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RESEARCH NOTES

LOCATION EFFECTS ON THE ADOPTION OF NEW FARM TECHNOLOGY, NORTH INDIA*

The production and diffusion of new farm technology¹ can be said to be one of the most significant factors responsible for breaking the age-old stagnation that has characterized the agriculture of some of the less developed countries. Indeed, the rapid progress achieved by some of these countries (India, Pakistan and the Philippines, for instance) in the field of agricultural production as a result of the introduction of new seeds and use of fertilizers has, of late, provided a sense of optimism in many of the developing countries. In fact, it has already brought some of these countries to the threshold of self-sufficiency in grains, while to others it has meant the promise of even converting them into new exporters. The fact that output of certain grains has doubled and even trebled in certain parts of Asia over the last decade would bear testimony to these possibilities.

One of the problems associated with new technology which does not seem to have caused enough concern among agricultural scientists and policy makers in several developing countries is that of the differential rates of diffusion of this technology. While factors like irrigation and farmer's resource position have been emphasized by some authors, the locational attributes of adoption and development have not been clearly recognized.

OBJECTIVES

The present paper represents an attempt to study specifically the question of the relationship between location and the rate of adoption of new agricultural technology in a developing agriculture. The study makes an important departure from previous studies on location. The location-adoption analysis has been extended to incorporate in the conceptual model the human capital variable expressed in terms of the schooling of farm population and the information systems disseminating knowledge about new production technology. The inclusion of education and information variables in the model is important, because the new technology demands the possession of knowledge and information on the part of farm operators. By the same token, the possession of knowledge enables the producers to successfully deal with the problem of disequilibria that new production technology introduces in agriculture (Schultz 8).

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1. Herein, technology refers primarily to the use of the High-Yielding Varieties (HYVs) and chemical fertilizers—often, termed the 'Green Revolution', or the 'Seed-Fertilizer Revolution'.

CONCEPTUAL FRAMEWORK

Enunciating his famous locational matrix hypotheses of economic development, Schultz (7) states that "economic development occurs in a specific locational matrix; there may be one or more such matrices", and "these matrices are primarily industrial-urban in composition." Following Schultz's pioneering postulates on locational matrices and agricultural development, a number of empirical studies have been undertaken to examine this relationship in the context of the U.S. experience, especially since the turn of the century. Most of the findings support the postulate that the industrial-urban centres have been associated with a more rapid development of agriculture in areas located at or near these centres [Katzman (3), Nicholls (4-5), Ruttan (6), Tang (11)]. A related field of intellectual inquiry is the area of technological change and its diffusion in agriculture. In his seminal article on hybrid corn, Griliches (13) used the logistic growth function² to study the factors responsible for differences in the diffusion of the new corn in U.S. and found that 'profitability,' determined by market density, innovations and marketing costs, was an important factor influencing the process of diffusion.

However, the logistic model has not been used by most of the studies on the relationship between rural and urban development. In most cases, the Cobb-Douglas type of function with appropriate transformations has been used to measure the functional relationships. These studies do not address themselves to the specific question of adoption of the new farm technology versus location; nor did they include variables such as education and information in their analytical framework.

The present study focuses on the adoption of the HYVs and incorporates in the model education and information variables. To the extent that it accounts for the effect of these variables, it provides an extension of the induced diffusion model formulated as under:

$$\text{ADOPT} = f(\text{LOCAD}, \text{EDUCA}, \text{INFOR}) \dots 1$$

$$f_2, f_3 > 0 > f_1. \quad (f_1, f_2, f_3 \text{ are partial derivatives of } f)$$

The variables in the above formulation and other variables used in the estimating model are defined in Tables I and II. Dummy variables have been used to account for differences in the levels of adoption over the regions and crops.

