitability: A False Dichotomy", *Rural Sociology*, Vol. 25, No. 3, September 1960.

[12] ———, "Hybrid Corn: An Exploration in the Economics of Technological Change", *Econometrics Journal of the Econometric Society*, Vol. 25, No. 4, October 1957.

[13] ———, "Research Costs and Social Return: Hybrid Corn and Related Innovations", *Journal of Political Economy*, Vol. LXVI, No. 5, October 1958.

[14] HAVENS, A. Eugene and Everett M. ROGERS, "Adoption of Hybrid Corn: Profitability and the Interaction Effect", *Rural Sociology*, Vol. 26, No. 4, December 1961, p. 410.

[15] HIEBERT, L. Dean, "Risk, Learning, and the Adoption of Fertilizer Responsive Seed Varieties", *American Journal of Agricultural Economics*, Vol. 56, 1974, pp. 764-767.

[16] KISLEV, Yoav and Nira SHCHONI-BACHRACH, "The Process of Innovation Cycle", *American Journal of Agricultural Economics*, Vol. 55, 1973, pp. 28-37.

[17] MOSCARDI, E.R., "Allocated Efficiency and Safety-First Rules Among Small-Holding Farmers", Giannini Foundation Working Paper Number 3, University of California-Berkley, 1975.

[18] O'MARA, F., "A Decision-Theoretic View of an Agricultural Diffusion Process". Paper presented at Purdue Workshop on *Empirical Studies of Small-farm Agriculture in Developing Nations*, West Lafayette, Indiana, 1972

[19] PERRIN, Richard and Don WINKELMANN, "Impediments to Technical Progress on Small Versus Large Farms", *American Journal of Agricultural Economics*, Vol. 58 1976, pp. 888-894.

[20] PURVIS, Malcolm J., "The New Varieties Under Dryland Conditions: Mexican Wheats in Tunisia", *American Journal of Agricultural Economics*, Vol. 55, 1973, pp. 54-57.

[21] ROGERS, Everett M., *Diffusion of Innovation*, New York: The Free Press of Glencoe, London, Macmillan, New York, 1964.

[22] ROCHIN, Refugio I., "Rural Poverty and the Problems of Increasing Food Production on Small Farms: The Case of 'Columbia' ", *Western Journal of Agricultural Economics*, December 1976, pp. 185-190.

[23] RYAN, Bruce and Neal C. GROSS, "The Diffusion of Hybrid Seed Corn in Two Iowa Communities", *Rural Sociology*, Vol. 8, No. 16, March 1943.

[24] SIDHU, Surjit S., "Economies of Technical Change in Wheat Production in the Indian Punjab", *American Journal of Agricultural Economics*, Vol. 56, 1974, pp. 217-226.

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