ESTIMATION AND RESULTS

The study draws on the author's earlier study of "Agricultural Technology, Activity Diversification, Employment and Wages" carried out at the G. B. Pant University of Agriculture and Technology, Pantnagar, Uttar Pradesh in 1973 and 1974 (10). The data were collected from a sample of 30 villages covering two Community Development (CD) blocks located in the western

2. Technological diffusion or adoption can be explained with the help of the logistic growth model expressed as:

$$P = K / 1 + e^{-(a + bt)}$$

where P is the cropped area under the HYV; K, the ceiling or equilibrium value; a, the constant of integration; b, the rate of growth; and t, the time variable.

region of Uttar Pradesh. There were 480 farm households in the sample. The data were pooled over three time periods, two regions, three locations, and three crops, giving a total of 54 ($3 \times 2 \times 3 \times 3$) observations. The three time periods were: 1966-67, 1971-72, and 1974-75.

Several forms of the function were estimated using the ordinary least square method. The results are presented in Tables I and II.

Locational Effects on Adoption

The estimated simple correlation coefficients for the variables included in the study showed a high degree of correlation between location and education ($r = -.82$), as well as between location and some of the information sources. High positive correlations were found between education and two information sources (the University and the government demonstration centres, $r = .8$ to $.9$). Thus correlation analysis helped in isolating the variables which exhibited multicollinearity and thereby made the task of formulation of the estimational equations easy with alternate sets of explanatory variables.³

The results of regression with the the location variables are presented in Table I. In all the estimating models, the coefficient of location (LOCAD)

TABLE I—RESULTS OF ESTIMATING COEFFICIENTS FOR ADOPTION MODELS, UTTAR PRADESH

Equation No.	(1)	(2)	(3)	(4)
Dependent variable	ADOPT (C) ^a	ADOPT (C) ^a	ADOPT (N) ^a	ADOPT (N) ^a
Form of function	Linear	Log	Linear	Log
Constant 'a'	20.4603	3.1669	17.3030	2.5879
Regression coefficients for:				
Location: ^b LOCAD	-1.5645*** (0.3164)	-0.1566*** (0.0461)	-0.9067*** (0.2164)	-0.2232*** (0.0462)
Time trend: TT	28.3797*** (1.5819)	0.5834*** (0.0379)	11.5511*** (1.0823)	0.5914*** (0.0380)
Regional dummy: ^c ZR	-3.4981* (2.5833)	-0.3049 (0.0619)	-0.2218 (1.7674)	0.0173 (0.0620)
Crop dummy: ^d ZP	-6.2928** (3.1638)	-0.0950 (0.0759)	-3.7316* (2.1646)	-0.1098 (0.0760)
Crop dummy: ^e ZM	-8.2228** (3.1638)	-0.1505** (0.0759)	-25.4191*** (2.1646)	-1.4349*** (0.0760)
R ²	0.8810	0.8402	0.8585	0.9364
n = 54				

Standard errors of the estimates are given in parentheses.

*** Significant at 1 per cent level; ** Significant at 5 per cent level; and * Significant at 10 per cent level.

a. ADOPT(C) refers to percentage areas under HYV to the total area under each of the respective crops studied and ADOPT(N), to net cultivated area in *rabi* season for wheat, and *kharif* for maize and paddy respectively.

b. LOCAD is measured by distance from the centre in kilometres.

c. ZR = 1 for Rudrapur and 0 for Bilaspur.

d. ZP = 1 for paddy and 0 for wheat and maize.

e. ZM = 1 for maize and 0 for paddy and wheat.

3. Regressions were however run with equations including all the explanatory variables. The result was that all the explanatory variables turned non-significant, with some coefficients giving unreasonable signs [$+$ for LD, $-$ for ED, Singh (9)].

is negative and statistically highly significant, suggesting a strong adverse impact of location on the rate of adoption in the study area. This means that as villages move away from the urban-industrial centres, there is a relative decline in adoption. The coefficient of **LOCAD** suggests that with a one unit (one kilometre) increase in distance of the villages from the centre, adoption declines by 1.56 per cent [Table I, equation (1)]. If new technology generates greater farm income, the existence of an inverse location-adoption relationship will imply that, other things being constant, differences in locational attributes may also lead to inequalities in the distribution of income.

Further, there are significant differences in the levels of adoption of the HYV of seeds among the three crops considered. Other things being equal, wheat has experienced higher levels of adoption than both paddy and maize as shown by the negative and statistically significant regression coefficients for the two dummy variables ZP and ZM. This is quite plausible because the so-called 'green revolution' in the country started more vigorously with varietal improvements in wheat. As between the two study areas no significant differences have been observed (Table I).

However, what is important is that the evidence of the present statistical analysis suggests a rejection of the hypothesis that there exists no relationship between the locational matrix and the process of diffusion of new agricultural technology in agriculture. New technology *per se* may be location-neutral, but its adoption is conditioned by factors (such as market, transportation, urban-industrial centre, level of education, accessibility to information systems, etc.) that may be unevenly distributed among villages and/or regions.

The two townships considered as centres of locational matrices for the purpose of the present study are the major urban-industrial centres in the region in which important marketing, administrative, educational and research and extension activities are concentrated. Villages located close to these centres have made faster progress in organizing their farm resources more efficiently than those of the locationally disadvantaged. This is reflected in greater adoption of the seed-fertilizer technology in villages located close to the urban industrial centres. Additionally, better transportation and marketing facilities seem to have provided farmers strong incentives for growing cash crops such as fruits and vegetables, raising livestock and poultry in combination with crop enterprises, and for seeking off-farm employment and income sources (Appendix Table 1).

Education and Adoption

Villages under study also differ significantly with respect to education and literacy. The data (Appendix Table 2) show that the farmers in villages situated at or near the urban-industrial centres enjoy higher levels of education than those located at distant places. A high degree of correlation ($r = -0.82$) was found between location and education. This suggests the existence of multicollinearity between the two; and to that extent the effect of the **LOCAD** variable on adoption will approximate the effect of the education variable also. In fact, the location variable represents a host of variables, education

TABLE II—RESULTS OF ESTIMATING COEFFICIENTS FOR ADOPTION MODELS[†] WITH EDUCATION AND INFORMATION, UTTAR PRADESH

(n = 54)

Equation No.	(1)	(2)	(3)	(4)	(5)	(6)
Form of function	Log	Log	Log	Log	Log	Log
Constant 'a'	3.0670	1.6505	0.1928	2.1207	1.6593	1.3314
Regression coefficients for:						
Educational index (average school years): EDUCA	0.0611 (0.2404)	0.4455*** (0.0770)	0.6892*** (0.1108)	0.3628** (0.1302)	0.4201** (0.1060)	0.4961*** (0.0674)
Learning about HYV from university: HYAG ^a	0.3318* (0.1651)	—	—	—	—	—
Learning about HYV from demonstrations: HYDEM ^a	—	0.0919* (0.0489)	—	—	—	—
Learning about HYV commu- nity develop- ment: HYCD ^a	—	—	0.2492* (0.1396)	—	—	—
Learning about fertilizer use, University: FAGU ^a	—	—	—	0.1256 (0.0853)	—	—
Learning about fertilizer use from demons- trations: FDEM ^a	—	—	—	—	0.1552 (0.1179)	—
Learning about fertilizer use from communi- ty development: FCD ^a	—	—	—	—	—	0.1798* (0.1061)
Regional dum- my: ^b ZR	0.0998 (0.0571)	0.0262 (0.0325)	-0.1164 (0.0724)	0.0531 (0.0470)	0.1344 (0.1060)	0.0145 (0.0313)
Crop dummy: ^c ZP	-0.0828** (0.0355)	-0.0820** (0.0361)	-0.0828* (0.0365)	-0.0828* (0.0377)	-0.0828* (0.0383)	-0.0828* (0.0368)
Crop dummy: ^d ZM	-0.1343*** (0.0355)	-0.1343*** (0.0360)	-0.1343*** (0.0364)	-0.1343*** (0.0377)	-0.1343*** (0.0383)	-0.1343*** (0.0362)
R ²	0.8339	0.8800	0.8774	0.8686	0.8644	0.8748

[†] Time trend (TT) variable was not included in the model for lack of data on education and information by time. The data for 1974 were used for estimating the model.

The dependent variable in all the equations of this table is ADOPT(C).

Standard errors of the estimates are given in parentheses.

*** Significant at 1 per cent level; ** Significant at 5 per cent level; and * Significant at 10 per cent level.

a. Variable expressed as percentage of farmers gathering information from a particular source.

b. ZR = 1 for Rudrapur and 0 for Bilaspur.

c. ZP = 1 for paddy (rice) and 0 for wheat and maize.

d. ZM = 1 for maize and 0 for paddy and wheat.

being one, through which it can be said to exercise its influence. The location-adoption response relationship cannot be said to be a straight but a complex one, and hence the need for caution in interpreting the results.

The education variable, though inversely correlated with location, exercises a positive impact on adoption. The regression coefficient for the education variable, considered along with information variables,⁴ is positive and statistically significant in five out of six cases (Table II). The result thus demonstrates the significant effect of schooling on the diffusion process. This relationship will appear still more interesting from another aspect. Farmers located at or near the urban-industrial centres have tended to invest more in education than those located at long distances from such centres. In one of the two study regions (Rudrapur), the farmers close to the urban-industrial centre (L_1) have had an average of 4 years of schooling as compared with only 2 years of schooling among the farmers at the farthest point (L_3). In the other area, it ranges from 2.6 years to 3.5 years (Appendix Table 2). Such differences can be explained in terms of differences in educational facilities, transport and communication infrastructure, as well as in the distribution of incentive structure influencing the demand for schooling. The availability of employment and other productive opportunities in and outside the region determines returns to education, and hence provides a strong incentive for investment in education. The villages which are located near the urban-industrial centres enjoy more diversified and higher levels of employment than the locationally disadvantaged villages (Appendix Table 1).

Information and Adoption

The three sources of information and learning about new agricultural techniques were the Community Development blocks, the agricultural universities, and national demonstration schemes. The coefficient of information is positive and statistically significant at the 10 per cent probability level in four out of the six equations tried [Table II, equations (2 to 6)]. This implies that the adoption of new agricultural technology is positively influenced by information. However, there is another aspect of the information variable. This is that while information can be of immense value to farmers in acquiring knowledge about modern inputs, it may also contribute to unevenness in the pattern of adoption. In a separate study Singh (9, 10) reports how some of the public institutions disseminating information have been biased towards large sized and better educated farms. Whatever the reasons for such biases this could be a matter of concern for public policy. In a country where 75 to 80 per cent of the rural population is illiterate, the existence of information and learning gaps can be a major source of adoption gaps. Information is indeed vital under changing conditions that new farm technology imposes on traditional agriculture.

4. Because of very high intercorrelation between LOCAD and EDUCA as stated earlier, the two variables were not included in the same equation. However, when regressions were run with location and information variables the effect of location became weaker though statistically significant. Equations with education and information variables yielded reasonable results though, and hence were retained for discussion.

Trend Variable

A positive and statistically highly significant regression coefficient for the trend variable (TT) suggests that the variables not explicitly included in the model exercised a strongly positive impact on adoption. It is true, however, that TT represents the 'compound' effect of a number of factors and as such nothing definitive can be inferred for policy purposes.

CONCLUSIONS AND IMPLICATIONS

The present evidence establishes the differentiating influence of location on the diffusion of new agricultural technology in agriculture. The results demonstrate that there exists an inverse relationship between adoption and location. Villages located at or near the centres have enjoyed better marketing facilities, higher education, greater access to information and communication, and diversified employment opportunities. Consequently, they have responded strongly and positively to technological changes and engaged in a relatively more diversified market-oriented system of farming than those located at long distances from the urban-industrial centres do. The present evidence would thus lend support to the hypothesis that location acts as a centre of technological transformation in agriculture.

Education emerged as an important factor influencing adoption of the new agricultural technology. Investment in education and training of farm population is indeed an important policy variable to which the developing countries would need to place adequate priority together with their investment in agricultural research and farm modernization programmes. This is an area which has persistently been relegated to the background in most of the developing countries. It will be a big mistake to consider that modernization of agriculture can or will be sustained over time with obsolete human agent of production! Similarly, the institutions concerned with research, extension, and demonstration for transmitting the new knowledge and skills to the farmers have a great role to play in the process of adoption of modern agricultural technology.

Differences in the rates of diffusion of new techniques cannot be said to be just accidental. The locational factor has certainly played an important role in the process. Income disparities associated with differences in the adoption of new technology caused by an uneven distribution of locational attributes would raise some questions relevant to public policy. For example, one question which seems pertinent is with respect to either the geographical dispersal or establishment of industrial units and building the necessary infrastructure which may help in reducing regional imbalances.

Briefly, the integrated analysis of the diffusion of new agricultural technology with the urban-industrial impact hypotheses leads to an important implication for development policy. This is to develop the institutional capacity to overcome the locational disadvantages of the areas which are not advantageously located relative to urban-industrial development.

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APPENDIX TABLE 1

ACTIVITY AND OCCUPATIONAL DIVERSIFICATION OF THE SAMPLE POPULATION IN DIFFERENT LOCATIONS* IN THE STUDY REGIONS, UTTAR PRADESH

Activity and occupational diversification	Farms in Rudrapur			Farms in Bilaspur		
	L ₁	L ₂	L ₃	L ₁	L ₂	L ₃
Percentage of population employed in:						
Secondary activities during slack seasons	6.19	1.95	0.95	2.49	3.51	0.61
Non-agricultural secondary occupations all round the year	8.84	1.77	1.52	1.50	1.20	0.85
Livestock, poultry and plantations as primary and subsidiary occupations ..	5.42	2.81	1.15	0.50	0.69	0.24
Percentage of total cropped area under vegetables, etc. ..	2.60	0.53	0.30	2.00	0.90	0.60
Percentage of net cultivated area under irrigation from all sources	89.3	83.3	74.9	92.3	80.6	88.1

Source: Sample Survey.

* L₁, L₂ and L₃ are locations in terms of distance (in kilometres) of farms/villages from the two urban industrial centres of Rudrapur and Bilaspur of the study area (L₁ being the nearest and L₃, the farthest).

APPENDIX TABLE 2

LITERACY AND EDUCATIONAL STATUS BY LOCATION* IN THE STUDY REGIONS, UTTAR PRADESH

Literacy/Education	Farms in Rudrapur			Farms in Bilaspur		
	L ₁	L ₂	L ₃	L ₁	L ₂	L ₃
Percentage of literates ..	52.22	46.59	21.36	30.17	22.87	17.77
Percentage of population with primary level education ..	38.06	29.06	17.23	17.10	15.35	12.46
Percentage of people with middle level education ..	4.42	7.60	2.86	4.26	3.98	3.17
Percentage of people with higher secondary level education	7.08	6.51	1.03	5.98	2.58	1.22
Percentage of people with higher level education ..	2.65	2.70	0.22	2.74	0.96	0.85
Education index	403	386	205	346	289	265
Average schooling years ..	4.0	3.9	2.0	3.5	2.9	2.6

Source: Sample Survey.

* The distance of each location from the centre is as follows: L₁ for villages located in the range of 0.5 kilometres from the centre; L₂, between 5 and 10 kilometres; and L₃, 10 kilometres and more from the centre.

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INTERSECTORAL RESOURCE FLOWS AND ECONOMIC DEVELOPMENT: THE CASE OF INDIA

Development economists have recognized that the performance of the agricultural sector is an extremely important factor in determining the overall success of a particular country's programme for development. More specifically, conventional economics argues that agriculture should serve as a source of food, raw materials, labour and possibly savings for the expansion of the industrial sector. In other words, a net outflow of resources from agriculture to industry should be generated and these resources should be used to promote the rapid expansion of the non-agricultural sector. Agriculture is thought to be the only sector capable of performing such a role since it is usually the largest and most important sector in the less developed countries.¹

Proponents of this view often point to the experiences of Japan and Taiwan to support their arguments. Indeed, Mundle and Ohkawa² have recently developed two measures of the intersectoral flow of resources and were able to show that there was a significant outflow from agriculture into non-agri-

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